Age-related Differences in Conscious and Unconscious Memory Processes:
An Investigation of the Process Dissociation Procedure

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Abstract

Age-related differences in the contributions of conscious and unconscious memory processes were investigated in order to evaluate the proposition that ageing only impairs conscious processes, whilst unconscious processes are largely spared. In addition, the experimental work evaluated the boundary conditions of the process dissociation procedure (PDP; Jacoby, 1991). The PDP was applied to a conceptually-oriented category exemplar generation memory task and to a perceptually-oriented associative word stem completion memory task. In a series of six experiments, two primary classes of encoding manipulation were applied to these memory tasks: divided attention and directed forgetting. Divided attention was investigated using a parametric manipulation of short-term memory load at encoding. Directed forgetting was operationalised in two ways: (1) an item-method cueing paradigm; and (2) a list-method cueing paradigm. These two basic paradigms were used to investigate the differential rehearsal and retrieval inhibition accounts of directed forgetting, respectively. The application of the PDP in these experiments revealed evidence convergent with the task dissociation literature; namely, age-related invariance was observed in the estimates of unconscious processes, whilst an age-related decline was found in the estimates of conscious processes. However, it is argued that the identification of the sources of variability in dependent measures of unconscious processes, rather than whether or not unconscious processes are impaired by age, is a more pertinent research question. The results are discussed with respect to three primary accounts of cognitive ageing: diminished attentional resources, impaired inhibitory processes, and deficits in the ability to spontaneously generate semantic, elaborative encoding. In addition, the findings suggest that further revision and specification of the PDP will be necessary in order to render veridical estimates of conscious and unconscious processes.
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1. Explicit-Implicit Memory and Ageing: Experimental Work

1. Explicit-Implicit Memory and Ageing: A Component-Process Oriented Review of the Experimental Work

1.0 General Introduction

The relation between normal ageing and cognition cannot be described by a simple function, because cognitive ageing is a selective process that is related to the differential changes that occur in cortical and subcortical neural regions. Functional regions, such as the association cortices, undergo more marked changes as a function of age than other anatomical regions such as the primary sensory areas (for a review, see Kemper, 1994). Therefore, cognitive functions that are mediated by these functional regions will be more sensitive to the effects of ageing. At a components of processing level, this will be expressed in tasks that involve greater mental effort, novelty, and informational complexity (Horn, 1982); namely, fluid cognitive abilities, rather than crystallised cognitive abilities (Cattell, 1972). Fluid abilities can be evaluated using measures of causal and deductive reasoning, spatial performance, and memory. In contrast, crystallised abilities are represented by performance on measures of general information, denotative word meaning, and other forms of knowledge that tend to remain stable. Consistent with much of the research on cognitive ageing, this thesis focuses on fluid abilities.

The nature of age-related differences in cognition represents the complex, heterogeneous processes that mediate cognition. Consequently, it is not surprising that the pattern of findings in the experimental literature reflects this complexity, since impairment, preservation, and improvement in cognitive abilities have all been reported (for comprehensive reviews, see Craik & Byrd, 1982; Light, 1991; Verhaegen, Marcoen, & Gossens, 1993). Schaie (1974) proposed that the three most common descriptions of age-related differences in cognition are irreversible-decrement, stability, and decrement-with-compensation. These are essentially taxonomic generalisations about observed relations between age and performance. Determining the pattern of preserved and impaired functioning, and identifying the various systems and processes implicated in cognition, is a major theme in cognitive ageing research.

The selective changes that occur in cognitive ageing are particularly evident in memory (for

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1 For instance, the posterior association cortex appears to have a role in episodic memory, although this has been challenged elsewhere (for a review, see Cabeza & Nyberg, 1997).
reviews, see Craik & Jennings, 1992; Hultsch & Dixon, 1990; Light, 1990). Although, recent work has shown that other cognitive abilities such as visuospatial functioning and reasoning may also be subject to age-related impairment (Ritchie, Ledesert, & Touchon, 1993). The neural correlates of age-related differences in memory are often conceptualised in terms of analogy to focal or degenerative lesions, as seen in some forms of amnesia and other neurological diseases (Gabrieli et al., 1994; Moscovitch & Winocur, 1992). The difficulty with characterising age-related differences in memory in this manner is that ageing is not associated with either focal lesions or degenerative diseases, rather the structural changes in the neural substrate are diffuse and heterogeneous (Jernigan et al., 1991). This does not negate the importance of work investigating pathological ageing or the anatomical and physiological deterioration associated with ageing (Creasey & Rapoport, 1985), rather, it serves as an important caveat that sound physiological data should dovetail with functional evidence from cognitive studies. Understanding how neural senescence maps onto age-related functional differences will, in fact, first require improved knowledge of brain function, rather than anatomical structure (Baddeley & Della Sala, 1998).

The investigation of age-related differences in memory has been critical for the development of general theoretical accounts of memory. For example, the impact of experimental work investigating age-related differences in memory is clearly illustrated by the research conducted by Talland (1968). Talland’s work was guided by the classic multistore model of memory (Shiffrin & Aktkinson, 1969). Short-term (primary) memory was distinguished from long-term (secondary) memory on the basis of differences in capacity, encoding processes, retrieval processes, and apparent perseveration of stored information (Waugh & Norman, 1965). The early accounts of the two store, and later the multistore, model proposed that the stores should be dissociated along an age dimension; namely, age-related impairment should be confined to the encoding and retrieval processes involved in long-term memory. Typical experimental findings that were used to support this notion include reports of impaired primacy effects along with an intact recency effect on serial position, and intact forward digit span combined with impaired single-trial free recall.

However, the development of a more operationally based perspective, reflected in the process-oriented levels of processing framework (Craik & Lockhart, 1972), and inconsistencies in the memory store literature (such as deficits in backward digit span, see Tulving & Patterson, 1968; Wicklegren, 1973), suggested that it may not be necessary to postulate different storage systems. These developments motivated a change in the way age-related differences in memory were interpreted. In the levels of processing framework, age-related differences in cognition are
characterised as a decline in the ability to 'deeply' or 'elaboratively' process information (Craik, 1977). The decline in processing ability is, in turn, attributed to a reduced information processing capacity or an impairment in the ability to deploy attention in a controlled manner. This general position has been more recently reconceptualised in terms of age-related deficits in the speed and accuracy of working memory (Cerella, 1985; Salthouse, 1985; Salthouse, 1996).

Notwithstanding which model of memory is adopted, there is evidence for the presence of an age-related decline in memory function. In addition, consistent with the general view of cognitive ageing, the pattern of age-related differences in memory is not a simple monotonic decline, since a significant number of studies have reported that the extent of the age-related deficit varies according to the memory task (Craik, 2000). This would be expected, since memory is rarely conceptualised as the output of a single process or system, mediated by a single neural region (Tulving, 1999). Accordingly, the presence of greater age-related impairment in recall than in recognition correlates well with neural regions that are subject to degeneration and that appear to have a role in these tasks (Verhaegen et al., 1993). The relative preservation of recognition memory suggests that despite the age-related deficits in information processing, some information is still encoded and retained successfully by older adults (Gardiner & Java, 1993a).

Contemporary cognitive theoretical frameworks have emphasised the importance of determining the effects of ageing on different types, or forms of memory, and component processes, as opposed to focusing on control processes and storage structures (Moscovitch, 1992a; Roediger, Buckner, & McDermott, 1999; Schacter & Tulving, 1994b; Squire, 1992b; Willingham, 1997). This approach is also reflected in the wider theoretical memory literature that can be characterised by structural dichotomy: explicit versus implicit (Graf & Schacter, 1985), conscious versus unconscious, aware versus unaware (Jacoby & Witherspoon, 1982), automatic versus controlled (Jacoby, 1991), working versus reference (Olton, Becker, & Handelmann, 1979), procedural versus declarative memory (Cohen & Squire, 1980), episodic versus semantic (Schacter & Tulving, 1994b), and perceptually-driven versus conceptually-driven (Blaxton, 1989). It is interesting that theoretical frameworks almost exclusively fractionate memory along such dichotic lines, especially since multiple memory systems theorists have argued that there are at least four long-term memory systems that can be distinguished (Schacter & Tulving, 1994a). Nonetheless, these frameworks have been productive both in descriptive and explanatory terms.

The present chapter, and the experimental work presented in this thesis, focuses on one such
1. Explicit-Implicit Memory and Ageing: Experimental Work

contemporary distinction as it relates to ageing: explicit versus implicit memory (Graf & Schacter, 1985). The review is not intended to be exhaustive, rather it is limited to those studies in which young and older adults were contrasted within a cross-sectional design, and those that have relevance to the experimental work presented in this thesis; namely, the investigation of age-related differences in conscious and unconscious memory processes.

1.1 Chapter Overview

In the first section, a brief overview of the early work that led to the distinction between explicit and implicit memory is presented. This will take the form of a treatise addressing the basic findings, with particular attention given to the perceptual-conceptual processing dichotomy, and difficulties associated with interpreting the experimental findings. A more theoretically oriented discussion of the perceptual-conceptual processing distinction is provided in Chapter 3. In the second section, a general overview of the explicit-implicit memory and ageing research is presented. The third section reviews memory for new associations, and the fourth section reviews item-specific priming of pre-existing materials. Both the third and fourth sections are not intended to provide an exhaustive review of the experimental work, rather, they are intended to highlight several neglected domains of research. This approach is designed to mediate between the needs for an exhaustive review, whilst retaining a selective, critical perspective in order to justify the focus of the experimental work included in this thesis. The fifth section concentrates on the effect of directed forgetting and divided attention on direct and indirect memory tests, since these variables were adopted to investigate some of the major accounts proposed to interpret age-related effects on memory.

1.2 Explicit and Implicit Memory

At a basic level, the distinction between explicit and implicit memory refers to the two different ways in which memories can be expressed. Explicit memory refers to the conscious retrieval of previous events, as measured by direct memory tests, whereas implicit memory refers to the unconscious effects of previous events on subsequent behaviour and performance, and is measured by indirect memory tests. Direct memory tests include tasks such as free recall and recognition, whereas indirect memory tests typically involve a task that does not ostensibly draw on the relation between the study and test phase.
Given that implicit memory reflects a diverse, but nonetheless distinct, set of processes that facilitate information processing, any discussion of implicit memory can only realistically be limited to a small subset of the findings. The present review focuses on the phenomenon of verbal priming (for a review of other forms of implicit memory, see Squire & Knowlton, 1995), and is organised in terms of the memory tasks and materials used to measure explicit and implicit memory. This approach is adopted in the absence of an adequately integrated theoretical framework for understanding the explicit-implicit memory dichotomy (cf. Bower, 1996). Finer distinctions within direct and indirect memory tests will be made, where appropriate. This method of organisation permits evidence of the differential sensitivity of the component processes that mediate performance in direct and indirect memory tests to be presented. Indeed, it is probably only a matter of time before particular classes of indirect memory test are shown to be reliably more susceptible to ageing than others.

1.2.1 Inchoate Terminology

The terms explicit and implicit, first formalised by Graf and Schacter (1985), have been used to refer to forms of memory and to the tasks used to index these forms of memory. This approach to the classification of memory tasks presents a difficulty, because ‘explicit’ and ‘implicit’ memory tests are often assumed to reflect the output of different retrieval strategies and memorial states of awareness, rather than represent atheoretical terms that refer to a particular set of retrieval instructions. Similarly, the terms direct and indirect memory test have been used in a similarly conflated manner (e.g. Johnson & Hasher, 1987; Seamon, Williams, Crowley, & Kim, 1995), because these memory tests are sometimes argued to measure the output from direct and indirect memory, respectively.

The a priori identification of a particular task with a particular form of memory has been termed the process-purity (Jacoby, 1991) and transparency (Dunn & Kirsner, 1989) assumption. Further, Gardiner and Java (1993a) argued that the application of a single term to refer to memory tasks, forms of memory, retrieval strategies, and memorial states of awareness represents a violation the inconvertibility of terms. The application of such a principle is necessary to avoid unacknowledged assumptions when using a single term to refer to more than one construct. On this basis, Richardson-Klavehn, Gardiner, and Java (1996) suggested alternative terms for the two primary classes of memory tests: intentional and incidental memory tests. They intended this distinction to avoid the process purity assumption. However, the contrast between the terms intentional and
incidental defines incidental memory tests by the exclusion of intentional retrieval influences, and this indirectly implies a process-purity assumption.

Specifying memory tasks in terms of observables, whereby the principle one is the type of retrieval instruction, represents the clearest manner in which to refer to the two types of memory task (Richardson-Klavehn & Bjork, 1988a). Accordingly, the terms direct and indirect will be used to refer to the two types of memory test. These terms are relatively neutral and atheoretical, because they are used to exclusively refer to the nominal set of instructions at test. Under the terms of this approach, a direct memory test explicitly refers to a past experience, whereas the concept of an indirect memory test is broadened to include instructions where reference to the study episode is made, but participants are instructed to nonetheless report the first items that come to mind at test. This revision confers the ability to include instances where ‘canonical’ indirect memory test instructions have been modified (e.g. Tulving, Schacter, & Stark, 1982).

The relatively content neutral terms conscious memory influences/processes and unconscious memory influences/processes are also used in the present chapter, and throughout the thesis, to refer to the heterogeneous collection of processes that contribute to direct and indirect memory test performance, because memorial state of awareness is the basal criterion for both task dissociation and process dissociation approaches. Clearly, these terms do conflate processing constructs, and more fine-grained distinctions will be made between retrieval strategies, memorial states of awareness, and the ‘use of memory’ once these constructs have been introduced.

1.2.2 Explicit-Implicit Memory

In a verbal indirect memory test, participants are exposed to words during a study phase, and then later asked to identify briefly presented words (perceptual identification, e.g., Jacoby & Dallas, 1981); to complete letter fragments of words with the first word that comes to mind (word fragment completion, e.g., Tulving et al., 1982); to respond with the first word they can think of when provided with the first three initial letters (word stem completion, e.g., Weldon, Roediger, & Challis, 1989); to decide whether a letter string constitutes a word or non-word (lexical decision, e.g., Scarborough, Gerard, & Cortese, 1979); or, to resolve an anagram (word anagram solution, e.g., Java, 1992). The completion of test items more frequently (or at a reduced latency or with increased accuracy) with previously studied items relative to an appropriate baseline (non-studied items; the control condition), is a phenomenon referred to as repetition priming, or more simply,
priming. Priming is only one form of dependent measure of implicit memory, since implicit memory can be measured using tasks in which motor or cognitive skills are acquired (for a review, see Salmon & Butters, 1995). However, priming remains the principle measure used to evaluate the output from implicit memory in the task dissociation literature.

The early experimental work was designed to generate priming effects in indirect memory tests, and at the same time dissociate direct tests from indirect memory tests. Specifically, the functional dissociation approach involves utilising experimental variables and/or subject variables to produce an effect on only one type of test whilst having no, or an opposite, effect on the other. Resulting double dissociations have been used as evidence to support the notion that separate systems and processes correspond to each memory test (Dunn & Kirsner, 1989). Dissociations as a function of age have been interpreted as evidence in favour of different ontogenetic origins for the processes or systems that mediate direct and indirect memory tests (e.g., Parkin, 1993). The functional dissociation approach has been a productive method for exploring the relation between explicit and implicit memory, but the limitations of this approach are addressed in Chapter 2.

Table 1.0 illustrates the effects of typical experimental and subject variables that have been used to dissociate direct and indirect memory tests. Graf (1994), Moscovitch, Vriezen, and Goshen-Gottstein (1993), Richardson Klavehn and Bjork (1988a), Roediger and McDermott (1993), Schacter (1987), Schacter and Buckner (1998), and Schacter, Chiu, and Ochsner (1993) all provide reviews of this research. The pattern of functional dissociations that are presented in Table 1.0 is only intended as a guide to the general trends in the experimental work, rather than represent any individual set of findings. Further, these trends are based on the task dissociation literature; the data becomes more complex when second generation, process dissociation approaches are also considered.
# 1. Explicit-Implicit Memory and Ageing: Experimental Work

Table 1.0 Task dissociating experimental and subject variables. X denotes no effect of the variable on the memory tasks, whereas ✓ denotes an effect of the variable on the memory tasks.

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Indirect Memory Tests</th>
<th>Direct Memory Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Levels of processing</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>(e.g., Jacoby, 1983b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generating versus reading a word</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Reading versus generating a word</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>(e.g., Jacoby &amp; Dallas, 1981)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modality change across study and test episodes</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>(e.g., Roediger &amp; Blaxton, 1987)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typography change between study and test episodes</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>(e.g., Roediger &amp; Blaxton, 1987)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subject Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alzheimer's disease (for a review, see Fleischman &amp; Gabrieli, 1998).</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Organic amnesia</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>(for a review, see Schacter et al., 1993)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>(for a review, see Light &amp; La Voie, 1993a)</td>
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<td></td>
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</tbody>
</table>

The prototypical functional dissociation study in which one direct memory test is contrasted with one indirect memory test has produced many important findings, but it has also left numerous inconsistencies. The inherent assumption made when a dissociation is obtained is that the result will generalise to other similar measures. However, it is well known that both direct and indirect memory tests can themselves be dissociated (Blaxton, 1989; Roediger, Srinivas, & Weldon, 1989a; Srinivas & Roediger, 1990). Given this situation, the generalisation of findings from one indirect memory test to another is similarly restricted, since important differences exist among indirect memory tests (e.g., Nelson, Canas, Bajo, & Keelan, 1987). Further, only a limited number of studies
have tried to compare multiple direct and indirect memory tests within one experiment (Roediger & McDermott, 1993). A multiple, direct comparison method is preferred because additional empirical information is obtained under conditions in which tasks are directly compared, enabling an improvement in the ability to account for the various dissociations observed among memory tasks (Roediger et al., 1999; Schacter, 1987).

An alternative form of the task dissociation approach involves testing for stochastic independence between individually studied items retrieved in direct and indirect memory tests (Jacoby & Witherspoon, 1982; Perruchet & Baveux, 1989; Tulving, 1985a; Tulving et al., 1982). This contingency analysis has been less widely used, because the independence between tests based on this approach is a moot issue. Competing explanations exist for instances when a low correlation between tests are reported. Low correlations may arise from the unreliability of the test, from low variance in some of the measures (Ostergaard, 1992), or participant by item effects may operate in different directions to cancel out correlations that exist and give the impression of independence among tests (Hintzman & Hartry, 1990). Derived variants, such as the method of triangulation (Hayman & Tulving, 1989a), have failed to be adopted because of limitations in the variety of tasks that can be used with such approaches.

### 1.2.2.1 Perceptual versus Conceptual Processing

Converging evidence suggests that the dissociations between direct and indirect memory tests are not only determined by type of instructions at retrieval (direct or indirect), but also on the match between the processing requirements of the encoding task and the retrieval task (Blaxton, 1989; Weldon et al., 1989). These processing demands are embodied by the general principle of transfer appropriate processing (TAP, Morris, Bransford, & Franks, 1977), whereby performance on any test of memory is a function of the overlap between the operations performed at encoding and those induced by the test (Blaxton, 1989; Morris et al., 1977; Roediger, Weldon, & Challis, 1989b); that is, the manner in which items are encoded and subsequently tested determines memory performance. Dissociations occur between direct and indirect memory tests because they typically require different modes, or types, of processing at test; consequently, they benefit from different types of encoding. The most widely applied processing dichotomy in the context of the explicit-implicit memory distinction is that between perceptually-driven and conceptually-driven processing (e.g., Blaxton, 1989; Roediger, 1990a; Roediger & Blaxton, 1987; Roediger et al., 1989b; Weldon & Roediger, 1987).
In purely descriptive terms, the format of memory tests that are predominantly perceptually-driven involves items at study being presented in a perceptually related form to the cue that appears at test phase. In contrast, in memory tests that are predominantly conceptually-driven, the test cue is frequently conceptually related to the studied stimulus, but has no perceptual similarity; consequently, it is assumed that retrieval requires the recapitulation of the semantic processing that occurred at encoding. Difficulties arise even at this ‘shallow’ level of specification, since a simple task analysis reveals that it is the overall task demands that determine the classification of a memory test (Toth & Hunt, 1999). For instance, it is not clear whether homophone spelling is a perceptual or conceptual task, since the test word is presented in isolation, so spelling would seem to fit the descriptions of a perceptually-driven memory test. However, the spelling of the homophone requires that a particular meaning be instantiated, which will necessarily invoke conceptually related processes. Importantly, the distinction between perceptually- and conceptually-driven processing is viewed as points on two continua, one for each type of processing (Weldon, 1991). Therefore, these two modes of processing can vary orthogonally, and are not coextensive with a particular class or type of memory test.

Roediger and colleagues proposed that perceptually and conceptually driven tests should be operationally defined in terms of the generate-read encoding manipulation (Jacoby, 1983b; Winnick & Daniel, 1970) and by varying the perceptual relations between stimuli at study and test. A test is considered perceptually-driven when reading the target produces better priming than generating it from a conceptual cue, such as found with perceptual identification, word fragment completion, word stem completion, word naming, and anagram solution (for an exception see Mulligan, 1998). Conversely, it follows that if performance on a particular test was better following the generate condition, the test is accordingly classified as conceptually-driven. That is, conceptual memory test performance is increased by semantic encoding (Hamann, 1990). The main difficulty with the generate-read criterion as an independent measure of perceptual-conceptual processing is that it is limited as a basis for theoretical explanation, but in terms of the procedural distinction it is useful. In addition, the generate-read criterion does not eliminate the interpretative uncertainty associated with the effects of conceptual information, because such effects can originate from conscious memory processes that rely on this information.

In relation to the perceptual overlap between study and test items, both cross modal or within modal manipulations have produced attenuated perceptual priming (e.g., Park & Gabrieli, 1995; Weldon,
1. Explicit-Implicit Memory and Ageing: Experimental Work

1991), whereas conceptual priming is largely unaffected (Blaxton, 1989; Srinivas & Roediger, 1990). Examples of conceptually-driven indirect memory tests include: the free association test, in which participants are instructed to spontaneously produce words when given a highly associated word (Shimamura & Squire, 1984); category exemplar generation/category association, in which previously studied category exemplars are cued by appropriate category names (Rappold & Hashtroudi, 1991); and, general knowledge question fact completion (Blaxton, 1989).

The existing data contains several discrepancies that cannot be explained by a simple distinction between the effects of perceptual and conceptual processing. First, some stimuli that have few or no surface features in common with the test stimuli do produce priming on perceptually-driven memory tests (e.g., Craik, Moscovitch, & McDowd, 1994; Curran, Schacter, & Bessenoff, 1996; Tenpenny, 1995). One possible interpretation is that priming on these tests involves a conceptually-driven component, as has also been suggested for anagram solution (Srinivas & Roediger, 1990) and word stem completion (e.g., Buckner et al., 1997). However, the nature of this conceptual processing in putatively perceptual memory tests is insufficiently specified (Craik et al., 1994; Masson & MacLeod, 1992). Additional difficulties with the framework are highlighted by findings such as the equivalent effect of variables across perceptual and conceptual indirect memory tests (Hunt & Toth, 1990), and dissociations across different conceptual tests (e.g., Cabeza, 1994; Mulligan, 1996; Tenpenny & Shoben, 1992; Vaidya et al., 1997; Weldon & Coyote, 1996) and perceptual tests when using the same variables (Fleischman, Vaidya, Lange, & Gabrieli, 1997).

Additional specification of the interaction between the stimulus items and the memory task, in order to incorporate the biases and modulations in processing that result from this interaction, will confer additional interpretative power to the framework. In spite of these difficulties, it is important to note that the perceptual-conceptual approach is somewhat similar conceptually to the levels of processing approach in that the perceptual-conceptual distinction was never specifically intended to be a theory, rather it has been treated as a theory. Given the ability of the distinction to describe much of the data that will be discussed, the following review will make extensive use of the framework.

1.3 Explicit-Implicit Memory and Ageing: A Primer

Most of the studies that have investigated age-related effects in explicit and implicit memory are primarily based on polarised comparisons between young and older adults; that is, the young adults
are aged between 18 to 35 years of age and the older adults are aged 60 years of age and over. A fundamental limitation of the polarised age-group design is that it is only able to provide data on age-related differences in cognition, rather than on the changes in cognition that accompany ageing. The continued development and application of multidimensional longitudinal designs will be necessary if the precise nature and source of age-related memory deficits are to be understood (Powell & Whitla, 1994). An additional caveat, common to all polarised age group designs, is that all of the observed individual differences should not be attributed solely to developmental mechanisms, since only a limited proportion of the inter-individual variance is directly related to age (Salthouse, 1991), and samples of older adults are not homogenous (Sliwinski, Lipton, Buschke, & Stewart, 1996).

A number of reviews evaluating the effect of ageing on explicit and implicit memory have been produced. For instance, Graf (1990) concluded that age-related differences in indirect memory tests were very small, averaging around 4%. Similarly, Howard (1988b) concluded that the effects of ageing on indirect memory tests are minimal, with the exception of instances in which initial acquisition requires a degree of cognitive effort—as is the case in paradigms examining memory for new representations. Brief reviews of implicit memory and ageing can also be found in Howard (1991), Light and Burke (1988), and Marko (1995). In a meta-analysis of the experimental work examining the effect of age on implicit memory, Light and LaVoie (1993b) concluded that there were age-related differences in indirect memory tests, and although smaller than those in direct memory tests, they were real nonetheless. The issues that need to be considered in order to arrive at such conclusions are complex, and this process is often complicated by the large discrepancies in methodology used across the studies. These issues form the units of analysis for the current chapter.

1.3.1 Age-Related Differences in Direct and Indirect Memory Tests

In order to develop a unified account of the experimental work examining age-related differences in direct and indirect memory tests, a components of processing view is adopted to evaluate the literature (Blaxton, 1995; Moscovitch, 1992a; Moscovitch et al., 1993; Roediger et al., 1999). Specifically, the review is primarily organised in terms of the nominal set of instructions used at test, with the interpretation of the findings being determined by the nature of the stimulus materials and encoding manipulations as they relate to established processing frameworks. This approach is intended to demonstrate a clear progression to the issues identified and addressed by the experimental work presented in this thesis. It is intended that this review will reflect greater
1. Explicit-Implicit Memory and Ageing: Experimental Work

operative precision and predictive power than other reviews in which a more general level of interpretation has been applied. In addition, the difficulty in identifying the information processing characteristics of explicit and implicit memory are highlighted by the approach that has been adopted.

The experimental work that has investigated age-related differences in direct and indirect memory tests is summarised in Table 1.1. The only criterion for inclusion of an experiment in the table was that young and older adults were assessed in a single experiment that included an indirect memory test. The findings presented in Table 1.1 fall into two basic categories: (1) impaired indirect memory test performance is observed in older adults relative to young adults; and, (2) indirect memory test performance in older adults is preserved and does not differ significantly from that observed in young adults. There are also instances in which a small difference has been found in favour of young adults, but this tends not to be statistically significant (e.g., Light & Singh, 1987; Light, Singh, & Capps, 1986).

Table 1.1. Indirect memory test performance in older adults relative to young adults

<table>
<thead>
<tr>
<th>Indirect Memory Test</th>
<th>Age-Impaired Performance in Indirect Memory Test(s)</th>
<th>Age-Invariant Performance in Indirect Memory Test(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Verbal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverted Word</td>
<td>Moscovitch, Winocur, &amp; McLachlan (1986, Expts., 2, 3)</td>
<td></td>
</tr>
<tr>
<td>Reading (as Repetition Priming)</td>
<td></td>
<td>Nilsson, Backman, &amp; Karlsson (1989)</td>
</tr>
<tr>
<td>Lexical Decision</td>
<td>Whetstone (1991, Expt., 2)</td>
<td></td>
</tr>
<tr>
<td>Non-word Naming</td>
<td>Wiggs &amp; Martin (1994, Expts. 1 &amp; 2)</td>
<td>Light (1996, Expts. 1, 2, &amp; 3)</td>
</tr>
<tr>
<td>Word-Pair Reading</td>
<td>Light et al. (1992, Expts. 1 &amp; 2)</td>
<td>Monti et al. (1997)</td>
</tr>
</tbody>
</table>
## 1. Explicit-Implicit Memory and Ageing: Experimental Work

<table>
<thead>
<tr>
<th>Word Completion</th>
<th>Stem</th>
<th>References</th>
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</thead>
<tbody>
<tr>
<td>Van der Linden, Bruyer, &amp; Dave (1992)</td>
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<tr>
<th>Word Fragment Completion</th>
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<tr>
<td>Rybash (1994, Expt. 1 &amp; 2)</td>
</tr>
</tbody>
</table>

### Novel Visual Stimuli

| Mere Exposure Effect for Novel Characters Object Decision Priming |
|-------------------------------------------------|-------------------------------------------------|
| Wiggs (1993, Expt. 3) | Schacter, Cooper, & Valdisseri (1992, Expts. 1, Expt.2) |

### Skill Learning

| Perceptual Identification Reading Transformed Script Serial Reaction Time |
|--------------------------------|------------------------------------------|
| | | | | | Howard & Howard (1992, Expt. 1 & 2) |

### Priming of Pre-existing Representations

<table>
<thead>
<tr>
<th>Perceptual Indirect Memory Tests</th>
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<tbody>
<tr>
<td>Anagram Solution</td>
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<td></td>
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<tr>
<td>Inverted Word Reading (as Repetition Priming)</td>
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<td>Lexical Decision</td>
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<td>Perceptual Identification</td>
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<td>Word Naming</td>
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<td>Degraded Word Naming</td>
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<td>Word Fragment Completion</td>
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1. Explicit-Implicit Memory and Ageing: Experimental Work

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<th>Word Completion</th>
<th>Stem Completion</th>
<th>References</th>
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<tr>
<td></td>
<td>Davis et al. (1990, Expt. 1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hultsch, Masson, &amp; Small (1991)</td>
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<td></td>
<td>Small, Hultsch, &amp; Masson (1995)</td>
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<td></td>
<td>Winocur et al. (1996)</td>
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<tr>
<th>Conceptual Indirect Memory Tests</th>
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<tr>
<td><strong>Answering General Knowledge Questions</strong></td>
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<th>Category Exemplar Verification</th>
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<tr>
<td>Category Exemplar</td>
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<td>Verification</td>
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<tr>
<th>Tests of Pictorial Stimuli</th>
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</table>
1. Explicit-Implicit Memory and Ageing: Experimental Work


Table 1.1 illustrates the absence of a clear trend indicative of either age impairment or invariance among indirect memory tests. The discrepant methodologies applied to investigate similar issues, combined with heterogeneity in subject variables, has precluded the production of a unified account that integrates all of the data (cf. La Voie & Light, 1994). Despite a lack of convergence in the experimental work, indirect tests do appear to be generally less susceptible to age-related impairment than direct memory tests (Howard, 1991; La Voie & Light, 1994; Marko, 1995). Indeed, a cursory examination based on the studies included in Table 1.1 reveals that the ratio of impaired compared to invariant indirect memory test performance is approximately 1:3. This partial dissociation between direct and indirect memory tests, as a function of age, is not only interesting on a purely empirical level, it also has important theoretical implications.

### 1.3.1.1 Age-related Differences in Indirect Memory Tests: A Reliable Artefact?

There are at least four principal explanations that have been proposed to interpret the variability in the extant research that has examined direct and indirect memory test performance as a function of age. The most common explanation is 'contamination' by conscious memory processes in indirect memory tests (e.g., Hultsch et al., 1991; Jennings & Jacoby, 1993; Light, 1991; Light & Albertson, 1989). Accordingly, when age-related impairment in a direct memory test co-occurs with a contaminated indirect memory test, young adults are able to benefit more from such conscious processes (Graf, 1990). This leads to an apparent, rather than veridical, age-related deficit in the indirect memory test. Evidently, test contamination needs to be addressed if the data are to accurately reflect age-related effects in indirect memory tests. However, caution is warranted when using this sort of post hoc explanation to interpret age-related impairment in indirect memory tests. The inclination to posit contamination from conscious processes when age effects are obtained—but not when they are not—can quickly become circular unless unbiased, objective measures of conscious and unconscious processes are applied. The methodologies designed to provide an objective measure of the relative contributions of conscious and unconscious processes are considered in Chapter 2.

A second, largely neglected, factor is the potentially small magnitude of any age-related differences
A significant proportion of the studies included in Table 1.1 were based on sample sizes of approximately 30 participants per age group or less, which is unlikely to have sufficient power to detect small age-related priming effects. Cohen (1992) formalised this issue by demonstrating that sample sizes of 393 per group are needed to achieve a .80 level of power to detect small effect sizes, when comparing differences between the means of two groups at the .05 level. None of the studies included in Table 1.1, or reported elsewhere in the literature, have used sample sizes of this magnitude. Consequently, when the effect size for age-related differences in priming are small, conventional sample sizes may only allow differences that approach significance to be detected. However, it would be an oversimplification to suggest that sample size will determine the direction of the age-related difference reported, since studies in which a large sample size is used have reported no age-related differences (Park & Shaw, 1992). Conversely, studies with small sample sizes sometimes reveal large age effects in indirect memory tests (e.g., Abbenhuis et al., 1990). Further, a study by Davis et al. (1990, Expt. 2) revealed that when given power to detect age differences, the effect of ageing on priming may be subtle, but progressive, since priming on word stem completion was only impaired in older adults that were above the age of 70. Nevertheless, such findings cannot be clearly evaluated without invoking additional factors such as the sensitivity of the measures being used.

A third factor is that older adults are impaired on tests that involve a prior encoding phase requiring elaborative processing (Howard, 1988a). Despite early reports of an absence of a levels of processing effect in indirect memory tests, more recent reviews of the experimental work have shown that semantic encoding may improve performance over non-semantic encoding (Challis & Brodbeck, 1992; Chiarello & Hoyer, 1988; Thapar & Greene, 1994). The sensitivity of indirect memory tests to differences in semantic processing, combined with the view that older adults are less able to spontaneously engage in semantic encoding than young adults, suggests that age differences, may in some instances, be attributed to differences in the encoding strategies, rather than differences in the unconscious retrieval processes alone.

A final explanation, based on an admittedly less common problem, is that some studies have failed to equate baseline performance across the age groups (e.g., Hashtroudi et al., 1991). Therefore, reported age differences may be a function of differences in performance, rather than competence, between age groups. Obviously, these four factors do not have a mutually exclusive role. Indeed, a judicious consideration of all of these factors is exercised when evaluating the data from each study included in the present review, particularly given the heterogeneity of the experimental protocols.
and participants utilised in the research. These and other potential confounds need to be avoided, or their consequences need to be systematically specified, both in the gerontological literature and in the general implicit memory literature.

1.4 Ageing: Item-Specific Retrieval versus Association-Specific Retrieval

Two initial basic criteria were adopted for the inclusion of a study in the main review. First, the study should include both young and older adults within the same experiment. Second, both direct and indirect memory tests should occur within the same experiment. Additional criteria were adopted in order to select studies that involved an evaluation of the extant theoretical accounts proposed to explain age-related differences in memory. These accounts are discussed in detail in Chapter 3, but for the purposes of the present discussion, the reviewed studies are considered in terms of three primary accounts of cognitive ageing: diminished attentional resources (Plude & Hoyer, 1985), impaired inhibitory processes (Hasher & Zacks, 1988), and deficits in the ability to spontaneously generate elaborative encoding (Rabinowitz, Craik, & Ackerman, 1982).

In addition, a broad distinction, which is of particular consequence for the study of explicit-implicit memory and ageing, was adopted in order to organise the data presented in the following two subsections: (1) memory tests that rely solely on the activation of single, pre-existing representations (item-specific retrieval); and, (2) memory tests that index memory for new representations (association-specific retrieval). In studies that have investigated item-specific retrieval, the critical items are either single words, familiar visual stimuli, or highly associated word pairs. The materials used to investigate association-specific retrieval include nonwords, novel visual stimuli, and unrelated pairs of words. The first major subsection will report the findings from studies that have examined memory for new associations. This subsection is followed by a review of item-specific retrieval, with the primary focus on studies that have investigated the effects of ageing on conceptual indirect memory tests. Each subsection concludes with a summary identifying areas that are addressed by the experimental work presented in this thesis.

1.4.1 Memory for New Associations

The proposition that the learning of new representations is more likely to engender age-related impairment has been recognised for over 60 years (Gilbert, 1935; Ruch, 1934). Typically, the early studies involved paired associates tasks, and age-differences were found to be greater when the
pairs had low associative strength (e.g., Ross, 1968). The fact that low associative strength items are, by definition, more likely to represent new information, suggests that age-related impairment is more likely when participants are encoding new information. However, age-related differences in the memory for new associations, as framed in terms of the explicit-implicit memory distinction, has only been investigated relatively recently. A variety of paradigms have been developed to investigate memory for new associations. These include memory for associations between unrelated pairs of words (associative word stem completion, Graf & Schacter, 1985), the learning of a repeating sequence of discrete events (skill learning tasks, Harrington & Haaland, 1992), memory for novel visual stimuli (Cooper, Schacter, Ballesteros, & Moore, 1992), and memory for nonwords (e.g., Light et al., 1996; Light et al., 1995; Wiggs & Martin, 1994).

Only minimal reference will be made to the priming of novel visual stimuli, the priming of nonwords, and skill learning tasks because the age effects associated with these tasks are heterogeneous and task dependent. More importantly, such tasks do not directly examine the priming of new associations by contrasting intact stimuli with recombinations of elements of the stimuli. Therefore, a comparison of priming mediated by the activation of existing stimulus elements and that mediated by the formation of new connections between stimulus elements is precluded (for a discussion of this issue, see Bowers, 1994; Dorfman, 1994). Only those studies that investigate the issues that are directly relevant to formation of new associations between unrelated words will be examined, since this is directly relevant to the experimental work presented in this thesis.

Nonetheless, it is worthwhile to note that for at least some forms of indirect memory tests of novel, non-verbal pattern skill learning, the emergent finding is one of age invariance (e.g., Howard & Howard, 1992; Howard & Howard, 1989). One explanation is that these tasks tend to reflect perceptual processes that are relatively spared in ageing, and so age invariance would also be expected for indirect tests of novel, visuospatial patterns. In accordance with this prediction, the priming of novel visual stimuli also appears to be age-invariant (Schacter et al., 1992). However, since older adults are generally slower than young adults in processing visual information (Cerella, 1985), they may reveal age-related deficits in priming that requires the processing of complex perceptual information.

Examination of Table 1.1 reveals that the balance of data for the priming of new associations does not favour a claim for either age-related impairment or invariance, whereas there is considerable
evidence for impairment in direct tests of new associations. A parallel with this overall pattern of findings can be found in clinical populations (for a review, see Bowers & Schacter, 1993). For instance, amnesics typically show normal item priming (cf. Ostergaard & Jernigan, 1993) but the evidence for associative priming is more variable (Cermak, Bleich, & Blackford, 1988; Mutter, Howard, Howard, & Wiggs, 1990; Schacter & Graf, 1986b; Shimamura & Squire, 1989). Evidence of a dissociation between item and associative priming as a function of age would suggest that these two forms of implicit memory are distinct, because they are obtained under different conditions (for a discussion of this position, see Chapter 3).

Despite such difficulties with describing a clear, emergent pattern, it is possible to generate specific predictions with regard to associative priming. First, an age-related decline in the formation of new associations will be less manifest in indirect tests than in direct memory tests. Second, associative priming is likely to be more sensitive to the effects of ageing than item priming (MacKay & Burke, 1990). The first prediction is based on the differences in the retrieval processes invoked by direct and indirect memory tests, whereas the second prediction reflects the additional encoding and retrieval demands associated with associative priming relative to item priming. Unfortunately, the second prediction cannot be easily verified because age-related differences in the formation of new associations have been largely investigated using recall and recognition memory tests. Accordingly, the lack of experimental work applying verbal indirect memory tests to examine the formation of new associations in older adults limits our understanding of the formation and retrieval of new representations to that mediated by conscious memory processes.

The following subsection is intended to address whether or not the age-related deficits that are observed in verbal associative priming reflect an age-related decline in the ease with which new associations are formed, or only a change in the likelihood of producing adequate encodings. This issue reflects the more general notion advocated by several theorists: compared with item priming, the priming of new associations requires additional cognitive processes such as attention (Nissen & Bullemer, 1987) and spontaneous semantic elaboration in order to encode a meaningful relation between pairs of words (Graf & Schacter, 1989). When this approach is combined with the characterisation of ageing in terms of a deficit in attention (Plude & Hoyer, 1985) and the ability to generate semantic elaborations (for reviews, see Craik & Rabinowitz, 1985; Kausler, 1985), it would appear that greater task demands will be imposed on older adults relative to young adults, increasing the probability that age-related impairment in the priming of new associations will be observed.
1.4.1.1 New Verbal Associations

One of the principle methods used to investigate associative priming involves the presentation of unrelated pairs of words at encoding, followed by an indirect memory test. The early work examining verbal associative priming was motivated by the differences in the performance of normal adults and organic amnesic patients, identified by Graf and Schacter (Graf & Schacter, 1985; Graf & Schacter, 1987; Graf & Schacter, 1989; Schacter & Graf, 1986a; Schacter & Graf, 1989). Graf and Schacter (1985; 1989) examined associative priming by using associative word stem completion as the indirect memory test. The paradigm involved participants initially studying a list of normatively unrelated context-target word pairs under elaborative encoding conditions. At test, a three letter word stem of the target word was either presented with the original context word (the intact condition) or with a new context word (the recombined condition). In both direct and indirect memory tests, memory for new associations was measured by the contrast between the original pairing and the recombined target word pairing. In addition, a pair of unstudied control words are often included at test in order to provide a measure of item-specific priming, as the contrast between the recombined word pair and control word pair. Memory for associative information is inferred when performance in the intact word pairs exceeds that of the recombined word pairs. Therefore, the associative priming effect is predicated on the principle that because individual items from both intact and recombined conditions were presented at study, the improved performance in the intact relative to the recombined condition can be attributed to the retention of associative information.

This relatively basic, but reliable, paradigm has produced a mixed pattern of findings when applied to older adults. A cursory examination suggests that an approximately equal number of studies have shown no age-related differences (Balota & Duchek, 1988; Christensen & Birrell, 1991, Expt. 1; Howard et al., 1991, Expts. 1 & 3; Light et al., 1995) as have reported associative priming favouring the young (Howard, 1988b, Expts. 1 & 2; Howard et al., 1991, Expt. 2; Moscovitch et al., 1986; Van der Linden et al., 1992). Therefore, in order to promote an interpretative framework to better understand the nature of verbal associative priming, three specific procedural factors need to be identified: (1) the time available at encoding and at test; (2) the number of individual study-trial presentations; and (3) the provision of study context. These factors are not only instrumental in generating the differences observed between young and older adults, but they are also theoretically important because some of the primary constructs used to account for age-related differences in memory can be addressed by these manipulations. In addition, these factors encompass
manipulations that optimise conditions for elaborative processing and unitisation, both of which appear to be necessary for successful associative priming (Graf & Schacter, 1989; Howard, 1988b). Adopting this approach will enable the experimental conditions that generate reliable single-trial associative priming in older adults to be identified.

The paradigm used to investigate memory for new verbal associations is also a significant factor. In addition to the associative word stem completion task, three other basic paradigms have been utilised, although these utilise reaction time as the dependent measure, rather than target completion rate, to assess memory for new verbal associations: lexical decision (McKoon & Ratcliff, 1979), speeded naming of degraded stimuli (Moscovitch et al., 1986), and perceptual identification (Musen & Squire, 1992). The lexical decision task is different from the other two paradigms because each member of the word pair is presented sequentially at test. A general difficulty with tasks that use latency as a measure of priming is that it is often compared with an accuracy measure such as recognition. Given the absence of systematic empirical evaluation of the effects of the three procedural factors on each paradigm, no claims can be made with regard to the priming effects obtained under each paradigm. Accordingly, each of these three procedural factors will be considered in turn by applying a factor by memory task interpretation.

1.4.1.1.1 Time at Encoding and at Test.

Several studies have reported that there are similar levels of memory for new associations in young and older adults. For example, age-invariant performance has been reported when using an item recognition task, which followed a 4 or 5 second study exposure of pairs of unrelated words (Rabinowitz, 1986). Reports of preserved single-trial memory for new associations are not limited to item recognition tasks. An early study by Moscovitch et al. (1986) examined the formation of new associations in young adults, normal older adults, and memory-impaired older adults (mainly Alzheimer's disease patients) in three experiments. Experiments 3 is of interest to the present discussion because this experiment involved presenting unrelated word pairs in isolation, followed by a speeded reading latency measure as the indirect memory test. All three groups had faster reading times for intact word pairs. Recognition memory yielded significant age differences favouring the young adults, but these differences were absent for the speeded reading latency measures. However, Moscovitch et al. (1986) employed study protocols in which the older adults were given a longer duration to study the word pairs than the young adults (5 seconds versus 3 seconds in Experiment 3, respectively), in order to equate baseline study performance between
young and older adults. It is unclear whether age differences would have emerged had study time been held constant and the informational demands of the direct and indirect memory tests been equated. This difficulty was also present in a study by Balota and Duchek (1988) that used item recognition.

Howard et al. (1991) systematically investigated the relation between the time available at encoding and memory for word pairs presented in a sentence context (Experiment 1) or presented alone with instructions to generate a meaningful sentence (Experiments 2 & 3). The time to generate study items was manipulated across experiments at three levels: self-paced (Experiment 2); eight seconds (Experiment 1) and 15 seconds (Experiment 3). A word stem completion procedure was used as both the direct and indirect memory test for unrelated context-target pairs of words. For the direct tests at all three study intervals, a significant age-related impairment was obtained, whereas for the indirect tests, the age-related deficits were only reduced in the self-paced study condition. Most studies that have allowed self-paced study (e.g., Balota & Duchek, 1988; Christensen & Birrell, 1991, Experiment 2), or more than one study opportunity, have reported no age-related differences in associative priming.

Evidently, time at encoding has a significant effect on the associative priming effect obtained in older adults. Clearly, any claims that self-paced encoding preserves priming of new associations in older adults is limited to the conditions under which associative priming is examined. In this regard, a number of features of the methods used by Howard et al. (1991) warrant further attention. First, both intact and recombined test word pairs were presented in the indirect memory test of all three experiments, whereas only intact word pairs were presented for the direct memory test (Experiments 1 & 2). Second, despite the fact that the retrieval cues were the same for the direct and indirect memory tests, the introduction of forced-cued recall instructions in Experiment 3 is likely to have invoked changes in the mode of processing used to complete the tasks. Third, the same test cues were used more than once; that is, the same test cues were used for both direct and indirect memory tests (Experiments 1 & 2). All of these factors raise the concern that the response criteria were not equated across direct and indirect memory tests, which may have introduced uncontrolled response bias differences between the two tests (particularly in Experiment 3).

The need for self-paced encoding conditions is likely to be related to the attentional deficits, the decreased working memory capacity, or the cognitive slowing that are associated with the course of normal ageing. One interpretation of the nature of the 'compensatory role' of self-paced study
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conditions is that effective elaborative processing can be instantiated. Consistent with this view, Howard et al. (1991) found that the age deficits in the indirect memory tests were ameliorated by precise elaborations at encoding. However, the provision of self-paced encoding is likely to introduce a systematic confound in terms of an increase in the time available at study for the older adults as compared with the young adults, due to the general slowing known to accompany ageing (Salthouse, 1985). By extension, the provision of long stimulus onset asynchronies may introduce additional demands on attentional control processes, which will increase the facilitation of performance by conscious processes, which is already a concern in measures of associative priming.

It is not yet possible to specify the conditions under which age-related differences in associative priming occur with reference only to the time at encoding. For example, Howard (1988b; Howard et al., 1991) proposed that age-related differences in associative priming after a single study trial exposure will persist unless the encoding conditions encourage elaborative processing and involve short study-test intervals. Therefore, specifying the encoding conditions necessary to yield age-invariant associative priming requires that at least two other factors be considered: (1) the number of individual study trial presentations; and (2) the nature of the encoding task.

1.4.1.1.2 Number of Individual Study Trial Presentations.

A convergent, but independent, source of evidence about the effect of presentation interval on memory for new associations comes from studies that have varied the number of individual presentations at encoding. Howard et al. (1986) found that when two or more study opportunities were provided, each of which were self-paced, age-related differences in item recognition task performance were absent. Musen and Squire (1993) failed to obtain evidence for single-trial associative priming in normal controls and amnesic patients when the dependent measure was the speeded naming of degraded stimuli (cf. Paller, cited in Mayes, 1992). Accordingly, Squire (1992b, p.214) has argued, “nondeclarative (implicit) learning is specialised for incremental, cumulative change and new associations can be acquired implicitly but only after many repetitions.”

Nevertheless, Musen and Squire (1993) did report a weak single-trial associative priming effect when using perceptual identification as the indirect memory test. Similarly, Moscovitch et al. (1986) reported preserved associative priming in older adults when using a speeded reading latency measure following a perceptually-based encoding manipulation. This finding is a problem for the activation models in which semantic, elaborative processing is necessary to establish the new
connections indexed by associative priming tests (Graf & Schacter, 1989). Further, the effect of the number of individual study trial presentations on associative priming is particularly interesting because of the absence of such an effect on serial pattern learning (Howard & Howard, 1989). One potential reason for this differential effect may be the extent to which associative priming and serial pattern learning are based on perceptual processing.

Apart from a series of studies conducted by Light and colleagues (Light et al., 1996, Experiment 1; Light et al., 1995) that investigated the role of varying the number of presentations at study in non-word memory for new associations, there do not appear to be any studies that have systematically compared the performance of young and older adults as a function of this factor. Nevertheless, the following subsection, which addresses the effect of the encoding task on memory for new associations, does include some studies that have applied a manipulation of the number of study-trial presentations.

1.4.1.1.3 Differences in the Encoding Task.

The notion that encoding conditions that encourage elaborative processing and unitisation are likely to produce successful associative priming (Graf & Schacter, 1989; Howard, 1988b), and reduce age-related differences in performance, has been demonstrated in the work conducted by Howard and her colleagues (Howard, 1988a; Howard et al., 1991). Specifically, they argued that age differences in associative priming will be found under encoding conditions that are not ‘optimal’; namely, conditions that do not foster elaborative encoding. Nevertheless, successful associative priming in young and older adults can occur under encoding conditions that do not require, or even engender, elaborative encoding (Carroll & Kirsner, 1982; Graf & Schacter, 1985; McKoon & Ratcliff, 1986). However, these studies were undermined by the use of an inappropriate baseline conditions to estimate associative priming (Smith, MacLeod, Bain, & Hoppe, 1989).

Direct manipulation of encoding conditions across direct and indirect memory tests has promoted a clearer understanding of the bases of memory for new associations. Some of the encoding variables include: manipulations of retroactive or proactive interference, which impairs direct tests, but does not effect associative priming (Graf & Schacter, 1987); the cross modal presentation of study and test items, which impairs associative word stem completion priming, but not direct associative word stem completion (Schacter & Graf, 1989). However, perhaps the most significant encoding variable, from a theoretical perspective, is levels of processing, since this provides a powerful method for
investigating the nature of the processes that mediate memory for new associations. Accordingly, applying the levels of processing variable has led to a reconceptualisation of memory for new associations within the perceptual-conceptual processing distinction (Bowers & Schacter, 1993; Goshen-Gottstein & Moscovitch, 1995a; Goshen-Gottstein & Moscovitch, 1995b). Memory for new associations can depend on two distinct encoding operations: (1) perceptual, or lexical processing operations—supporting the formation of a unitised perceptual representation; and (2) semantic/elaborative processing operations—supporting the formation or reactivation of a semantic relation between the word pair.

Four encoding tasks have been developed to focus attention and encourage perceptual processing in associative word stem completion tasks: (1) reading the word pair out aloud (e.g., Reingold & Goshen-Gottstein, 1996b); (2) vowel comparison (e.g., Graf & Schacter, 1985); (3) copying the word pair onto a card (e.g., Micco & Masson, 1991); and, (4) presenting a line drawing depicting the context word along with a corresponding word pair that is read out aloud (Reingold & Goshen-Gottstein, 1996a). In contrast, encoding tasks that orient attention to the encoding of conceptual processes include: (1) providing a sentence continuation for sentences containing the word pair (Howard et al., 1991, Expt. 1); (2) generating a sentence that relates a pair of words (Howard et al., 1991, Expts. 2 & 3; Schacter & Graf, 1986a); (3) encoding the individual words of each pair semantically (Schacter & Graf, 1986a); and (4) judging how well a word pair in a sentence go together (McKone & Slee, 1997, Experiment 1).

Most of these perceptual encoding paradigms do not require that the words are encoded beyond an initial item identification stage; rather, they encourage the processing of the word pair to form a unitised, perceptually distinct representation that can be retrieved unconsciously. However, both Reingold and Goshen-Gottstein (1996b, Experiment 1) and Graf and Schacter (1985) failed to obtain a reliable associative priming effect following perceptual encoding using the first two encoding tasks outlined above. This may, in part, be due to the truncated perceptual, and lexical, processing engendered by these perceptual encoding procedures. Encoding conditions that foster more distinctive, relational perceptual analysis, such as using copy instructions, have produced a small, but significant perceptual associative priming effects (Micco & Masson, 1991; Reingold & Goshen-Gottstein, 1996b, Experiment 3). Reingold and Goshen-Gottstein (1996a) increased the magnitude of perceptual associative priming by presenting a line drawing depicting the context word at study. At test, either a context-target word stem and the corresponding line drawing were presented (the strong cue condition) or the context-target word stem was presented alone (the weak
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cue condition). Clearly, this manipulation of cue strength is based on the principle identified in the transfer appropriate processing framework (Roediger et al., 1989b). Accordingly, the encoding procedure was designed to increase the perceptual context for target words, and was sufficiently powerful to produce associative priming in both the weak and strong cue retrieval conditions, with the magnitude of the associative priming effect being 5% and 10%, respectively.

The implication of these findings for older adults are significant, because the reduced role for semantic information in these tasks suggests that this form of associative priming may be less susceptible to an age-related decrement, because perceptual processing is not as prone to an age-related decline as semantic processing (Craik, 1994). Nonetheless, categorising memory for new associations as either perceptually- or conceptually-driven does not imply that these forms of processing exclusively mediate associative priming performance (Micco & Masson, 1991). Further, the perceptual Gestalt that the word pair form, following item registration, will be further influenced by the storage and reactivation of the word pairs in semantic memory (Goshen-Gottstein & Moscovitch, 1995b), in addition to the elaborative encoding that may be develop. This raises the possibility that deficient encoding can be dissociated from other factors that influence associative priming effects.

In addition to examining the effect of time available at encoding, Howard et al. (1991) also manipulated the degree of elaborative encoding. Despite the fact that time at encoding needed to be disentangled from the mode of encoding in this study, it appeared that age-differences were only reduced when encoding was self-paced, even when the encoding conditions involved the generation of a meaningful sentence linking the pairs of words. This encoding task is likely to invoke the necessary level of conceptual processing for associative priming to be obtained in older adults. Therefore, this may suggest that for older adults, time at encoding is at least as critical, as the nature of the encoding task. However, Rybash (1994) failed to obtain evidence of associative priming in either young or older adults when word fragments served as the retrieval cues in context-target word pairs following self-paced, sentence generation based encoding conditions.

On the basis of the evidence reviewed, it would appear that associative priming can be produced under two qualitatively distinct forms of encoding; namely, conceptual and perceptual encoding. These encoding conditions have different effects on the semantic analysis of the word pairs and the perceptual specificity of the unitised representations of word pairs. In addition to the differences in the encoding operations, associative priming under perceptual encoding conditions is relatively
smaller in magnitude than under elaborative encoding. For example, associative effects obtained under copy instructions are small; 4% in Micco and Masson (1991) and 5% Reingold and Goshen-Gottstein (1996b, Experiment 3), but can be enhanced if perceptual distinctiveness is increased, since Reingold and Goshen-Gottstein (1996a, Experiment 2) reported a 10% associative repetition effect.

In relation to cognitive ageing, it is particularly important to distinguish between perceptual and conceptual associative priming, because of the different effects of ageing on conceptual and perceptual processing. Accordingly, it should be possible to observe a reduction in the degree of age-related impairment, or age-invariance, under conditions of perceptual associative priming. At present, this prediction has not been empirically evaluated. The ability of the perceptual encoding task developed by Reingold and Goshen-Gottstein (1996a) to obtain reliable demonstrations of associative priming in young adults suggests that this paradigm would be ideal for evaluating this proposition. Consequently, the perceptual encoding paradigm developed by Reingold and Goshen-Gottstein (1996a) was applied in the experimental work that will be reported in this thesis.

1.4.1.2 Priming of New Associations: Memory Task Contamination

The extent to which conscious and unconscious processes contribute to direct and indirect associative memory tests has not been established with any certainty in the task dissociation research. The primary approach used to indicate a role for unconscious processes in memory for new associations is a functional dissociation between direct and indirect associative memory tests. As described in section 1.4.1.1, manipulation of levels of processing (Schacter & Graf, 1986a), retroactive and proactive interference (Graf & Schacter, 1987), attention at retrieval (Kinoshita, 1998), and changes in modality between study and test (Schacter & Graf, 1989), all dissociate associative priming from the conscious retrieval of associative information.

However, the functional dissociation evidence is equivocal, because upon closer inspection, task factors, other than the experimentally manipulated variable(s), may differ between direct and indirect memory tests. Indeed, despite the fact that the series of studies conducted by Graf and Schacter satisfy the conditions of the retrieval intentionality criterion (Schacter, Bowers, & Booker, 1989), in that only the instructions at test were varied, it is evident that complex, spontaneous retrieval strategies can arise in the course of performing memory tests (e.g., Hauselt, 1998). Further, only limited inferences can be made when using a one-way function dissociation as the benchmark.
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...for determining the extent to which processes represent independent bases for responding (Dunn & Kirsner, 1989; Jacoby, 1991; Reingold & Merikle, 1988, Chapter 2). These concerns are not recent, however, since they can be traced back to early studies that examined memory for new associations in organic amnesic patients (Schacter & Graf, 1986b).

There are four factors that suggest the associative priming of words, at least in some instances, is mediated by conscious memory processes. First, associative word stem completion is sensitive to the levels of processing encoding manipulation, which contrasts with the typical finding in perceptual item priming (but see, Brown & Mitchell, 1994). As discussed earlier, the most reliable demonstrations of memory for new associations are produced by manipulations that instantiate semantic relational processing between the pair of words (e.g., Graf & Schacter, 1985; but see Micco & Masson, 1991). Sensitivity of an indirect memory test to a levels of processing manipulation has been interpreted as evidence that a test is mediated, at least in part, by conscious recollective processes at retrieval (but see, Nelson, McKinney, & Bennett, 1999, and Chapters 5 and 9).

Second, there is no evidence for reliable associative word stem completion priming or associative priming of nonwords in moderate to densely amnesic patients (e.g., Bowers & Schacter, 1993; Musen & Squire, 1993; Schacter & Graf, 1986b; Shimamura & Squire, 1989), whereas mild amnesics, with a degree of spared conscious recollection, are capable of successful associative word stem completion priming (Mutter et al., 1990; Schacter & Graf, 1986b). Nonetheless, amnesic patients appear to demonstrate intact associative word identification (Gabrieli, Keane, Zarella, & Poldrack, 1997a) and associative speeded naming of degraded stimuli (Moscovitch et al., 1986, Expts. 2 & 3). One approach to disentangling these apparently discrepant findings is to evaluate the amount of residual conscious recollective ability in amnesic patients. Accordingly, Shimamura and Squire (1989) reported that the amount of associative priming obtained in amnesic patients was correlated with residual conscious recollective ability. Consequently, this overall pattern of findings suggests that conscious processes are invoked, at least occasionally, during associative priming. Nevertheless, this pattern of data can also support the contention that the failure to produce associative priming in amnesic patients is a consequence of deficiencies in their ability to either encode elaboratively (Bowers & Schacter, 1993), or form the novel representations that support the unconscious retrieval of associative information (Musen & Squire, 1993). More generally, there is an inherent circularity in the logic involved in utilising amnesic performance as a benchmark for unconscious retrieval (Ratcliff & McKoon, 1996).
Third, evidence of associative priming being compromised by conscious retrieval comes from the post-experimental assessment of awareness of the relation between study and test. Bowers and Schacter (1990) reported that only those participants classed as ‘aware’ produced reliable associative priming (see also, Gooding, Mayes, van Eijk, Meudell, & MacDonald, 1999; cf. Howard et al., 1991; McKone & Slee, 1997, Expt. 2; Rybash, 1994). This suggests that associative priming, at least under certain experimental conditions, can be more accurately attributed to conscious processes, although others have argued that these influences are more likely to reflect the automatic activation of conscious processes (Rybash, 1994), which has been referred to as involuntary conscious memory (e.g., Richardson-Klavehn et al., 1996, see also, Chapters 2, 6, & 9).

Fourth, the encoding conditions that are necessary for memory for new associations to be reliably produced such as self-paced study conditions, the elaborative semantic encoding of each word pair, more than a single study trial (under some conditions), and long stimulus onset asynchronies (SOA) between items, are all factors that foster the use of conscious memory processes (Durgunoglu & Neely, 1987; Roediger & McDermott, 1993). Specifically, for the associative word stem completion task, the potential contamination by conscious processes is particularly acute when the encoding conditions are self-paced in both young and older adults (Howard et al., 1991) and remains significant, particularly in young adults, even when the study interval is relatively short (Howard et al., 1991, 15s, Experiment 3). A reduction in the SOA simply eliminates the associative priming, even when elaborative encoding is performed at study (e.g., McKone & Slee, 1997; Smith et al., 1989). In addition, very short SOAs cannot be simply implemented when testing old adults, because of the generalised slowing associated with ageing (Salthouse, 1996).

In a typical task dissociation paradigm, both conscious and unconscious processes can lead to an increased tendency to respond to test cues with studied words. Following the review of the experimental conditions under which associative priming is reported, it would appear that the phenomenological status of associative priming is, as yet, unresolved. Indeed, both word stem completion and lexical decision are susceptible to contamination by conscious processes under indirect memory test retrieval instructions (McKone & Slee, 1997). Nonetheless, in the absence of data to the contrary, the speeded naming of degraded stimuli may represent a retrieval task that is likely to approach a veridical measure of the unconscious retrieval of associative information, but this task may not be appropriate for use with older adults (see Chapter 9).
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1.4.1.2.1 Memory for New Associations: The Process Dissociation Approach.

The process dissociation procedure has been applied to investigate memory for related pairs of words (Jacoby, 1994; Jacoby, 1996), and in two instances, memory for unrelated pairs of words (Reingold & Goshen-Gottstein, 1996a; Reingold & Goshen-Gottstein, 1996b). However, these studies have only examined performance in young adults. The present subsection introduces and evaluates the critical issues identified by the studies conducted by Reingold and Goshen-Gottstein. These studies formed the basis for portions of the experimental work that investigated the nature of age-related differences in the contributions of conscious and unconscious memory to perceptual-associative word stem completion (Chapters 6 and 8). The application of the process dissociation procedure enables two distinct forms of memory for new associations to be specified, within a dual process conceptualisation of memory: (1) an associative memory effect mediated by conscious processes; and (2) an associative memory effect mediated by unconscious processes. Consistent with the independence relational model adopted by the process dissociation procedure (Jacoby, 1991), each of these forms of memory is assumed to independently contribute to memory task performance.

Reingold and Goshen-Gottstein (1996b) evaluated the contributions of conscious and unconscious processes to associative word stem completion. Semantically unrelated context-target pairs of words were presented during study, and context words and stems were presented during test in one of three combinations: context-target (intact), context-different (recombined), and context-new word (control). In Experiment 1, the semantic encoding paradigm used by Schacter and Graf (1986a) was applied, in that participants were instructed to form a sentence that meaningfully related the word pairs. However, Reingold and Goshen-Gottstein changed the perceptual encoding task from a vowel comparison task to a task that involved simply reading out the word pairs following presentation, since it has been argued that this encoding task represents a purer measure of shallow encoding (Roediger et al., 1989b). Cued recall and word stem completion revealed the standard pattern of findings associated with a levels of processing manipulation.

Experiment 2 was a replication of Experiment 1, with the addition of instructions at test modified in accordance with the process dissociation procedure. The findings suggested that in the semantic encoding condition, memory for new associations were largely mediated by conscious rather than unconscious processes (see also, Rybash, Santoro, & Hoyer, 1998). However, this conclusion needs to be tempered by the fact that there was no significant difference between the intact and
recombined conditions for the estimates of unconscious processes. In order to demonstrate the influence of the encoding instructions on the contributions of conscious and unconscious processes, Experiment 3 employed the perceptually oriented copy instructions utilised by Micco and Masson (1991). The parameter estimates revealed that perceptually based associative word stem completion was almost exclusively mediated by unconscious processes.

Reingold and Goshen-Gottstein (1996a, Experiment 2) applied the process dissociation procedure to the perceptual encoding paradigm that involved presenting a line drawing depicting the context word alongside a corresponding word pair. Both the strong and weak cue encoding conditions were mediated by conscious and unconscious processes. The extent to which associative retrieval was based on unconscious processes was modified by the variation in overlap between encoding and retrieval, since the reduction in the overlap in the weak cue condition led to an increased role for the unconscious retrieval of associative information (5% [weak cue] versus 8% [strong cue]; this difference was statistically significant). This is consistent with the nature of the encoding manipulation, since the line drawing is likely to enhance the perceptual distinctiveness of the encoding episode, which in turn supports the conscious recollection of associative information (Reingold & Goshen-Gottstein, 1996a). Evidently, conscious processes are also modified by the extent to which perceptual processing is invoked across study-test conditions.

1.4.1.3 Summary

Age-related differences only occur consistently when people are given a single, brief opportunity to study the new pairs, and consequently insufficient time to complete the semantic elaboration necessary for associative priming. With longer study times, or more than one opportunity to study each pair, age-related differences are still apparent on the direct memory tests, but less so on the indirect memory tests. A mediating factor in single-trial associative priming appears to the extent to which perceptual processing is emphasised at encoding and test (Reingold & Goshen-Gottstein, 1996a). Therefore, it may be possible to obtain age-invariant single-trial perceptual-associative priming in older adults using the strong cue condition of the paradigm developed by Reingold and Goshen-Gottstein (1996a). Further, conscious processes are present following elaborative encoding, whereas under shallow encoding that emphasises perceptual distinctiveness, the associative repetition effect is attributable, in part, to a mix of both conscious and unconscious retrieval processes (Reingold & Goshen-Gottstein, 1996a). Combining this knowledge with a judicious selection of variables applied in accordance with the process dissociation logic will provide
information related to nature of the processes that support retrieval of perceptual-associative information. Accordingly, this strategy was applied in the experimental work that addressed perceptual-associative word stem completion. Specifically, two basic variables, divided attention and directed forgetting, were applied to the perceptual-associative word stem completion task.

1.4.2 Pre-existing Verbal Representations: Item-Specific Retrieval

Age-related differences in item-specific priming have been characterised as negligible, or even absent, whereas age-related deficits are often obtained in direct memory tests such as free recall, cued recall, and recognition (for reviews, see Craik & Jennings, 1992; Fleischman & Gabrieli, 1998; Light & La Voie, 1993a; Marko, 1995; Rybash, 1996). However, additional work is needed to identify those paradigms that provide alternative ways to access a particular form of priming, and which paradigms provide measures of quite independent forms of priming, in order to interpret the sources of variability of the age-effects associated with priming. Indeed, since implicit memory is unlikely to be a unitary construct, age-related differences are likely to emerge on some types of indirect memory tests but not others (Fleischman & Gabrieli, 1998; Rybash, 1996).

Further, the extensive differences in the operations that mediate item priming precludes a simple synthesis of the findings. Task performance in both direct and indirect memory tests is determined by factors such as task difficulty, the degree to which test instructions emphasise the relation between study and test, the interaction between an encoding or retrieval manipulation and the task, and the degree to which the brain area supporting a task is impaired in older adults. These considerations make it difficult to predict, in a simple manner, the performance of older adults. Therefore, a bootstrapping procedure is applied in the following review of item-specific priming. The operational framework provided by the distinction between conceptually- and perceptually-driven processing is adopted, since a number of theoretical arguments lend support to the possibility of an age-related interaction with this processing distinction (for additional information, see Chapter 3).

The research that has examined the effect of ageing on item priming has primarily employed perceptually-driven memory tests. Studies that have involved perceptually-driven tests typically report age invariance, or only small non-significant differences (for reviews, see Fleischman & Gabrieli, 1998; Light & La Voie, 1993a; Rybash, 1996). More specifically, latency-based paradigms such as perceptual word identification (cf. Abbenhuis et al., 1990; e.g., Light et al.,
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1992), word naming (e.g., Wiggs & Martin, 1994), and lexical decision (e.g., Balota & Ferraro, 1996) are almost always age-invariant, whereas age-related deficits are reported in the direct form of these tasks. Age-invariant perceptual priming has also been obtained in completion paradigms such as word stem completion (e.g., Java & Gardiner, 1991; Park & Shaw, 1992) and anagram solution (Java, 1992), although age-invariant word stem completion priming is not a particularly robust phenomenon (Davis et al., 1990; Hultsch et al., 1991; Small et al., 1995). Further, relatively reliable evidence of age-related impairment in perceptual priming has been reported for the homophone spelling task (cf. Christensen & Birrell, 1991, Experiment 1; Davis et al., 1990; Rose et al., 1986); although this task may, in fact, be more accurately categorised as a conceptual indirect memory test (Toth & Reingold, 1996).

The role of conceptual factors in the production of unconscious processing has received less attention with regard to ageing. The fact that ageing has been characterised by a depletion in cognitive resources (Craik, 1986; Hasher & Zacks, 1988) and the ability to spontaneously engage in semantic elaboration (for reviews, see Craik & Rabinowitz, 1985; Eysenck, 1974; Kausler, 1985), combined with the fact that conceptual priming involves semantic processing that makes greater demands on cognitive resources compared with perceptual processing (e.g., Schmitter-Edgecombe, 1999), would suggest that conceptual direct and indirect memory tests will be sensitive to the effects of ageing. Accordingly, the basic question that will be addressed by the following subsection is whether or not there is evidence of an age-related deficit in conceptual priming.

1.4.2.1 Conceptual Direct and Indirect Memory Tests

Conceptual indirect memory tests, like direct memory tests, are sensitive to encoding manipulations that effect conceptual processing. As discussed earlier, these manipulations include levels of processing, read versus generate, and organisation (Hamann, 1990; Rappold & Hashtroudi, 1991; Srinivas & Roediger, 1990). Superficially, the effects of these variables suggest that conceptual direct and indirect memory tests are mediated by similar processes, which are different from those involved in perceptual indirect memory tests (Roediger et al., 1989b). However, conceptual indirect memory tests can themselves be dissociated from direct memory tests using variables such a verbal versus performed-action encoding manipulation (Nyberg & Nilsson, 1995) and amnesia (Moscovitch et al., 1993), which affect conceptual direct memory tests, but do not appear to affect conceptual indirect memory tests. In addition, evidence of stochastic independence between conceptual direct and indirect memory tests supports the contention that important differences are
present between these tests (Cabeza & Ohta, 1993).

The effect of ageing on conceptual direct and indirect memory tests has been investigated using a variety of conceptual tasks. Specifically, age-related invariance has been obtained in general knowledge priming (Rastle & Burke, 1996; Small et al., 1995), word association priming (McEnvoy et al., 1995), and category exemplar verification priming (Light et al., 1999). Category exemplar verification is distinct from other conceptual memory tasks, since it involves the representation of exemplars at test, which clearly has parallels with perceptual memory tasks, but the task does require access to conceptual or semantic information (Light et al., 1999). The majority of studies that have investigated the effects of ageing on conceptual direct and indirect memory tests have employed the category exemplar generation memory task.

For example, Isingrini et al. (1995) examined the difference in direct and indirect category exemplar generation as a function of age and divided attention. Four age groups were compared: 20-35, 40-55, 60-75, and 76-90. Both increasing age and divided attention impaired direct category exemplar generation performance. In contrast, category exemplar generation priming was unaffected by these two factors. The authors argued that these findings illustrate that the direct and indirect memory tests are mediated by different processes (cf. Mulligan, 1997; Mulligan, 1998; Mulligan & Hartman, 1996; Schmitter-Edgecombe, 1999). Specifically, the absence of an effect of divided attention on category exemplar generation, at least in the Isingrini et al. (1995) study, was argued to support the notion that conceptual priming is not dependent on the allocation of attention.

In contrast, Grober et al. (1992b) reported an age-related impairment in an indirect category free-association task and a direct category cued recall. Unfortunately, Grober et al. (1992b) also reported evidence that young adults engaged in conscious retrieval during the free-association test, although this was not found in older adults. Contamination was to be expected because the cued recall task preceded the free association task and an intentional encoding strategy was employed. These factors may have contributed to the impaired free association performance, because category cued recall was impaired in the older adults; although the source of the contamination in older adults may have reflected involuntary conscious memory. Jelicic et al. (1996) also reported an age-related impairment in category exemplar generation priming. However, the indirect category exemplar task was also administered after a direct memory test to some participants.

Monti et al. (1996) examined the effect of levels of processing and age on direct and indirect
category exemplar generation. In both young and older adults, a standard levels of processing effect occurred for both tests. Older adults were only impaired in the direct memory test. However, in the absence of an independent assessment of awareness and the fact that the levels of processing manipulation does not dissociate conceptual direct and indirect memory tests, the extent to which unconscious conceptual processing mediated performance in the indirect test cannot be easily determined. A study by Light and Albertson (1989) is the only other study to have examined category exemplar generation priming in older adults. Comparable priming effects were obtained for young and older adults in category exemplar generation, when people who explicitly denied attempting to produce list members were excluded from their analysis. However, the samples were small, and consequently the power to detect any age-related differences may have been low.

In addition to differences in the extent to which task contamination compromised conceptual priming, the inconsistent findings may be due to the differences in the experimental protocols that were employed and the age of the older adults (the implications of task related factors for the functional demands associated with the category exemplar generation task are considered in Chapter 9). First, both the Light and Albertson (1989) and Isingrini et al. (1995) studies measured priming by taking the number of targets that appeared in the first eight category members produced, whereas in the category free association test used by Grober et al. (1992), only the first word produced was taken into account. Both of these procedures have been used in studies that have investigated conceptual priming in young adults (Rappold & Hashtroudi, 1991; Schmitter-Edgecombe, 1999; Srinivas & Roediger, 1990). The unique category exemplar approach is probably less susceptible to effects associated with organisational strategies at retrieval. Under these conditions, deficiencies in the ability of older adults to invoke greater semantic processing and cognitive resources needed for strategic retrieval may bias task performance in favour of young adults (but see, Chapter 9). Second, the difference in the mean ages of the older adults across the studies suggests that a decline in conceptual priming may occur in late adulthood. Specifically, the mean ages of the older adults in the Light and Albertson (1989) and Grober et al. (1992) study were 69 and 78 years, respectively; however, the findings from the Isingrini et al (1995) study did not support the notion of a progressive decline with age, since there was still no reliable deficit in category exemplar generation priming even for the oldest age groups that had a mean age of 81 years. However, the absence of an effect of divided attention on conceptual priming does suggest that their dependent measure was not particularly resource demanding.
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1.4.2.2 Summary

The difficulties associated with the studies that have investigated the effects of age on conceptual direct and indirect memory tests underscores the need to replicate and extend this research to establish the reliability, and evaluate the validity, of any age effects that may be present. The majority of studies that reported age invariance in conceptual priming employed the category exemplar generation task (Isingrini et al., 1995; Light & Albertson, 1989; Light et al., 1999; Maki & Knopman, 1996; Monti et al., 1996), whereas when evidence of age-related decline in priming in category exemplar generation has been obtained (Grober et al., 1992b; Jelicic et al., 1996), contamination by conscious processes, which can produce effects in the same direction as conceptual unconscious processes, could not be excluded. Indeed, Mulligan and Hartman (1996) reported that the percentage of test-aware participants in indirect category exemplar generation was 93%, whereas Jaciw and McAndrews (1993) reported that the category exemplar generation task was primarily mediated by conscious processes (see also, Schmitter-Edgecombe, 1999).

As discussed earlier, ageing appears to reduce attentional resource capacity (Craik, 1986; Hasher & Zacks, 1988; Plude & Hoyer, 1985), thus if conceptual unconscious processes are demonstrated to be attention demanding under certain experimental conditions, age-related deficits may appear in both conceptual conscious and unconscious processes. Therefore, in addition to obtaining a veridical measure of conceptual unconscious processes, examining the effect of changes in the availability of attention at encoding on the estimates of unconscious processes in a category exemplar generation task will inform the conclusions that have been made with regard to the demands that these processes place on cognitive resources. The following section reviews studies that have applied a manipulation of divided attention at encoding to conceptual direct and indirect memory tests.

Given that a particular memorial state of awareness is unlikely to be associated uniquely with a particular retrieval strategy or memory content (Gardiner & Java, 1993b), an evaluation of the proposition that ageing does not affect performance on indirect memory tests (Light & La Voie, 1993a) and that unconscious memory processes are largely age invariant (Jennings & Jacoby, 1993) requires that the distinction between perceptual and conceptual processing is crossed with the distinction between item- and association-specific retrieval. More specifically, given the component processes that contribute to conceptual item-specific and perceptual associative-specific memory tasks (Craik, 1986), an overall research strategy that compares these two forms of memory under a
variety of equivalent encoding conditions represents a powerful method for investigating the nature of age-related differences in the processes, and for determining the extent to which conscious and unconscious processes in these tasks represent independent bases for responding.

### 1.5 Directed-Forgetting and Divided Attention

This section addresses the effect of two encoding manipulations as applied to direct and indirect memory tests: directed forgetting (also termed instructed or intentional forgetting) and divided attention. The operation of these variables is of particular interest for both defining the boundary conditions of the process dissociation procedure and as a means of investigating some of the specific mechanisms that have been proposed to account for cognitive ageing. Particular attention will be focused on the effect of directed forgetting and attention on the two basic categories of memory test that were identified in the foregoing sections; namely, conceptual direct and indirect memory tests and direct and indirect tests of memory for new associations.

The directed forgetting effect refers to the relatively poorer retrieval associated with a direction or instruction to forget, rather than to remember, a previously presented item. Thus far, the principal focus in directed forgetting research has involved direct memory tests, usually recall and recognition. Notwithstanding the type of the memory test, the basic elements of a directed forgetting study are constant. Namely, the procedure involves the presentation of a list of items that are cued to-be-remembered (R) or to-be-forgotten (F). The prototypical directed forgetting condition consists of a list of an equal number of R and F items in which participants are instructed that only R items will be tested, but at test, all items are tested. The typical outcome is that the R items are better remembered than the F items (for an archival review, see MacLeod, 1998). Depending on the mode of presentation of the R and F cues, directed forgetting is argued to operate through two primary mechanisms: inhibition and differential, elaborative rehearsal (e.g., Basden & Basden, 1998; Basden, Basden, & Gargano, 1993; Bjork, Bjork, & Anderson, 1998; Johnston, 1994). Both of these mechanisms have been variously implicated in models of cognitive ageing (Hasher & Zacks, 1988; Hashtroudi, Parker, Luis, & Reisen, 1989; Salthouse & Meinz, 1995).

Attention is a multidimensional construct that has been conceptualised as selective, sustained, or divided. The functional properties of attention will be discussed in terms of the contrast between full versus divided attention. In the prototypical paradigm investigating the effects of divided attention on memory, the memory (primary) task and secondary task are performed both alone and
concurrently. A major model of cognitive ageing is the limited processing resource model, in which the resource limit is assumed to directly effect the ability of older adults to perform tasks. Resource deficits are typically characterised in relation to attentional resources (Craik, 1994, see also, Chapter 3). Divided attention deficits are thought to occur when insufficient resources are allocated to multiple simultaneous inputs (Schiffrin & Schneider, 1977; Schneider & Shiffrin, 1977), or when unsustainable demands are made on the central pool of processing resources (Norman & Bobrow, 1975; Wickens, 1984). Thus, older adults would be expected to be more susceptible to age-deficits in performance under dual-task conditions (e.g., McDowd & Craik, 1988; cf. Salthouse, Fristoe, Lineweaver, & Coon, 1995). However, when the limited processing resource model is examined in terms of the effect of divided attention on memory task performance, there does not appear to be convincing evidence to either support or negate the notion of a deficit (for reviews, see Hartley, 1992; Salthouse, 1991).

1.5.1 Directed-Forgetting and Direct-Indirect Memory Tests

The R and F instructions can be provided in a variety of formats, but typically only two paradigms are routinely used. First, the item method of cueing involves presenting the R cue or the F cue after each word. The alternative is the list method paradigm, which originated in study conducted by Bjork (1970). In the canonical version of this paradigm, a list of items are initially designated to-be-remembered (R), however, midway through the study list one of two instructions is provided: (1) the first list should be forgotten, since it was for practice only, and instead, the remaining list of words presented represents the R list (F-R study list condition); or (2) the first list should be remembered, and the following list should also be remembered (R-R study list condition). At test, all items presented at study are tested.

MacLeod (1989a) conducted the first study to include a comparison between direct and indirect memory tests following item method cueing. In Experiment 1, MacLeod (1989a) reported an item method directed forgetting effect in both recognition (cf. Geiselman, Bjork, & Fishman, 1983) and indirect word fragment completion. In Experiment 2, the contrast was between free recall and indirect lexical decision. Consistent with the data from Experiment 1, an item method directed forgetting effect was obtained in recall and indirect lexical decision. MacLeod (1989a) argued that the directed forgetting effect in the direct and indirect memory tests reflected the operation of inhibitory processes acting on the F words at the time of retrieval (cf. Bjork, 1989; see also, Geiselman & Bagheri, 1985; Geiselman et al., 1983).
Although these early data were suggestive, the directed forgetting effect in indirect memory tests did not appear to be a robust phenomenon. For example, Basden et al. (1993) and Paller (1990) failed to obtain an item method directed forgetting effect in word stem completion and word fragment completion. Nonetheless, these authors both successfully replicated MacLeod's (1989a) directed-forgetting results with word fragment completion, when the experimental protocols utilised by MacLeod were applied. Basden et al. (1993) argued that two components of the procedure adopted by MacLeod were responsible for the item method directed forgetting effect in the indirect memory tests: (1) item method cueing, rather than the list method cueing was used; and (2) the indirect tests were compromised by conscious retrieval because of a failure to adequately disguise the relation between the study and test, the list of test items was a long list (32 words), and because the word fragments only had one possible completion (for an exposition of the logic underlying this interpretation, see Chapter 2).

Basden et al. (1993) conducted four experiments that had implications for the hypothesis that the item and list method directed forgetting effects may reflect the operation of two distinct mechanisms. It was proposed that the item method directed forgetting effect is associated with item-specific (distinctive) processing that leads to the selective, elaborative rehearsal of R items, whereas the list method directed forgetting effect reflects the operation of a retrieval inhibition mechanism acting on F cued items that have formed a retrieval unit, following relational processing at encoding (Basden et al., 1993; Einstein & Hunt, 1980; Hunt & Einstein, 1981, for discussion of these mechanisms, see Chapters 3, 7, 8, and 9). These two distinct mechanisms can account for a variety of phenomena. For example, the greater directed forgetting effect under the item method relative to the list method in recall is consistent with the notion that inhibition is probably a weaker mechanism than differential rehearsal (for additional relevant findings, see Chapters 3, 7, and 8).

The first two experiments conducted by Basden et al. (1993) investigated memory for related pairs of words under the item and list method paradigms. Performance was assessed in four memory tests, two were direct memory tests (yes/no recognition memory and direct paired-associate generation), whereas the other two were indirect memory tests (word fragment completion and indirect paired-associate generation). Only the results from Experiment 2 are reported here because the two experiments only differed in terms of the strength of the association between the paired associates. A significant item method directed forgetting effect was obtained in both recognition and direct paired-associate
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generation and indirect word fragment completion. The list method directed forgetting effect was limited to direct paired-associate generation. In Experiment 3, the item and list method paradigms were applied to recall and direct and indirect word fragment completion. An item and list method directed forgetting effect was obtained in the recall task, whereas in the word fragment completion task, a directed forgetting effect was only found in the direct word fragment completion task following item method cueing.

Additional specification of the differential rehearsal mechanism was reported in a recent series of experiments conducted by Hauselt (1998). In particular, the effects of maintenance and elaborative rehearsal on the magnitude of the item method directed forgetting effect was investigated. The contribution of maintenance and elaborative rehearsal was evaluated by changing the delay between the presentation of the critical item and the onset of the R and F cues (immediate versus delayed; Experiment 1), or by contrasting the delayed cue condition in Experiment 1 with a constrained, rote rehearsal procedure (Experiment 2). A directed forgetting effect was obtained in both experiments in cued recall and direct word stem completion tasks. The magnitude of the item method directed forgetting effect did not vary as a function of the two latency intervals (Experiment 1), whereas the item method directed forgetting effect was eliminated by the constrained, rote rehearsal condition in Experiment 2. This latter finding suggests that differential rehearsal, rather than retrieval inhibition, was responsible for the item method directed forgetting effect, since if retrieval inhibition was responsible for the item method directed forgetting effect, then the type of rehearsal at study should not influence the effect (Hauselt, 1998).

Only a limited number of studies have directly investigated the item and list method paradigm effect in young and older adults, despite the opportunity afforded by these phenomena to evaluate the operation of differential rehearsal and retrieval inhibition in these age groups. The earliest study is only of limited importance for evaluating the effect of ageing on the 'canonical' list and item directed forgetting effect, because the significance of the R and F cues was explained before the presentation of the study list (Pavur, Comeaux, & Zeringue, 1984, see also, Chapter 7). Camp and McKitrick (1989) and Giambra and Howard (1994) also reported the effects of directed forgetting in young and older adults, however, these studies were cited in an experiment reported by Zacks, Radvansky, and Hasher (1996); and only minimal information related to the experimental protocols was reported. The only systematic examination to date of the effect of ageing on the magnitude of the item and list method directed forgetting effects was conducted by Zacks et al. (1996). Therefore, given the paucity of experimental data, this study will be discussed in detail in the appropriate
sections of the experimental chapters that reported the effects of ageing on the magnitude of the item and list method directed forgetting effects (Chapters 7 and 8).

In summary, it appears that some indirect memory tests are sensitive to directed-forgetting manipulations (e.g., word fragment completion), whereas others are not (e.g., word stem completion), although this difference may be artifactual, because contamination by conscious retrieval cannot be eliminated in instances where a directed forgetting effect is reported in an indirect memory test (Basden et al., 1993; Hauselt, 1998). It is evident even from the perspective of this limited review that the pattern of findings is relatively complex, but several features of the experimental protocols employed appear to directly modulate the item and list method cueing directed forgetting effects. One approach to resolving the apparent inconsistencies within the research is to objectively evaluate the contribution of conscious and unconscious processes to memory task performance.

1.5.1.1 Item and List Method Directed Forgetting Effects: Contribution of Conscious and Unconscious Processes

Russo and Andrade (1995) investigated the contributions of conscious and unconscious processes to a word fragment completion task as a function of the item method paradigm. At test, word fragments were completed in accordance with indirect retrieval instruction, inclusion test instructions, and exclusion test instructions. In the indirect memory test, Russo and Andrade were able to replicate the findings reported by MacLeod (1989), since the estimates of conscious and unconscious processes revealed that the R-F difference was largely mediated by conscious processes.

In a series of studies, Allen and Vokey (1993; 1998; Vokey & Allen, 1993) investigated the effect of the item method paradigm on several different memory tasks using a derived variant of the process dissociation procedure (Jacoby, 1991). In the 1998 study, the effect of the opportunity to rehearse R items on the magnitude of the item method directed forgetting effect was explored. The opportunity for rehearsal was manipulated either by varying the interval between the presentation of the R or F cue and the next trial (1 or 3 secs.), or by varying the number of F items that intervened between the R items. Given that a reduction in the time available for rehearsal has been shown to reduce item method directed forgetting in free recall (Wetzel & Hunt, 1977), a similar effect was predicted for recognition and word fragment completion. The second encoding paradigm was
predicated on the notion that memory for R items that are followed by one or more F items is likely to benefit from additional rehearsal relative to R items that are immediately followed by one or more R items (Bjork, 1972).

A significant directed forgetting effect was obtained only for recognition, and the magnitude of this effect was not influenced by the time available at rehearsal. In addition, there was no effect of varying the number of intervening F cued items. Allen & Vokey (1998) argued that a potential explanation for the variance of these data from those reported by Wetzel and Hunt (1977) is that rehearsal time only has an effect when multiple recall opportunities precede the final recognition task. Nonetheless, several other competing explanations also exist (such as providing an ineffective manipulation of rehearsal, see Expt. 3 in Allen & Vokey, 1998); however, these will be discussed in the appropriate sections of Chapters 3, 7 and 8. Therefore, concluding that the item method directed forgetting effect is not sensitive to differences in the opportunity for differential rehearsal is premature.

In a second experiment, a derived variant of the exclusion test was employed. In both recognition and word fragment completion, no effect of directed forgetting was obtained in the estimates of unconscious processes, but an effect of directed forgetting was obtained in the estimates of conscious processes. The absence of a directed forgetting effect in the estimates of unconscious processes is consistent with the notion that directed forgetting is a function of rehearsal differences that are mediated by conscious processes (but see, Chapter 7 for the effect of differential rehearsal on a conceptual memory test). Further, the estimates of conscious and unconscious processes were not influenced by the number of rehearsal opportunities.

Dual process models of memory are not limited to the distinction between conscious and unconscious processes. One important dichotomic distinction is that between remember and know (R-K, Gardiner & Java, 1991; Tulving, 1985b). The R-K distinction has been operationalised in a task that requires participants to determine whether recognised words are associated with an accompanying feeling of specific spatio-temporal context ('remembered'), or whether they simply feel that a recognised word was studied ('know'). A study by Gardiner, Gawlick, & Richardson-Klavehn (1994) applied the R-K test procedure to investigate the effect a manipulation of maintenance and elaborative rehearsal had on the magnitude of the item method directed forgetting effect. In the elaborative rehearsal condition, item method directed forgetting was only associated with remember judgements, whereas in the maintenance rehearsal condition, the directed forgetting
effect also only occurred for remember judgements, but the magnitude of the R-F difference was reduced.

1.5.2 Summary

The differential rehearsal and retrieval inhibition accounts of directed forgetting have proved to be capable of explaining a variety of experimental phenomena (Basden & Basden, 1996; Basden & Basden, 1998; Bjork et al., 1998). However, it is possible that, at least in some circumstances, differential rehearsal and retrieval inhibition are instantiated in the list and item method paradigms, respectively. For instance, differential rehearsal may also operate in the list method paradigm, because F items are not subject to extended rehearsal, and so are less accessible, potentially interfering less with R items (Whetstone, Cross, & Whetstone, 1996, see also Chapters 7 & 8). In addition, the item and list method directed forgetting effect is also assumed to be supported by item-specific and relational processing, respectively (Basden & Basden, 1996; Basden et al., 1993; Einstein & Hunt, 1980; Hunt & Einstein, 1981); although, both forms of processing can operate under each method cueing, since the relative contribution of these forms of processes varies in accordance with the method of cueing (Basden & Basden, 1996).

Despite the fact that directed forgetting can be used to control remembering, the effect size can be modulated by varying item relatedness and precue elaborative processing, since the effectiveness of the F cue has been shown to be undermined by increasing the strength of these variables (e.g., Golding, Long, & MacLeod, 1994; Horton & Petruck, 1980). Inserting a delay between the item and the cue merely suspends precue processing until the cue appears (Wetzel & Hunt, 1977), at which point a R cue will release the potential of the precue processing and permit further rehearsal (in the form of elaboration), subject to the demands of the paradigm. However, as demonstrated by Hauselt (1998), and as found in the experimental work presented in this thesis, the constraints imposed by the encoding paradigm are often insufficient to ensure that a manipulation of maintenance versus elaborative rehearsal operates in accordance with the encoding instructions.

Directed forgetting effects in indirect tests appear to be smaller relative to direct memory tests. This suggests that the advantage for R items is limited to conscious processes, rather than unconscious processes, which has been one source of evidence used to support the notion that the item method directed forgetting effect arises from differences in rehearsal (Basden et al., 1993). More generally, when directed forgetting is allied to major dual process models of memory, the findings have been
informative for both fields, since some rapprochement between the experimental data and the theories proposed to explain them has been achieved. For example, process dissociation analyses revealed convincing evidence that directed forgetting in the direct and indirect memory tests is mediated by differences in conscious, rather than unconscious processes (Allen & Vokey, 1998; Russo & Andrade, 1995; Vokey & Allen, 1993). This conclusion is confined to item method directed forgetting, since only this method has been investigated using the process dissociation procedure.

Further, the application of the item and list method directed forgetting paradigms to primarily to perceptual indirect memory tests or paired associates (without an objective measure of conscious and unconscious processes), necessarily limits our understanding of the boundary conditions of the directed forgetting phenomena. Therefore, the experimental work that was conducted as part of the thesis was designed, in part, to address both the boundary conditions of the item and list method directed forgetting effect and the extent to which the differential rehearsal and retrieval inhibition mechanism are able to account for the data obtained (see Chapters 7 & 8). As a general paradigm, directed forgetting enables the control of remembering to be explored in a diverse set of experimental conditions; however, the results of the process dissociation analyses underscore the difficulty associated with ensuring process purity in indirect memory tests (e.g., Russo & Andrade, 1995).

From the perspective of understanding cognitive ageing, the opportunity afforded by the item and list method paradigms to investigate age-related effects in differential rehearsal and retrieval inhibition based mechanisms is appealing because these mechanisms are regarded as impaired in older adults (Craik, 1986; Hasher & Zacks, 1988; Hashtroudi et al., 1989; Salthouse & Meinz, 1995; Zacks & Hasher, 1994). Accordingly, the role of attentional inhibition and differential rehearsal as factors mediating cognitive ageing were investigated by applying the two directed forgetting cueing paradigms to the category exemplar generation task and perceptual-associative word stem completion task.

1.5.3 Full versus Divided Attention and Direct-Indirect Memory Tests

The present subsection is concerned with studies that have examined the effect of full versus divided attention on direct and indirect memory tests. Several studies have established that manipulating attention at study is capable of dissociating direct and indirect memory tests.
Typically, attention is manipulated as a polarised variable: full versus divided attention. An established pattern of impaired performance with increases in attentional load has been found in direct memory tests (e.g., Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Fisk & Schneider, 1984; Parkin, Reid, & Russo, 1990). However, the effect of divided attention is more complex because direct memory tests differ in their sensitivity to the amount of attention available at encoding (e.g., Craik et al., 1996). In relation to ageing, the age effects associated with divided attention at encoding are less clear. For instance, Park, Smith, Dudley, and Lafronza (1989) reported greater impairment in recall for older adults relative to young adults under divided attention (cf. Anderson, Craik, & Naveh-Benjamin, 1998), despite equivalent secondary task performance across both age groups. In contrast, Puglisi, Park, Smith, and Dudley (1988) observed that the effects of divided attention on recall performance were generally equivalent in young and older adults.

The general trend is more ambiguous with respect to the effect of divided attention at encoding on indirect memory tests. If it is assumed that processes of activation, familiarity, or perceptual processing that mediate some forms priming are indeed automatic (as suggested by a number of findings) then, it follows that indirect tests are not resource demanding, so little or no effect of divided attention should be obtained (Bentin, 1994; Jacoby, Toth, & Yonelinas, 1993b; Shallice et al., 1994; Szymanski & MacLeod, 1996, termed the attentional view). However, others, such as Carrier, Pashler, and McFarland (1994; see also, Hartman & Pirnot, 1995; Whitlow, 1990) have proposed that the processes underlying priming are not automatic, although the attentional requirements for these processes may be less than those supporting recall and recognition. Therefore, an effect of divided attention on unconscious processes would be expected, in at least some instances. Accordingly, divided attention should influence indirect memory tests, but only under certain experimental conditions and with particular types of secondary tasks (e.g., Gabrieli et al., 1996b; Mulligan, 1997; Mulligan, 1998; Mulligan & Hartman, 1996; Stone, Ladd, Vaidya, & Gabrieli, 1998). The effect of divided attention on memory for new verbal associations is even less well understood, largely due to the limited amount of experimental work investigating this issue.

One approach to resolving the variability in the effects of divided attention at encoding on memory tests is to identify factors such as the rate of presentation, task emphasis, the modality of the primary and secondary task, and secondary task ‘difficulty’. The rate of presentation of the stimuli is important because slow, or self-paced conditions are likely to permit shifts in attention between the primary and secondary tasks, which results in the adoption of a time-sharing strategy (Parkin et
The role of task emphasis reflects the trade-off between the primary and secondary task, characterised as the operation of an executive function, and has been systematically investigated by varying the priority of each task across a series of levels in order to generate a curve of resource allocation called an Attention Operating Characteristic (AOC, Gopher & Navon, 1980; Sperling & Melcher, 1978). The shape of the AOC describes the ability of the participants to distribute their attention between the primary and secondary task. Young and older adults appear to be equally able to vary task emphasis between two tasks when a block-wise manipulation is utilised (Salthouse, Rogan, & Prill, 1984).

A particularly significant task factor is the compatibility between the modality of the primary and secondary task, since when different modalities are used, no effect of divided attention in indirect memory tests has been obtained. By contrast, presentation of the primary and secondary tasks in the same modality is likely to induce a greater impairment (e.g., Femades & Moscovitch, 2000; Wickens, 1984; cf. Wolters & Prinsen, 1997), because of a greater effect of interference caused by the shared neural correlates that do not favour parallel processing (Shallice, 1988). The relevance of the ‘difficulty’ of the secondary task has been cast in terms of the ability of the secondary task to reduce the attention available for the primary task (Hawley & Johnston, 1991). Clearly, this does not objectively characterise the difficulty of the secondary task independently of the effect it has on the performance of the primary task (Della Sala, Baddeley, Papagno, & Spinnler, 1995). Nevertheless, resource demanding secondary tasks that involve a greater degree of conscious control, such as performing arithmetic calculations (e.g., Hawley & Johnston, 1991; Pickering, Mayes, & Shoqerat, 1988), are typically associated with impaired indirect memory test performance. By contrast, secondary tasks that can be assigned to a more automatic, peripheral role, such as perceptual classification tasks (e.g., the detection of deviant tones), do not appear to impair indirect memory tests (Jacoby et al., 1993b; Parkin & Russo, 1990).

If direct and indirect memory tests are, in fact, differentially sensitive to the effect of divided attention, it may not be appropriate to evaluate the effects of divided attention on conscious and unconscious processes using polarised, binary manipulations of attention. Therefore, in order to more accurately describe the function between attention and memory performance, a parametric manipulation of attention can be utilised. Further, all of the task factors that have been identified are likely to interact to determine the effect of a divided attention manipulation. For example, the differential sensitivity of direct and indirect memory tests to the ‘difficulty’ of the divided attention manipulation may override the effect of the rate of presentation. The introduction of age as a
variable introduces an additional interpretative difficulty, since differences in sensitivity between young and older adults to task factors (such as the rate of presentation Salthouse, 1996) necessitates the selection of dual task paradigms that do not confound the effects of divided attention with age group differences on the primary and secondary task (Salthouse et al., 1995).

### 1.5.3.1 Item-specific Retrieval and Divided Attention

A large variety of paradigms have been utilised to modulate the effect of attention at study. Understanding the manner in which attention is modulated is critical for understanding the effect it has on indirect memory test performance. In contrast, several studies have reported that indirect memory test performance is insensitive to changes in the availability of attention when it is modulated by varying the presentation epoch for the stimulus at study (e.g., Greene, 1986; Neill, Beck, Bottalico, & Molloy, 1990, Experiment 1; Wolters & Prinsen, 1997, Experiment 3). Wolters and Prinsen (1997, Experiment 3) reported that priming reached a maximum at an epoch of about 1 sec, at which time conscious processes were argued to begin to operate. This effect is important because the manipulation of attention often has a monotonic relationship with the effective study time. Therefore, the absence of an effect of presentation time beyond a 1 sec latency on unconscious processes suggests that a slow rate of presentation in some paradigms, and as often found in ageing research, may not represent a serious confound when interpreting the effect of divided attention (cf. Wood, Stadler, & Cowan, 1997).

As discussed in the introduction to this section, the negative effect of divided attention on direct memory test is a well established phenomenon, whereas in indirect memory tests the data is less consistent. Under a variety of indirect memory tests such as word stem completion (Jacoby et al., 1993b), word fragment completion (Mulligan, 1998; Mulligan & Hartman, 1996; Parkin et al., 1990), lexical decision (Smith & Oscar-Berman, 1990; Szymanski & MacLeod, 1996), perceptual identification (Gabrieli et al., 1997b), a spelling task (Wippich, Mecklenbrauker, & Halfter, 1989), and picture fragment completion (Parkin & Russo, 1990; Russo & Parkin, 1993) there was no effect of divided attention on perceptual priming. Other researchers have reported both no effect and an effect on perceptual priming depending upon the particular arrangement of study and test conditions (e.g., Gabrieli et al., 1997b; Mulligan, 1998; Mulligan & Hartman, 1996; Smith & Oscar-Berman, 1990), whereas other studies have found reductions in perceptual priming under divided attention (e.g., Crabb & Dark, 1999; Hawley & Johnston, 1991; Light & Prull, 1995; Weldon & Jackson-Barrett, 1993). However, in the studies that have reported impairments in perceptual priming, the
secondary tasks substantially reduced the identification of items at study, disrupting access to lexical information (for a review, see Mulligan & Hartman, 1996). Consequently, they represent a qualitatively different manipulation of attention when compared with divided attention tasks that limit their effects to post-perceptual encoding operations (Mulligan, 1998; Weldon & Jackson-Barrett, 1993).

In contrast, conceptual priming would be expected to be impaired by divisions of attention, because semantic or conceptual processing are dependent on attention (Cowan, 1995; Craik, 1983); at least when conceptualised within a transfer appropriate processing framework. Accordingly, Gabrieli et al. (1997b), Mulligan (1997, 1998), Mulligan & Hartman (1996), Light et al. (1995), and Light et al. (1999) have all reported that this was the case for category exemplar generation priming, whereas Anooshian (1989) and Schmitter-Edgecombe (1996) reported a similar impairment in category association priming. In contrast, and as discussed in section 1.4.2.1, Isingrini et al. (1995) found no effect of dividing attention on the amount of priming in category exemplar generation (for a null effect of dividing attention on priming in a word association task, see Jacoby, Woloshyn, & Kelley, 1989), whereas Gabrieli et al. (1997b) and Light et al. (1999) failed to obtain an effect of divided attention on category verification priming (for an explanation of this difference between conceptual tests, see Chapter 9). Isingrini et al. (1995) also reported a greater disruption of cued recall in older adults following divided attention at encoding, although the significance of this is less clear given the lower performance of the older adults in the full attention condition. However, the manipulation of attention in their study was relatively weak. Indeed, no effect of divided attention was found for any of the four age groups included in the study.

In a series of experiments, Mulligan (1997) examined the effect of changes in the attentional load on direct and indirect category exemplar generation. The availability of attention was varied using four levels of a short-term memory load. The task involved maintaining a string of digits and letters comprised of zero, three, five, or seven items in memory until an instruction to recall was presented a few seconds later (for additional studies in which the paradigm has been used, see Baddeley & Hitch, 1974; Engle, Conway, Tuholski, & Shisler, 1995; Logan, 1979). Further, the divided attention task and critical items were presented in a constrained, sequential order that ensured access to lexical information in full and divided attention conditions. Category cued recall was progressively impaired at all levels of divided attention, whereas an effect on conceptual priming was only obtained at the five-item load of attention, at which point priming was, in fact, largely eliminated. Mulligan (1997) argued that the conceptual priming performance obtained at the five-
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item load and full attention condition corresponded to the levels of category exemplar generation priming reported by Mulligan and Hartman (1996, Experiment 1) when a polarised binary manipulation of attention, with digit-monitoring as the secondary task, was employed.

Mulligan (1998) investigated the effects of the secondary task employed by Mulligan and Hartman (1996) on the conceptual indirect tests, general knowledge questions (Experiment 1) and word association (Experiment 2), because this secondary task had been previously shown to be sufficiently 'strong' to impair category exemplar generation priming (see also, Gabrieli et al., 1997b). Divided attention impaired conceptual priming in both tasks. Indirect memory test awareness was also evaluated, using a post-experiment questionnaire. The evidence from the post-experiment questionnaire did appear to support the notion that a veridical measure of conceptual priming was obtained under divided attention. However, the difficulties associated with the post-experiment questionnaire method clearly impose limitations on the claims that can be made with respect to the role of conceptual unconscious processes in these tasks (for a full discussion of these issues, see Chapter 2).

The interaction between the primary and the secondary task is instrumental in determining the effect of divided attention on conceptual priming (see also, Chapter 9). For example, the word association task involves the use of highly associated items, whereas the exemplars in category exemplar generation are typically less strongly associated with the category names that serve as the test cues. This difference in associative strength between study and test cues may reduce, or eliminate, the need for elaborative processing to provide accessible memory traces (Bentin, Kutas, & Hillyard, 1995). Several different secondary tasks have been employed with conceptual indirect memory tests: a short term memory load task was used by Mulligan (1997) and Gabrieli et al. (1999b); a digit-monitoring task was used by Gabrieli et al. (1997b), Mulligan and Hartman (1996), and Mulligan (1998, Experiment 1 and 2); and a digit symbol task was used by Koriat and Fuerstein (1976). As discussed earlier, these tasks vary in terms of their ability to divide attention, therefore it is clearly important to demonstrate a negative effect on a direct test before employing the manipulation to dissociate a direct test from an indirect test (Mulligan & Hartman, 1996).

With respect to ageing, several studies suggest that divided attention may have a larger detrimental effect on the recall performance of older adults (Isingrini et al., 1995; Park et al., 1989; Puglisi et al., 1988), whereas other studies have failed to obtain similar effect in recall (Anderson et al., 1998; Light et al., 1995; Puglisi et al., 1988). A similar lack of consistency has been observed for the
effect of divided attention on recognition memory in young and older adults, since both age-related invariance and impairment have been obtained. Overall, it would seem that for direct memory tests there is no clear emergent pattern favouring a claim for an age-related invariance or deficit as a function of divided attention (for reviews, see Hartley, 1992; Light & Prull, 1995; Salthouse, 1991). In relation to indirect memory tests, an equivalent effect of divided attention has been obtained in perceptual and conceptual priming in young and older adults (Isingrini et al., 1995; Light et al., 1995; Light et al., 1999). However, the limitations imposed by the difficulties identified in these studies suggest that additional experimental work is warranted.

1.5.3.2 Association-specific Retrieval and Divided Attention

The foregoing subsection demonstrated that there appears to be a dissociation between perceptual and conceptual item priming as a function of divided attention at encoding. However, specifying the effect of divided attention on perceptual and conceptual associative priming in any substantive detail is not possible at present because of the absence of experimental work that has addressed this question. Nonetheless, given the significant role for conceptually based processing in conceptual-associative verbal priming (independent of the nature of the test cues), such tasks would be expected to be sensitive to a division of attention at encoding (for further discussion of this issue, see Chapters 3, 6, & 9). However, it is not clear whether a similar claim is appropriate for perceptual-associative verbal priming. To my knowledge, there have been no studies examining the effect of divided attention at encoding on perceptual-associative word stem completion.

Evidence to suggest that conceptual associative priming is not sensitive to the effects of divided attention comes from a study reported by Wippich, Markert, Hannig, and Mecklenbräuker (1990), since there was no effect of divided attention on the conceptual-associative word stem completion. However, a relatively long stimulus onset asynchrony of 6 seconds was used, which would have allowed attention switching between the primary and secondary tasks, without noticeable disruption to the performance in the secondary task. Therefore, the results probably reflect associative priming under conditions of partial attention, rather than divided attention. Given the early difficulty associated with obtaining reliable effects of perceptual associative priming, it is not surprising that there does not appear to be published research examining the role of attention in the formation of new associations between pairs of words under perceptual encoding conditions.

Although not directly relevant, the data from a study conducted by Jacoby (1996), in which the
effect of divided attention and a change in study-test modality on pre-experimentally associated word pairs was examined, is of some interest. Specifically, given that no new conceptual relations are likely to be formed at encoding, paired-associate priming is believed to be largely mediated by the retrieval of the perceptual Gestalt formed at encoding, if the associative context is maintained (Goshen-Gottstein & Moscovitch, 1995b; but see Jacoby, 1996). No effect of divided attention was found for the estimates of unconscious processes; which is consistent with the attentional view, as espoused by advocates of the process dissociation procedure.

Light et al. (1996) conducted three experiments that investigated single-trial associative priming as a function of full and divided attention in young and older adults. However, the findings are also of limited relevance for the present purposes because associative priming was characterised in terms of the naming of novel nonwords. Nonetheless, it is worthwhile reporting that under conditions that fostered perceptual associative priming in young and older adults, performance under divided attention was impaired relative to full attention in Experiments 2 and 3 for both young and older adults. Divided attention also impaired recognition memory for new associations in both age groups.

1.5.3.3 Process Purity

It is apparent from the foregoing subsection that the effect of divided attention on conscious and unconscious processes needs to be considered in the context of the distinction between perceptual and conceptual processing, because although memory content is orthogonal to the conscious and unconscious processes (Jacoby, 1996), the effect of divided attention appears to be modulated by the interaction between these two processing dichotomies (see Chapter 3). However, a more basic concern that needs to be addressed is the problem of process purity in studies that have applied the task dissociation approach to investigate the effects of divided attention.

As discussed earlier, conceptual item-specific priming and association-specific word stem completion priming are susceptible to contamination by conscious processes. For example, Light and Albertson (1989) reported that in full attention versus divided attention, 88% and 34% of participants, respectively, adopted a conscious retrieval strategy in an indirect category exemplar generation task. Similarly, Mulligan and Hartman (1996, Experiment 1) reported that the proportions were 93% and 57% in the full and divided attention conditions, respectively, in category exemplar generation priming. Clearly, there is a need to conduct process dissociation
analyses. Nonetheless, it is an oversimplification to regard instances in which an effect of divided attention is found in indirect memory tests as evidence for contamination by conscious retrieval.

As discussed earlier, given that conscious and unconscious processes are regarded as coextensive with the distinction between effortful and automatic processes, respectively (e.g., Jacoby, 1991), and effortful processes require attention, conscious processes are presumably sensitive to divisions of attention. Evidence from several studies indicates that the estimates of unconscious processes are immune to the effects of divided attention, whereas the influences of conscious processes are reduced under divided attention (e.g., Jacoby, 1998; Jacoby et al., 1993b; Jacoby, Yonelinas, & Jennings, 1997b; Wolters & Prinsen, 1997). However, these findings are primarily based on the evidence from perceptually-driven, item-specific memory tests.

As will be demonstrated in this thesis, when the effect of divided attention is examined in a broader range of experimental environments and memory tasks, the findings based on process dissociation analyses become less consistent (see also, Schmitter-Edgecombe, 1999). In particular, two experiments were conducted to investigate the effect of a parametric manipulation of attention at encoding on category exemplar generation and perceptual-associative word stem completion. The implications of this research are important. For example, the findings reported by Mulligan (1997, 1998) and Mulligan and Hartman (1996), regarding the effect of divided attention on conceptual indirect memory tests, cannot now simply be attributed to contamination by conscious processes.

**1.5.3.4 Summary**

The fact that attention is central to theories of memory encoding underscores the importance of determining the effect of divided attention on direct and indirect memory tests. Differences in primary and secondary task methodology have contributed to the inability to characterise the effect of divided attention on indirect memory tests in a simple manner. Similar difficulties can be levelled at the studies that have investigated whether or not there are age-related memory effects following divide attention at encoding. Such empirical questions are particularly important for evaluating the validity of more general accounts of cognitive ageing, and more specific accounts of age-related cognitive decline (see Chapter 3). For example, establishing the effects of divided attention on various memory tasks is one approach that can evaluate the more general proposition that different 'pools' of attentional resources are involved in mediating different types of tasks (Wickens, 1984).
Further, both the category exemplar generation task and the perceptual-associative word stem completion tasks are well placed to provide an evaluation of the competing attentional and transfer appropriate processing accounts of the effects of divided attention on conscious and unconscious processes. The parametric manipulation of attention enabled a more precise characterisation of the effects of divided attention than a polar manipulation of divided attention on two different classes of memory task, which is theoretically important because memory tasks differ in their sensitivity to the amount of attention available at encoding (Craik et al., 1996; Mulligan, 1998), and these differences may interact with age (Anderson et al., 1998).

1.6 Conclusion

The early work that addressed the relation between memory and ageing involved broad contrasts between primary versus secondary memory or episodic versus semantic memory. The episodic-semantic distinction has continued to be a source of research, and has been joined most recently by the distinction between explicit and implicit memory. The focal interest in this chapter, and the experimental work motivated by the conclusions drawn from this review, was the clarification of the effects of ageing on conscious and unconscious memory processes. The paradigms employed in the research that was reviewed are as widely varied as the conclusions, and this precludes a simple synthesis of the findings.

A components of processing approach was adopted to both organise and conceptually frame the research that was reviewed. In particular, the structural and functional properties associated with memory tasks were characterised as the operation of independent, and potentially interactive, components that are instantiated in the performance of a memory task (Moscovitch, 1992a; Moscovitch, Goshen-Gottstein, & Vriezen, 1994). It is proposed that these structural and functional properties can be described in terms of taxonomic categories of memory tasks that divide into a four-cell, process-based matrix: (1) item-specific perceptually-based memory tasks; (2) item-specific conceptually-based memory tasks; (3) association-specific perceptually-based memory tasks; and (4) association-specific conceptually-based memory tasks. The conceptualisation of memory task performance within this matrix represents a powerful method for interpreting the effects of ageing on memory.

Even with the four-cell process matrix to guide the interpretation of the effects of ageing on conscious and unconscious processes, the findings have not produced an entirely coherent pattern.
Nonetheless, there are several reasons for predicting that association-specific priming, unlike item-specific priming, should be subject to age-related differences (Light & La Voie, 1993b; MacKay & Burke, 1990, see also Chapter 3). Further, it is plausible to assume that the magnitude of age-related differences can be modulated to the extent that a memory test is mediated by conceptual information, independently of whether a memory task evaluates the retrieval of item-specific or association-specific information. In relation to the experimental work that was conducted, it was assumed that age-related effects in perceptual-associative word stem completion priming would be smaller than in conceptual-associative word stem completion priming. Evidence of reliable, single-trial perceptual-associative word stem completion priming in older adults would represent both a novel empirical finding and would have significant theoretical implications.

In a meta-analysis of 16 associative priming and 23 item priming studies that incorporated a contrast between young and older adults, La Voie and Light (1994) reported that effect sizes for the age effects in these two categories of priming were equivalent (the category exemplar generation task was not included in their analysis). This finding is, in part, attributable to significant differences between the paradigms used in these two categories of priming; although the effect sizes were also homogenous across the different memory tasks. For example, most studies of item priming are based on the single presentation of test items, whereas most of the associative priming studies included in the meta-analysis involved multiple presentations of each study trial. Second, non-equivalent dependent measures are used with associative and item priming; namely, response latency and response accuracy. These confounds may have obscured the larger age deficit in associative priming than in item priming. For example, the fact that older adults are typically slower than young adults, may lead to their priming effects being larger as well (for an exposition of the logic underlying this prediction, see Laver & Burke, 1993).

From the perspective of the current review, a fundamental problem with the conclusions derived from the meta-analysis conducted by La Voie and Light (1994) was that they failed to distinguish between item and associative priming in terms of the distinction between perceptual and conceptual processing. This may be another factor that was responsible for the presence of equivalent effect sizes across item-specific and association-specific priming tasks. Indeed, Rybash (1996) reinterpreted the findings from the meta-analysis conducted by La Voie and Light (1994) by applying a revised taxonomy and found that perceptual item-specific and association-specific priming were not subject to age-related deficits, whereas conceptual item-specific and association-specific priming were impaired as a function of age. However, the allocation of tasks to the
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taxonomy used for this reinterpretation was idiosyncratic, since both word fragment completion,
word stem completion, and homophone spelling tasks were categorised as conceptual item-specific
priming tasks, whereas perceptual-associative word stem completion was categorised as a
conceptual association-specific priming task. Clearly, the outcome of any meta-analysis, or review
for that matter, is predicated on the scheme adopted for allocating tasks to the taxonomic categories
identified to interpret the data, and the strategy for the inclusion and exclusion of studies within the
analysis.

An additional factor that is potentially relevant to the functional demands associated with a memory
task is the operations required at retrieval. Indirect memory tests that require the production of the
target word, such as homophone spelling, category exemplar generation, and word stem and
fragment completion, may be more susceptible to being compromised by conscious retrieval than
tests that do not require the production of the target word, such as perceptual identification. For
example, it is plausible that the linear series of operations that are necessary to provide multiple
solutions to each category name in category exemplar generation are more resource demanding than
the rapid, binary processing involved in some perceptual indirect tests (Perruchet & Baveux, 1989).
However, in spite of the theoretical arguments that underscore the notion that age-related effects
should be greater in conceptual, as opposed to perceptual, priming, the empirical evidence remains
equivocal. It is difficult to reconcile this apparent incompatibility with underlying theory without
resorting to post hoc explanations such as contamination, sample sizes, and response bias
differences.

In summary, four primary questions were addressed in the experimental research that was
conducted: (1) does the conclusion that conscious processes are more vulnerable to ageing than
unconscious process (Jennings & Jacoby, 1993), as conceptualised and assessed using the process
dissociation procedure, still hold when unconscious processes are supported by conceptual item-
specific and perceptual association-specific information; (2) is age-related memory decline
associated with a reduction in the ability to recruit the component processes that support encoding
under conditions of divided attention, as implied, for example, by the 'frontal lobe' hypothesis of
cognitive ageing (West, 1996); (3) does the ability to inhibit no longer relevant information in
working memory, within the constraints of item and list method directed forgetting, undergo some
sort of functional change with advancing age, in the same way the attentional inhibition appears to
be impaired in negative priming (as suggested, for example, by Zacks et al., 1996); and (4) does the
putative age-related difference in the ability to perform spontaneous elaborative encoding extend to
perceptual elaborative encoding, as conceptualised with the perceptual-associative word stem completion task.

Therefore, the two primary classes of variables introduced in this review, divided attention and directed forgetting, have implications for several theoretical accounts that have been proposed to explain age-related differences in memory. In addition, when the application of these two variables is combined with the logic that underlies a dissociation and association strategy, the nature of processes that mediate conscious and unconscious processes that occur within category exemplar generation and perceptual-associative word stem completion can be identified. More general questions that were addressed relate to the boundary conditions under which the process dissociation procedure can be successfully applied. In addition to directly addressing issues such as contamination by conscious retrieval and response bias differences across direct and indirect memory tests, the process dissociation procedure permits the estimation of the contribution of conscious and unconscious processes to the category exemplar generation task and perceptual-associative word stem completion task as a function of age.

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2. Investigating Explicit and Implicit Memory: Task Dissociation, Process Dissociation, and Phenomenology

2.0 Introduction and Chapter Overview

Much of the early experimental work investigating implicit memory was underscored by an often unstated process-purity assumption (Jacoby, 1991)—an a priori assumption that direct and indirect memory tests reflect different underlying retrieval strategies and states of awareness. Little attempt was made to control or evaluate the actual retrieval strategies; rather, implicit memory was operationalised in terms of an absence of a reference to the relation between study and test episodes. Nevertheless, as early as 1985 it was appreciated that indirect memory tests can be potentially contaminated by conscious memory processes (Schacter, 1985b). Similarly, investigators studying amnesic patients recognised that unconscious memory processes can contribute to performance in direct memory tests (for a review, see Richardson-Klavehn & Bjork, 1988b).

In contrast to the early failure to adequately address these concerns, more recent work has focused on the development of frameworks that objectively estimate the contributions of the putative processes involved in direct and indirect memory tests (for reviews, see Richardson-Klavehn et al., 1996; Roediger & McDermott, 1993; Schacter et al., 1993). The primary processing distinction made by such frameworks is the dichotomy between what has variously been termed explicit memory, conscious memory, controlled memory, and recollection, as contrasted with implicit memory, unconscious memory, automatic memory, and familiarity (e.g., Jacoby, 1991; Yonelinas, 1994). At a basic level, all of the frameworks that specify these processing distinctions attempt to distinguish between consciously controlled influences/processes of memory and automatic, unconscious influences/processes of memory. The term ‘influences/processes of memory’ is used in its broadest, functional sense—accessing information in order to respond to the demands of the test. Further, there is no general consensus as to what represents an adequate operationalisation of constructs such as conscious awareness and retrieval (Reingold & Merkle, 1988; Reingold & Toth, 1996).

The need for a formal model is fundamental if the issues of process purity are to be directly addressed. Even in those instances when a dependent measure is a pure measure of the underlying processes, the comparisons between tasks can be theoretically uninformative because response...
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scaling and the output transformation between the processes and the dependent measure(s) are not specified (Howe, Rabinowitz, & Grant, 1994). Formal modelling permits the mapping of the underlying levels of processes that mediate the task onto the dependent measures utilised to measure these processes (Brainerd, Reyna, & Mojardin, 1999). Although, even with a formal model, such as the process dissociation procedure (Jacoby, 1991), only a linear output transformation is specified.

Several approaches for determining the phenomenological status of memory tasks will be considered. In the first section, the task dissociation approach, and a derived variant—the retrieval intentionality criterion (Schacter et al., 1989)—will be discussed. The difficulties associated with the task dissociation approach are used to demonstrate the need for a formal model. In the second section, the process dissociation approach, initially formalised in the terms of the process dissociation procedure (Jacoby, 1991), will be discussed. Particular attention will be paid to the process dissociation procedure, since the assumptions made in order to derive the theoretical quantities in the model have motivated considerable criticism. Both the task and process dissociation approaches use instructions in order to attribute conscious and unconscious processes to task performance, but the methods differ in terms of the theoretical specification of the processes involved in task performance and in their ability to quantify the relative contributions of these processes. This section concludes with revisions to the process dissociation procedure that will be necessary to overcome some of the limiting properties of the process dissociation model. In the third section, the empirical findings from the process dissociation approaches and task dissociation approach will be contrasted in order to determine whether or not convergence can be achieved between these two methods, since some researchers have argued that such comparisons are invalid (e.g., Graf & Komatsu, 1994). The final section attempts to provide a unified view of the various approaches, and suggest directions for future research and theoretical development.

2.1 Task Dissociation Approach and the Retrieval Intentionality Criterion

The difficulties associated with comparing direct and indirect memory tests can be identified by describing five factors along which the tasks differ (Merikle & Reingold, 1991): (1) the nature of the test stimulus; (2) the required response; (3) the response criterion for completing cues; (4) the instructions given to the participants; and, (5) the role of cognitive processes that are not 'mnemonic-based' (Dennett, 1991; Nadel, 1992), such as visual processing, response production and response selection. Both individually and in combination, these five factors have obscured the interpretation of the task dissociation-based experimental work. For example, double dissociations
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between direct memory tests such free recall and graphemically cued recall (Blaxton, 1989) cannot be explained purely in terms of differences in retrieval processes. Such dissociations occur because the informational demands of each test, as characterised in terms of the perceptual-conceptual processing dichotomy, interact with the type of information encoded at study.

An early task dissociation study by Graf and Mandler (1984) is illustrative of the importance of response criterion and process purity considerations. Graf and Mandler (1984) reported a dissociation between a direct and indirect word stem-completion task as a function of a levels-of-processing manipulation under conditions in which the test cues were identical across the two tests, but the retrieval instructions were varied according to the test. However, the interpretation is complicated by differences between the two memory tasks in the response criterion for completing the cues: participants were required to give a response to every stem in the indirect stem-completion task, but not in the direct test. One method that has been used to equate response criterion across participants and tasks is the forced cued recall procedure (Graf, Squire, & Mandler, 1984), whereby participants are instructed to provide a response to all test cues. However, a consequence of using this procedure is that it invokes changes in the mode of processing used to complete the tasks, such as when generating a response to a test cue in the absence of subjective phenomenal awareness. Consequently, difficulties occur when trying to interpret the findings resulting from this approach.

The Graf and Mandler (1984) study is an example of a successful application of the retrieval intentionality criterion (Neely, 1989; Schacter et al., 1989). In particular, the retrieval intentionality criterion requires that the retrieval cues in the direct and indirect memory tests are the same, and that an experimental manipulation selectively affects performance in only one of the memory tasks. The approach was designed to directly address the problem of 'intentional retrieval' contaminating indirect memory tests. However, direct and indirect memory tests also need to be equated in terms of their response criterion, a task dimension not addressed by the retrieval intentionality criterion (Reingold & Merikle, 1990). Indeed, even a cursory examination of the task dissociation literature reveals that different baselines response rates between direct and indirect tests have been widely reported. Further, given that only a limited set of constraints are imposed by the retrieval intentionality criterion, satisfying the conditions of the retrieval intentionality criterion does not ensure that the retrieval intentionality can be determined unequivocally. Test instructions may induce more complex strategies than simply pure conscious or unconscious retrieval (e.g., Jacoby et al., 1993b).

More generally, a single functional dissociation, by itself, provides little evidence for functional
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independence, because such dissociations can be explained by a single-process model (Dunn & Kirsner, 1988; see also, Reingold & Merikle, 1990). Dunn and Kirsner (1988) suggested that a crossed double dissociation between direct and indirect memory tests represented stronger evidence for establishing that indirect test performance does not reflect conscious memory (cf. Russo & Andrade, 1995; for an exposition of this logic within the context of the process dissociation procedure, see Toth, Reingold, & Jacoby, 1994). But such analyses cannot be informative about the relative contribution of individual processes to direct and indirect memory tests, because both standard tests constitute paradigms in which both conscious and unconscious processes are expected to facilitate task performance (Jacoby, 1991).

An alternative, or complementary approach, to evaluating the functional incompatibility between direct and indirect memory tests is to examine performance for instances of stochastic independence (Eich, 1984; Perruchet & Baveux, 1989; Tulving et al., 1982). The approach is based on the premise that if performance is uncorrelated across two tests, then the tests represent independent bases for responding. Stochastic independence has been demonstrated between direct and indirect memory tests (e.g., Tulving et al., 1982) and between different indirect memory tests (e.g., Jacoby & Witherspoon, 1982). However, as discussed in Chapter 1, numerous methodological objections have been identified concerning the measure of stochastic independence (Hintzman & Hartry, 1990; Ostergaard, 1992). In addition, despite the development of revised techniques such as the method of triangulation (Hayman & Tulving, 1989a), these techniques cannot be easily generalised across disparate memory tests (Roediger et al., 1999). More fundamentally, stochastic independence has been reported across different visual arrangements of the same retrieval cue (Hayman & Tulving, 1989b); namely, different fragments of the same target item in a word fragment completion task. Clearly, such findings do not support the view that each form of fragment is mediated by a different memory system. Progress will only be made when principled criteria are established to determine when stochastic independence is evidence of more than one memory system and when it is evidence of hyperspecific operations within a single system.

Finally, the phenomenological status of direct and indirect memory tests has also been evaluated by comparing performance on the last few trials with that of the first few trials at test (e.g., Schacter & Graf, 1986a). Specifically, this approach is designed to determine whether or not participants modify their retrieval strategy to a consciously determined one, despite indirect retrieval instructions. The difficulty with this method is that the interpretation remains equivocal because some participants could become suspicious about the nature of the test, resulting in the use of conscious retrieval at the outset of the test. Consequently, under these circumstances the
appropriate use of the first few trials as a baseline for unconscious retrieval is undermined.

### 2.1.1 Procedural Manipulations that Minimise ‘Task Contamination’

One avenue of recourse available to practitioners of the task dissociation approach is to limit the potential for task contamination by the judicious use of procedural constraints (for a review, see Roediger & McDermott, 1993). For instance, some studies have gone to great lengths to minimise awareness of the relation between the study and test phases, and therefore limit the extent to which conscious retrieval strategies are invoked in indirect memory tests. Several methods have been utilised, these include instructing participants that the indirect memory test is an ancillary task, requiring participants to provide completions as rapidly as possible, administering the direct memory test after the indirect memory test, increasing the latency between study and test, and including a large ratio of distractor items not related to the studied items in order to minimise the identification of studied items as a source for responses. The latter approach inevitably results in a long test list that itself can result in ‘involuntary conscious memory’ by providing an increased opportunity for becoming aware of the relation between study and test. However, whilst the successful application of these approaches may limit awareness of the relation between study and test, participants may also fail to capitalise on the study episode at all.

An alternative method to minimise the probability of task contamination is to employ reaction time (RT) based paradigms such as perceptual identification, rather than completion based paradigms, since they operate in the range of 300 to 700 milliseconds, so there is no need to invoke additional conscious strategies to supplement task performance (Monsell, 1985). At a more detailed procedural level, studies that employ ‘long’ (600 ms and over) stimulus onset asynchrony (SOA) may increase the possibility that priming will be mediated by conscious memory processes because attentional control processes operate at long, but not short, SOAs (Neely, 1991). However, employing short SOAs to minimise the use of conscious retrieval strategies may result in no priming being obtained (Carroll & Kirsner, 1982). Therefore, in spite of the intuitive appeal of RT paradigms with respect to task purity, the validity of this assumption remains an empirical issue that can only be addressed by process dissociation type analyses.

If an indirect completion paradigm is used, it is also important to avoid simple procedural confounds. For example, if word fragments only have one possible completion, the resultant extended search strategy is likely to increase the potential for controlled, conscious retrieval. Evidence supporting this position was reported by Squire, Shimamura, and Graf (1987); patients
with amnesia did not produce evidence of priming when there was only one possible completion for each stem or fragment, but produced a normal level of priming when multiple completions were possible. Nevertheless, providing cues with only one possible completion may be necessary if the informational demands associated with an indirect test are to be equated with a direct test with respect to the search for a single item. However, it is sometimes impossible to preclude a role for conscious processes in indirect completion paradigms, because inherent features of the paradigm foster conscious retrieval. For instance, Perruchet and Baveux (1989) argued that conceptual indirect memory tests involved the type of responses that are the product of end-directed procedures that are time consuming, and so are more likely to involve conscious retrieval than immediate, binary memory tasks.

In sum, the essential problem with using the retrieval intentionality criterion and task dissociation approach as empirical benchmarks is that the assumption of process purity between a particular task and a particular process is preserved. The only robust conclusion that can be drawn from a functional dissociation is that the indirect test is not accessing memory in the same way as the direct test. These considerations have wider implications for theoretical accounts that predicate separate memory systems on the basis on functional independence (see Chapter 3). More generally, the attempt to circumvent the limitations imposed by the process purity assumption led to a paradigm shift towards methods that expressed empirical quantities in the terms of a formal model in order to derive theoretical quantities (conscious and unconscious processes). The following section provides an overview of these methods, focusing on the process dissociation procedure and some of the derived variants that have been developed (e.g., Allen & Vokey, 1998; Banks, Chen, & Prull, 1999; Buchner, Erdfelder, & Vaterodt-Plunnecke, 1995; Mulligan & Hirshman, 1997; Richardson-Klavehn et al., 1996; Wainwright & Reingold, 1996).

### 2.2 Process Dissociation Approaches

The process dissociation procedure was initially developed to separate the contributions of the dual processes of familiarity and recollection contributing to recognition memory performance, although the method is applicable to a variety of memory and judgement tasks. The distinction between familiarity and recollection was originally formalised by Mandler (1980). Recollection was conceptualised as a slow recall operation that involves accessing semantic, elaborative or associative information, along with an associated experience of explicit recall of the study episode. In contrast, familiarity was conceptualised as a faster process that engenders a feeling of resemblance in the absence of explicit recall (Atkinson & Juola, 1974; Mandler & Boeck, 1980),

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and accesses a store that integrates item specific, sensory and perceptual information (Jacoby & Dallas, 1981; McEltree, Dolan, & Jacoby, 1999). More recent accounts have described the relationship between memory content and the recollection-familiarity distinction as orthogonal (Clark & Grolund, 1996; Jacoby, 1996), whilst preserving Mandler’s (1980, cf. Gillund & Schiffrin, 1984) assumption of speed differences. The main motivation for this change was to lend greater flexibility to the specification of the processes, but the corollary has been a reduced ability to interpret dissociations in a principled manner.

The original formulation of the process dissociation procedure was defined over a recognition test in which participants study two lists and then make one of two types of recognition judgement about a test list composed of targets and unrelated distractors. One instructional condition requires that only the second list of target items are accepted as old, the exclusion test, whereas the other requires that both lists of targets items are accepted as old, the inclusion test. This dual study list implementation of the process dissociation procedure incorporates a source recognition memory component, but will not be directly examined because the processes that mediate spatio-temporal source information are not involved in the same way when the process dissociation procedure is applied to direct and indirect tests. Indeed, in the dual-list implementation, there is a need to additionally specify the interaction of the processes related to source information with familiarity and recollection based retrieval processes (McEltree et al., 1999). Accordingly, the present discussion will be restricted to those issues that directly relate to the application of the process dissociation procedure to direct and indirect memory tests, although it is acknowledged that much of the debate and criticism of the framework was motivated by this original dual-list methodology.

One of the core assumptions of the process dissociation procedure is that conscious and unconscious processes are independent processes in retrieval, so there should be manipulations that affect conscious processes but not unconscious processes and some that affect unconscious processes but not conscious processes. The experimental work applying the process dissociation procedure has produced findings that cannot easily be accommodated by single process theories (Jacoby et al., 1997b; McEltree et al., 1999; Yonelinas, 1994), however, there have been claims that single process models can adequately account for at least some of the data described using a dual process conception (e.g., Ratcliff & McKoon, 1997; Ratcliff, Van Zandt, & McKoon, 1995). Whilst the process dissociation approach presents an important move towards the decomposition of tasks into processes, it is the diffuse, 'shallow' theoretical specification of these processes, in addition to the limiting properties of the procedure, that will serve as a source for continuing theoretical development.
First, an account of the process dissociation procedure in terms of its goal to estimate the contribution of consciously controlled and automatic, unconscious processes to tasks will be presented. The important advances in dual processes accounts needs to be tempered with a balanced consideration of the concerns regarding the theoretical and methodological implications of the process dissociation procedure. Consequently, the second section addresses the three main untested assumptions of the process dissociation procedure and their consequences for parameter estimation (Buchner et al., 1995; Curran & Hintzman, 1995; Dodson & Johnson, 1996; Graf & Komatsu, 1994; Hirshman, 1998; Joordens & Merkle, 1993; Mulligan & Hirshman, 1997; Roediger & McDermott, 1994). The most prominent of these assumptions is that an independence relational model accurately describes the relation between the conscious and unconscious parameters. The independence relational model is evaluated by comparing and contrasting it with two additional relational models, ‘redundancy’ and ‘exclusivity’, which have also been proposed to account for instances when conscious and unconscious processes co-determine target item retrieval. The third section considers the three different relational models in terms of specific models of retrieval. The theoretical specification of conscious and unconscious processes in terms of memory content, retrieval volition, and memorial states of awareness is examined in the fourth section. In the final section, it is argued that the process dissociation procedure lacks the capability to verify whether the empirical quantities are generated by the theoretical quantities in accordance with the restrictions expressed in the computational formula, in effect rendering the core assumptions unverifiable (Brainerd et al., 1999).

2.2.1 The Process Dissociation Procedure: Estimates of Conscious and Unconscious Processes

The process dissociation procedure is intended to provide a formal model that permits the influences of conscious control to be operationalised as the contrast between trying to respond with target words (inclusion) versus trying to avoid responding with target words (exclusion). The opposition logic underlying the joint use of inclusion and exclusion tests represents the most clear advance over the task dissociation approach (Brainerd et al., 1999; Hintzman & Curran, 1994). Much of the evidence reported from experimental work that employed the process dissociation procedure has described dissociations between the conscious and unconscious parameters that would be predicted by a dual-process model (Jacoby et al., 1993b; Jacoby et al., 1997b).

The following description of an experiment by Jacoby et al. (1993b) is instructive for the purpose of
outlining the basic paradigm. In this study, the process dissociation procedure was employed to investigate the effects of divided attention on the empirically derived parameter estimates of conscious (C)\(^2\) and unconscious (U) processes in a word stem completion task. Two test conditions were used. The inclusion test (I), which corresponded to a standard cued recall test, with instructions to guess when recall failed. The participant could complete a stem with a studied word either because they recollected the studied word, with a probability C, or because, even though recollection failed (1-C), the studied word came to mind unconsciously as a completion: C + U (1-C). In the exclusion test (E), participants were instructed to complete word stems with unstudied words. Therefore, in the exclusion test, a word stem would be completed with a studied word only if recollection failed and the word came to mind unconsciously: U (1-C). The exclusion test is an "opposition" paradigm, since conscious and unconscious processes are placed in competition with one another. Intrusion errors (to the extent that they exceed the baseline for completion of unstudied items) are attributed to the unconscious retrieval of the items.

Encoded items are regarded as discretely represented in conscious and unconscious memory stores, with some, or all, of the items located in both stores or states. In addition, the items are precluded from having continuous/partial degrees of C or U information (cf. Yonelinas, 1994); therefore, exclusion performance is assumed to reflect only those items that do not have a representation in the conscious store. This is reflected in the equation in which the difference between the proportion of studied item completions in the inclusion and exclusion tests provides a measure of the C parameter: I - E. This part of the model is largely accepted because it is not affected by instances where task performance is co-determined by conscious and unconscious processes (Joordens & Merikle, 1993). In the process dissociation procedure, the formula for the calculation of the U parameter is specific to an assumption whereby C and U are independent (CU, Joordens & Merikle, 1993). Given the assumption of independence, the probability of a studied word coming to mind unconsciously as a completion can be derived: U = E/(1-C). The findings from the experiment reported by Jacoby et al. (1993b) showed that divided, as compared to full, attention at encoding significantly decreased the estimate of C (.25 vs. .00), but had no effect on the estimate of U (.47 vs. .46).

\(^2\) The notation C and U are sometimes used in the process dissociation procedure literature to refer to both the theoretical entities, conscious and unconscious influences of memory, and the empirically derived parameter estimates. In order to avoid potentially conflating these entities in the present discussion, the C and U notation are used to only refer to the empirically derived parameter estimates.
A basal assumption that is required to sustain this opposition logic is that conscious processes enable controlled, selective responding, whereas unconscious processes are not subject to intentional control, and can only be expressed when conscious processes fail (Jacoby, 1991). The appearance of a studied item in the exclusion test in spite the active intention to avoid a particular response has parallels with the Stroop “Gold Standard” measure of attentional control (MacLeod, 1992). Further, given that several theorists have characterised ageing as an impairment in conscious control or effortful processing, accompanied by the preservation or invariance in unconscious, automatic processing (Hasher & Zacks, 1979; Hasher & Zacks, 1988; Hay & Jacoby, 1996), the ability to investigate the opposing influences of conscious control and prepotent automatic responses makes the process dissociation procedure particularly valuable for investigating memory and ageing.

2.2.2 Untested Assumptions: Response Criterion, Parameter Invariance Between Tests, and Independence Between Conscious and Unconscious Processes

The discussion now turns to the three main untested assumptions of the process dissociation procedure. The evaluations of these assumptions have been instrumental in drawing attention to the difficulties associated with the original process dissociation model (Brainerd et al., 1999; Cowan & Stadler, 1996; Curran & Hintzman, 1997; Dodson & Johnson, 1996; Hintzman & Curran, 1997; Jacoby, Begg, & Toth, 1997a; Jacoby & Shrout, 1997; Jacoby et al., 1997b; Joordens & Merikle, 1993; Komatsu, Graf, & Uttl, 1995; Mulligan & Hirshman, 1997; Toth, Reingold, & Jacoby, 1995; Wainwright & Reingold, 1996), but the results of these evaluations have, in part, also demonstrated the limited impact that some violations of these assumptions have for the final parameter estimates. Nevertheless, the consequences of violating one or more of the assumptions does make the identification of the C and U parameters unspecifiable, because the model’s parameter space is saturated (Brainerd et al., 1999). The situation is particularly acute when the independence assumption is violated, because an unknown function with an unknown number of free parameters needs to be introduced to express the relation between C and U (Brainerd et al., 1999).

2.2.2.1 Response Criterion and Correcting for Guessing

The process dissociation procedure incorporates three a priori boundary conditions that need to be met in order to estimate the contributions of conscious and unconscious processes under conditions that rule out confounding from differences in the response criterion between the inclusion and exclusion tests. First, it needs to be demonstrated that for a given level of an encoding task, test cues
are completed with studied items above baseline in the exclusion test. Second, the inability to exclude studied items should not be due to a general difficulty in completing test cues with new, unstudied items. Therefore, for another level of an experimental factor, participants should be better able to exclude these items relative to the items encoded at another level of the factor. Third, the baseline rates of responding for inclusion and exclusion tests need to be equivalent.

Nevertheless, despite the judicious selection of the experimental protocols, differences in the baseline rates responding in inclusion and exclusion tests still occur. Unless base-rates are corrected across the exclusion and inclusion tests, performance cannot be meaningfully compared. Therefore, there has been a need to develop procedures that correct for base rate differences in order to evaluate whether or not there is an effect on the estimates of the memory parameters (Banks et al., 1999; Buchner & Erdfelder, 1996; Buchner et al., 1995; Curran & Hintzman, 1997; Yonelinas & Jacoby, 1996b; Yonelinas, Regehr, & Jacoby, 1995). These procedures can be organised into two broad categories. One procedure, exemplified by the work by Buchner and colleagues, involves distinguishing between consciously controlled processes, unconscious processes, and a guessing process (G, Buchner & Erdfelder, 1996; Buchner et al., 1995; Buchner & Wippich, 1996). Each of these three processes is assumed to make an independent contribution within a direct-retrieval multinomial model. The mathematical expressions of process dissociation model are modified in order to integrate inclusion and exclusion false-alarm rates using linear correction for guessing formulas. Specifically, guessing is modelled as a simple additive term that does not originate because of prior exposure, but contributes to responding on the basis of familiarity.

An alternative approach, adopted by Yonelinas and colleagues (Yonelinas, 1994; Yonelinas & Jacoby, 1996b; Yonelinas et al., 1995), makes use of use signal detection theory to obtain separate estimates of the response criterion for the inclusion and exclusion tests. Specifically, receiver operating characteristic (ROC) curves are generated, whereby the proportion of Hits is plotted against the proportion of false alarms. One motivation for this approach is that by plotting Hits as a function of FA it overcomes the overly restrictive constraint imposed by the learned or not learned state of items that is assumed in the model proposed by Buchner and colleagues. More specifically, the unconscious parameter is reconceptualised as a graded signal detection process that expresses the probability that a target exceeds the response criterion. The revised model assumes that signal detection strength is normally distributed (i.e., a continuous function). Yonelinas and colleagues have shown that empirical and signal detection theory generated ROC curves are both curvilinear, however these ROC curves differ in terms of their symmetry, since the curves generated from inclusion and exclusion data were asymmetric, unlike the symmetrical curves generated under the
assumptions of signal detection theory (Yonelinas et al., 1995). The explication of this divergence requires an evaluation of two different models underlying signal detection theory, but these issues are beyond the scope of the current discussion (compare Curran & Hintzman, 1995; and Yonelinas et al., 1995).

Differences in the response criterion can produce spurious dissociations between C and U parameters (Brainerd et al., 1999; Curran & Hintzman, 1995; Dodson & Johnson, 1996; Graf & Komatsu, 1994). Brainerd et al. (1999) demonstrated that when a response criterion difference occurs under a manipulation that simultaneously increases (or decreases) both parameters, the effects of the manipulation on one of the parameters will then to be masked by a bias in its estimation. As an additional example, C will be overestimated and U will be underestimated when the response criterion in the inclusion test is greater than in the exclusion test, and the opposite will be true when the response criterion in the exclusion test exceeds the inclusion test. These inappropriate biases in the estimates are a consequence of using the probability of non-recollection as the denominator in the expression for U, so that only items for which recollection fails are used to estimate U (Brainerd et al., 1999). Further, if the variance of studied items performance is greater than unstudied items when the response criterion is below chance, chance performance can potentially be mistaken for weak, but above-chance performance (Brainerd et al., 1999).

A violation of the response criterion assumption clearly imposes a limit on the inferences that can be made about the contributions of conscious and unconscious processes to performance between experimental conditions and between groups (Roediger & McDermott, 1994). Therefore, it is imperative that the condition of response criterion invariance is verified using the methods outlined above, since without such independent measures, reports of process dissociations need to be treated with caution. In addition, measures of response criterion also need to be orthogonal to measures of memory strength.

### 2.2.2.2 Invariance of Conscious and Unconscious Processes Across Inclusion and Exclusion Tests

In contrast to violations in the response criterion assumption, the assumption of invariance in the conscious and unconscious parameters between the inclusion and exclusion tests is not verifiable because the computational expressions of the process dissociation model cannot be modified to verify this assumption (Brainerd et al., 1999). An analogous situation to the violation of response criterion assumption develops when the assumption of between test invariance in the parameters is
not satisfied, since misleading paradoxical dissociations and associations can be obtained. More specifically, if the assumption of parameter invariance is violated, the process dissociation model parameters become \( I = C_i + U_i (1 - C_i) \) and \( E = U_e (1 - C_e) \) — the subscripts \( i \) and \( e \) refer to the inclusion and exclusion tests, respectively (Brainerd et al., 1999). Therefore, if, for example, the equivalence of \( C \), but not \( U \), is relaxed, then the \( U \) parameter will be underestimated when \( C_e > C_i \) and overestimated when \( C_i > C_e \) (Brainerd et al., 1999).

Very little attention has been focused on developing variants of the process dissociation model that can detect the violation of between condition parameter invariance. A notable exception has been conjoint recognition model developed by Brainerd et al. (1999) in which a third instructional condition and two classes of distractors are added to provide the additional degrees of freedom needed to enable tests of the between condition parameter invariance assumption.

2.2.2.3 Relational Models: The Relation between Conscious and Unconscious Processes

A formal model is required to specify the relation between conscious and unconscious processes when retrieval is co-determined by conscious and unconscious processes. Presently, there is no empirical method for estimating the proportion of trials in which these two memory processes overlap. Therefore, in lieu of an empirical measure, four theoretical models have been articulated to specify the relation between conscious and unconscious processes: independence, exclusivity, redundancy, and no relation (Buchner et al., 1995; Hirshman, 1998; Jones, 1987).

The original formulation of the process dissociation procedure posited that conscious and unconscious processes make an independent contribution to the direct retrieval of items (e.g., Jacoby et al., 1993b; Jacoby et al., 1997b; Toth et al., 1994). In this model, the proportion of overlap trials is expressed as \( C \) times \( U \) (CU). Within the exclusivity model, conscious and unconscious processes cannot simultaneously co-occur (Gardiner & Java, 1993a). Therefore, the intersection between \( C \) and \( U \) is zero. The antithetical model to exclusivity is the redundancy relational model, since this is predicated on the notion that the majority of mental processes are unconscious, and that only a small proportion of processes reach the 'threshold' of consciousness (Joordens & Merikle, 1993). Items associated with conscious retrieval are assumed to form a subset of those associated with unconscious processes, and consequently, the intersection between \( C \) and \( U \) is expressed by \( C \).

The primary method for evaluating the independence relational assumption advocated by Jacoby
and colleagues over the two other relational models is to demonstrate null effects of experimental variables (such as divided attention) on the estimates of unconscious processes, in conjunction with large effects of the same manipulations on conscious processes (Jacoby et al., 1993b). However, such an argument is fundamentally circular, since invariance in the estimates of unconscious processes is only observed when the data are analysed using the independence assumption, since a reanalysis using the redundancy or exclusivity assumptions would produce a different pattern of dissociation or association (e.g., Russo & Andrade, 1995). Moreover, even in more complex multinomial process dissociation models, the effect of variables such as divided attention on the estimates of the unconscious parameter are constrained, a priori, to be invariant (e.g., Jacoby, 1998). Further, a negative correlation between performance in the inclusion and exclusion tests can result in a constant value of U (Hirshman, 1998). Under these circumstances, it is not appropriate to assume support for the independence model because it is not possible to distinguish between the independence model and the redundancy model (Curran & Hintzman, 1995). Therefore, interpreting patterns of dissociation between conscious and unconscious processes having, a priori, assumed independence is associated with interpretative difficulties.

A more convincing argument for the adoption of the independence assumption is that the independence model is the only model that does not conceptualise either the inclusion or exclusion tests as process-pure measures (Jacoby, Toth, Yonelinas, & Debner, 1994). The redundancy model conceptualises the inclusion test as a process-pure measure of unconscious memory \[I = C + U - C = U; U = E + C]\, whilst under the exclusivity model, the exclusion test is a process-pure measure of U and the inclusion test measures both conscious and unconscious processes \[C + U\]. However, the process dissociation procedure does assume that each test provides a 'process-pure' measure of two hypothesised modes of retrieval [i.e., \(I = C + U (1 - C)\) and \(E = U (1 - C)\)], which cannot be measured objectively (for a discussion, see Graf & Komatsu, 1994; Richardson-Klavehn et al., 1996; Roediger & McDermott, 1994). This issue will be addressed in more detail in a later subsection that examines the specification of the three relational models in terms of models of retrieval. More generally, the conceptualisation of the inclusion and exclusion tests entirely in terms of the contribution of conscious and unconscious processes re-describes, rather than fully addresses, the problem of process-purity.

The computation of the C parameter is independent of which relational model is adopted, because consciously controlled trials contribute to the proportion of studied items only under the inclusion test, but not under the exclusion test. However, the equivalence in the computational expressions for the C parameter does not extend to the manner in which conscious control is conceptualised (Section 2.2.4.2 will address these differences). In contrast, the estimate of the U parameter is dependent upon which of the three relational models is adopted to describe the overlap (Joordens & Merikle, 1993). In the independence and redundancy models, the exclusion test is not a process pure measure of unconscious processes because conscious control can override unconscious processes. Accordingly, it is necessary to calculate the proportion of such overlap trials in the exclusion test to avoid systematically underestimating the proportion of items associated with unconscious processes. These items are included in the inclusion test \(C + U - (CU)\), but excluded in the exclusion test \(U - (CU)\). Dividing by \(1 - C\) increases the exclusion test value in order to take account of these items [i.e., \(U = E/(1 - C) = E + (CU)\)].

Violation of the independence assumption has been shown to lead to biases that either overestimate or underestimate the model parameters (Curran & Hintzman, 1995; Curran & Hintzman, 1997; Jacoby et al., 1997a). For instance, the U parameter will be underestimated when C and U are positively correlated, and the amount of this underestimation increases as C increases. The consequences of a variable that raises both the C and U parameter estimates relative to a control condition are more complex, since a disproportionate bias across the two parameters is produced (for a discussion, see Curran & Hintzman, 1995; Curran & Hintzman, 1997). Specifically, the underestimation of the U parameter will be larger under conditions that also increase the C parameter, because fewer intrusions will occur in the exclusion test, thereby masking the effect of the variable on the U parameter.

Given the consequences of a violation of the independence assumption, several methods for detecting violations in this assumption have been developed. For example, Curran and Hintzman (1995) reported interitem correlations between the estimates of conscious and unconscious processes by aggregating data within item types across participants. Only positive item correlations are of concern as potential sources of erroneous estimates and spurious dissociations (Curran & Hintzman, 1997). These observations were consistent with their view that the dual memory processes are, in fact, positively correlated rather than stochastically independent (cf. Jacoby & Shrout, 1997). Jacoby and his colleagues have explored the effects of positive correlations in two recent papers (Jacoby et al., 1997a; Jacoby & Shrout, 1997). Several important conclusions emerged from this work, two of which are especially relevant to the present section. First, although
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U is underestimated when C and U are correlated, the amount of underestimation is so small as to be virtually undetectable with correlations in the range reported by Curran and Hintzman (1995) and Jacoby (1996). Importantly, the degree to which U is underestimated appears to only be marginally increased with increases in the magnitude of the correlation, and the amount of underestimation remains small even when correlations are perfect (Cowan, 1996; Jacoby et al., 1997a), but this only holds if the variances in the parameter estimates are small (Curran & Hintzman, 1997; cf. Jacoby & Shrout, 1997).

The need to identify which model accurately reflects the relation between conscious and unconscious processes is not limited to process dissociation approaches. Indeed, the interpretation of functional dissociations in the task dissociation literature have typically involved applying an independence relational model. However, unlike process dissociation research, little effort has been focused on determining the task conditions under which such an independence model is valid. These issues are therefore critical to both task dissociation and process dissociation approaches. A more detailed consideration of the relative merits of each of the relational models can be found in: (Curran & Hintzman, 1995; Curran & Hintzman, 1997; Jacoby et al., 1997a; Jacoby & Shrout, 1997; Joordens & Merikle, 1993; Richardson-Klavehn et al., 1996). Nonetheless, a number of theorists have argued that there is no need to posit an a priori relational assumption (Buchner et al., 1995; Hirshman, 1998).

2.2.3 Conscious and Unconscious Process: Models of Retrieval

One of the most important boundary conditions for operating in accordance with the assumptions of the process dissociation procedure is the adoption of a direct-retrieval strategy by participants (Jacoby, 1998; Jacoby et al., 1997b). The direct retrieval model proposes independent, consciously controlled and unconscious retrieval processes that are asynchronous at both their respective input and output stages. In line with theories of automaticity, unconscious processes are assumed to be typically faster than conscious processes (Hasher & Zacks, 1979; Hasher & Zacks, 1988). However, the temporal subjective experience and the underlying retrieval processes are subject to a more complex output transformations than this assumption implies (e.g., Dennett & Kinsbourne, 1992). Therefore, given the hypothesised asynchronies between the input and output stages of conscious and unconscious processes, the direct model of retrieval is, at present, only conceptualised at a 'shallow' level of theoretical specification.

Retrieval instructions need to be specified in accordance with a direct-retrieval strategy in order to
maintain the independence between conscious and unconscious processes (Jacoby, 1998; Jacoby et al., 1997b). In addition, direct-retrieval instructions have been shown to produce comparable levels of baseline responding across the inclusion and exclusion tests, and encourage exclusion of studied items only using conscious recollection (Jacoby, 1998). However, there is no direct means for verifying the retrieval strategy employed by participants. One approach to verifying the use of a direct-retrieval strategy is on the basis of invariance in unconscious processes that is predicated a priori grounds (Jacoby et al., 1997a, see also, Chapter 9). Jacoby (1998) contrasted the effect of generate-recognise retrieval instructions with the original process dissociation procedure retrieval instructions on the parameter estimates of conscious and unconscious processes. As hypothesised, generate-recognise retrieval instructions produced results consistent with a redundancy model of retrieval, while direct retrieval instructions produced results consistent with an independence model of retrieval. Accordingly, Jacoby (1998), Jacoby et al. (1997a), and Jacoby et al. (1997b) argued that when the process dissociation procedure is applied in accordance with the boundary conditions that engender a direct-retrieval strategy, the estimates of conscious and unconscious processes are veridical for the underlying model.

The specification of each of the three relational assumptions in terms of a specific model of retrieval will permit progress in the determination of the boundary conditions under which these models of retrieval operate. For example, retrieval based on a generate-recognise strategy has been observed in tasks such as indirect word fragment completion, where generation was argued to reflect unconscious retrieval processes followed by an explicit recognition judgement to select studied items from those generated, and this was conceptualised without reference to a dual-process conceptualisation of memory (Challis, 1999). However, it is not sufficient to simply align the results from a process dissociation to a particular model of retrieval without a direct measure of retrieval. Indeed, in the same way that memory tasks cannot simply be assumed to be awareness-pure or retrieval strategy-pure, a particular memorial state of awareness is unlikely to be associated uniquely with a particular retrieval strategy or memory content (Gardiner & Java, 1993b). Such assumptions reflect a doctrine of concordance that is increasingly difficult to sustain (Tulving, 1989). These issues will be developed in the next section, where the theoretical specification of conscious and unconscious processes are examined.

2.2.4 Conscious and Unconscious Processes: Content, Retrieval Volition, and Memorial States of Awareness

The theoretical specification of conscious and unconscious processes, as defined with the process
dissociation procedure, needs to reflect substantive psychological content if they are to represent the correlates of explicit and implicit memory, respectively. In the first subsection, the implications of specifying the C parameter as a capacity limited, slow, item-specific recall operation, which accesses semantic information, and the U parameter as an unlimited, fast, global retrieval operation, which accesses perceptual information are evaluated (Clark & Grolund, 1996; Jacoby, 1996). Specifically, experimental findings that are at odds with the differences in content dependence and speed between the two processes are addressed. The second subsection assesses the status of a more fine-grained phenomenological distinction between retrieval volition and memorial states of awareness; namely, the concept of involuntary conscious memory (Graf & Komatsu, 1994; Richardson-Klavehn & Gardiner, 1995; Richardson-Klavehn, Gardiner, & Java, 1994a; Richardson-Klavehn et al., 1996).

2.2.4.1 Content and Speed of Conscious and Unconscious Processes

As discussed earlier, the specification of dual process conceptions of memory as distinct bases for item retrieval dictates that double dissociations between conscious and unconscious processes should be obtainable. Accordingly, single dissociations affecting conscious processes have been reported for full versus divided attention at study (Jacoby, 1996; Jennings & Jacoby, 1993), target presentation rate (Curran & Hintzman, 1995; Hay & Jacoby, 1996), typicality of cue-target pairs (Hay & Jacoby, 1996), and response time at test (Hay & Jacoby, 1996). However, the patterns of process dissociations reported have not been entirely consistent with the way in which processing constructs such as content were originally specified for the parameters.

For example, both manipulations in the degree of semantic encoding (e.g., levels of processing) and perceptual manipulations (e.g., cross form manipulation between study and test) appear to affect the C parameter (e.g., Jacoby et al., 1993b), whereas the U parameter has been shown to be influenced by manipulations in semantic content (e.g., increasing the associative relatedness of cue-target pairs, Jacoby, 1996) and semantic encoding (Richardson-Klavehn & Gardiner, 1998). However, a revised conceptualisation of the conscious-unconscious distinction to a more content neutral position (Jacoby, 1996), in which content is orthogonal to the dual processes distinction, does not provide a problem-free solution, because if both perceptual and semantic/conceptual content are involved in conscious and unconscious processes, one interpretation would be that the memory processes should not be dissociated by the type of content manipulations discussed earlier. These issues will be addressed in more detail in the following experimental chapters and in Chapter 9.
In relation to speed distinction between conscious and unconscious processes, Gardiner and Java (1993a) argued that a difficulty with the independence assumption is that it also implies that conscious and unconscious processes can operate simultaneously. Reingold and Toth (1996) conceded that the independence relational model does in principle allow both processes to co-occur, but, as mentioned in Section 2.2.3, the processes are regarded as asynchronous and therefore do not necessarily always operate simultaneously. Indeed, the output of the slower, conscious processes should be experienced after the output from the fast, unconscious processes. Therefore, the temporal simultaneity between the conscious and unconscious processes is only a difficulty if a direct casual relation is hypothesised between these processes and subjective states of awareness (which are mutually exclusive). Further, Yonelinas and Jacoby (1994) have demonstrated that unconscious processes operated more quickly than consciously controlled processes.

A parallel concern is the complexity associated with interpreting task manipulations that result in dependence between the processes is reported. For example, Russo and Andrade (1995) found that an item directed forgetting manipulation in a word fragment completion task produced estimates of conscious and unconscious processes that covaried. Unconscious processes were greater for to-be-forgotten words than for to-be-remembered words, whereas a canonical directed forgetting effect was obtained in the estimates of conscious processes. Such instances of crossed interactions between the parameter estimates have been reported for generate-read manipulations (Toth et al., 1994), level-of-processing manipulations (Richardson-Klavehn et al., 1994a), and target presentation rate (Curran & Hintzman, 1995).

Crossed interactions have been used as evidence to support the notion of independence between the conscious and unconscious processes, in the manner that double dissociations are interpreted in the clinical literature (e.g., Toth et al., 1994). However, such an analysis implies that the manipulation that causes the negative covariation has a simultaneously opposing effect on the conscious and unconscious processes. Consequently, a single manipulation that causes a crossed interaction needs to be reconceptualised as two variables, with each level defined as a different variable, for this interpretation to be sustained (Russo & Andrade, 1995). However, this approach cannot be extended to all variables that have produced crossed interactions. For example, it is hard to see how each level of a variable such as target presentation time can be reconceptualised as a discrete variable (Russo & Andrade, 1995).

Given that inclusion and exclusion tests are likely to reflect the influence of more than two hypothesised component of processing, process dissociation methods are likely to also index these
co-occurring processes. Inevitably, a more complete decomposition of the processes that mediate memory task performance will need to identify and described the relation among all of these processes.

2.2.4.2 Retrieval Volition and Memorial States of Awareness

The conscious-unconscious processing distinction has also been criticised on the grounds that it does not capture the concept of involuntary conscious memory. Involuntary conscious memory has formed the basis of a number of theoretical and empirical critiques of the process dissociation procedure (Graf & Komatsu, 1994; Richardson-Klavehn & Gardiner, 1998; Richardson-Klavehn et al., 1994a; Richardson-Klavehn et al., 1996). As early as 1987, Schacter formalised the concept as a “case in which a test cue leads to an unintentional not fully conscious and explicit ‘reminding’ of the occurrence of a prior episode” (p. 510). The status of involuntary conscious memory continues to be unresolved in the task dissociation literature, but has formed the basis of the on-line first person process dissociation approach developed by Richardson-Klavehn et al. (1994a). Involuntary conscious memory has been used to explain the failure of the process dissociation procedure to detect the difference between memorial states of awareness (conscious versus unconscious) as distinct from retrieval volition (voluntary versus involuntary, Richardson-Klavehn et al., 1996).

One implication of the revised phenomenological scheme that incorporates involuntary conscious memory is that the process dissociation procedure parameters only measure voluntary conscious and involuntary unconscious memory (Graf & Komatsu, 1994; Richardson-Klavehn et al., 1994a; Richardson-Klavehn, Lee, Joubran, & Bjork, 1994b). The logic can be extended to the direct-retrieval model, whereby a perfect correlation between ‘voluntary-conscious’ processes and ‘involuntary-unconscious’ processes is indicated. Accordingly, the process dissociation approach is expected to “overestimate how contaminated implicit tests are by intentional retrieval processes” because the process dissociation approach captures “only a subset of involuntary influences—those that are unaccompanied by an awareness that an item has been previously encountered” (Roediger & McDermott, 1993, p. 77).

More specifically, Richardson-Klavehn et al. (1994b) argued that in the exclusion test, items are excluded as studied if they are recalled by voluntary conscious memory, but also if they are retrieved due to involuntary conscious memory. The consequence would be an underestimation of unconscious processes and an overestimation of conscious processes (Richardson-Klavehn et al., 1994b). However, there are inherent difficulties with developing theories based on concepts that...
largely reflect introspective experience (Dennett & Kinsbourne, 1992). For example, participants are not typically aware of the mechanisms underlying retrieval. Therefore, in terms of subjective experience, given that retrieval intentionality cannot be considered equivalent to retrieval instructions, and cannot be directly observed, it is not clear how voluntary retrieval can be distinguished from involuntary retrieval (Reingold & Toth, 1996). The concept of retrieval intentionality will need to be operationalised if a more substantive theory is to be eventually realised.

Further, the development of the concept of involuntary conscious memory as a benchmark to assess measures of memory requires that the concept be identified in the terms of specific models of retrieval connected with specific experimental tasks (Reingold & Toth, 1996). Accordingly, two models of retrieval that can incorporate the concept of involuntary conscious memory have been proposed: generate-recognise and direct retrieval models. Reingold and Toth (1996) argued that it is relatively straightforward to map the subjective experience of involuntary conscious memory onto the two-stage sequence of processing underlying performance in the generate-recognise retrieval model. The involuntary, unconscious generation is unaccompanied by episodic detail, and then the studied item could be recognised, resulting in the subjective experience of remembering the prior occurrence of the item. Within the direct retrieval model, the output of the faster unconscious processes are available before the output from the slower, conscious processes on trials that are associated with the subjective experience of involuntary conscious memory (Reingold & Toth, 1996). Involuntary conscious memory is only a problem for the generate-recognise retrieval model specified in the terms of an independence relational model of retrieval (Reingold & Toth, 1996).

In general, therefore, Reingold and Toth (1996) argued that the subjective temporal sequentiality associated with involuntary conscious memory is a misleading epiphenomenon, because it suggests dependence between processes that are, in fact, independent. However, Richardson-Klavehn et al. (1996) specified the concept of involuntary conscious memory in terms of the exclusivity model as applied to the distinction between retrieval volition and memorial state of awareness, as discussed earlier. Therefore, the meaning of involuntary conscious memory changes within this conceptualisation, and so, a relational model needs to be specified not only at the level of retrieval, but also at the level of memorial states of awareness.

For the direct retrieval model in the exclusion test, instances in which involuntary conscious memory is associated with conscious and unconscious processes should result in an underestimation of unconscious processes because these trials would be excluded as a response. The degree of
underestimation, if the independence formula are applied, is determined by the actual proportion of ‘overlap’ trials minus the independence estimate of the co-determined trials (Reingold & Toth, 1996). In contrast, under a generate-recognise retrieval strategy, involuntary conscious memory would result in an overestimation in the proportion of overlap trials in comparison to the direct-retrieval model. Accordingly, the proportion of ‘overlap’ trials would be the computational expression used by a redundancy model; that is, C (Reingold & Toth, 1996). The exclusivity model defines the process of conscious control quite differently from the independence model, because the generation of completions, and to a lesser extent the recognition stage, is assumed to be automatic and so not subject to conscious control (see also, Jacoby & Hollingshead, 1990).

At present, involuntary conscious memory represents an under-specified concept, because the distinction between subjective experience and underlying retrieval mechanisms has not been sufficiently developed. Involuntary conscious memory reflects the phenomenology of remembering rather than the underlying dynamics of memory retrieval. Nevertheless, Richardson-Klavehn et al. (1996) argued that participants will adopt a generate-recognise strategy in the exclusion test under some situations, independent of task instructions, because such a strategy is less effortful and time-consuming than a voluntary one (see also, Chapters 5, 7, & 9). For example, Nyberg et al. (1997b) found evidence suggesting that participants given inclusion instructions in a fragment-completion task adopted an generate-recognise retrieval strategy, despite instructions to try to complete fragments with studied items. In sum, process dissociation approaches tend to simply assume—rather than empirically verify—that participants are operating in accordance with the retrieval instructions.

2.2.5 Model Testing: The Goodness-of-Fitness Test

There are several properties that are missing from the process dissociation procedure. In particular, the specification of only two empirical quantities, the inclusion and exclusion tests, and two theoretical quantities, the conscious and unconscious processes, leads to the process dissociation model not possessing any degrees of freedom (Brainerd et al., 1999). Consequently, goodness-of-fit tests cannot be conducted, since the basic requirement for goodness-of-fit test is that the number of theoretical quantities in a model must be less than the number of empirical quantities. Goodness-of-fit tests allow the relation between the empirical and theoretical quantities to be evaluated by determining whether the sample empirical values can be generated by the theoretical quantities in accordance with the restrictions specified by the computational formulas (Theios, Leonard, & Brelsford, 1977).
In relation to the process dissociation model, the importance of goodness-of-fit tests is the evaluation of the core assumptions. Consequently, the acceptance of the model's core hypothesis can only be grounded in a priori assumptions, rather than an empirical criterion of fit. For instance, in order to evaluate the redundancy relational model using standard model testing procedures, the existing computational expressions for the redundancy model require an additional parameter representing the covariation of conscious and unconscious processes (Brainerd et al., 1999). The consequence of this additional parameter would be that there are more parameters than there are data points. Multinomial models have been developed to evaluate the process dissociation procedure, with additional parameters added to provide sufficient degrees of freedom for goodness-of-fit tests (Jacoby, 1998; for an exposition for the logic underlying the multinomial modelling approach, see Riefer & Batchelder, 1988).

The inability to empirically evaluate the process dissociation model's core assumptions undermines the central theme of process dissociation research, namely the interpretation of parameter dissociations as evidence for independent memory processes. Goodness-of-fit tests enable the model most likely to have generated the sample data to be identified. Ratcliff, Van Zandt, and McKoon (1995) demonstrated this point in a series of simulations, and demonstrated that the process dissociation model was unable to detect the fact that simulated data in which C and U were dissociated had actually been generated by the one process model of Gillund and Schiffrin (1984). Further, the one process model of Gillund and Shiffrin (1984) was able to produce the same types of parameter dissociations as those reported in process dissociation experiments. Therefore, without goodness-of-fit tests to determine whether or not the process dissociation model could have generated sample data, parameter dissociations cannot provide direct support for a dual-process model (Brainerd et al., 1999).

2.3 Task Dissociations Revisited

An objection often proposed by the advocates of the task dissociation approach is that the inclusion and exclusion tests of the process dissociation procedure are methodologically limiting. For instance, floor effects in the exclusion test are typically interpreted as a methodological deficiency that needs to be remedied by increasing exclusion performance, either experimentally, or by re-analysing data to minimise the impact of such scores (e.g., Jacoby et al., 1997a; Toth et al., 1994); however, increasing exclusion test performance may exaggerate the role of unconscious processes in the memory task. In contrast, the role of strategic control that underlies the opposition logic has
been argued to overestimate the contribution of conscious processes 'because subjects are forced to try to recall items when they might not do so if left to their own devices’ (Russo & Andrade, 1995, p. 421).

Many of the problems identified are not specific to the process dissociation processes, since issues such as the assumption of a dual process conception of memory can also be levelled at the task dissociation approach. Indeed, some of the issues (e.g., involuntary conscious memory) raised as concerns unique to the process dissociation approach, were originally introduced as problems for the task dissociation approach (Schacter, 1987). More generally, Graf and Komatsu (1994) asserted that that the process dissociation approach is invalid for learning about direct versus indirect memory tests. However, when compared with the direct and indirect memory test data, the parameter estimates are assumed to be equivalent to pure versions direct and indirect memory tests. Accordingly, Toth et al. (1994) found that estimates of unconscious processes were nearly identical to the probability of completing stems in indirect word stem completion under the same encoding conditions, whereas instances in which the estimates of unconscious processes do not match indirect test performance are attributed to conscious contamination of indirect memory tests (e.g., Toth et al., 1994). Nonetheless, the retrieval instructions are different in an indirect memory test, since they encourage retrieval based on involuntary conscious memory; the instruction to respond with the ‘first word that comes to mind’ is likely to engage an involuntary retrieval strategy that may involve a conscious recognition stage. Consequently, since Jacoby (1998) argued that this mode of retrieval leads to the violation of the core assumption of the process dissociation procedure, a direct correspondence between indirect memory tests and the estimates of unconscious processes cannot be assumed.

The process dissociation procedure is not intended to study indirect and direct test performance, rather it was intended to study the phenomena that such tests were originally designed to investigate (Reingold & Toth, 1996). Therefore, it is an oversimplification to argue that the findings from process dissociation analyses are not appropriate for comparison with task dissociation approaches, since this position ignores the benefits associated with convergent evidence (Reingold & Toth, 1996).

2.4 Conclusions

The distinction between explicit and implicit memory has been applied to tasks, strategies, and memorial states of awareness. However, there is clearly a need for greater precision in the
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terminology and theoretical specification if the understanding of the relation between memory and consciousness is to be advanced. Process dissociation approaches, such as the one proposed by Richardson-Klavehn and colleagues, are designed to avoid conflating tasks, strategies, memorial states of awareness, and underlying theoretical constructs such as retrieval processes or memory systems. Interestingly though, despite the substantive discussion of the process purity problem, this has not led researchers to re-evaluate the theoretical relevance of the early findings (a notable example is a widely cited review by Roediger & McDermott, 1993). Notwithstanding which position is adopted, a basal requirement for the development of future methodologies is that they will no longer be able to be based on a series of implicit, untested assumptions. This position is particularly pertinent when the extant data is of strong theoretical significance and the data from amnesics are in conflict with those of normal matched adults. Following the review in Chapter 1, it would appear that memory for new associations and conceptual priming both satisfy these conditions, and so re-evaluation of these memory tasks using the process dissociation procedure is warranted.

The process dissociation procedure has brought the relationship between memory and consciousness, particularly as it relates to intentionality, to the fore of the implicit memory research. However, much of the interest generated has tended to be in the form of criticisms of various aspects of the process dissociation procedure. The process dissociation procedure represents a novel mode of framing the measurement of conscious control, and of studying the conscious and unconscious use of memory (Nelson et al., 1999). The extent of the criticism can, in part, be attributed to the fact that the process dissociation procedure includes explicitly stated assumptions regarding the relation between memory and consciousness, whereas the assumptions of the task dissociation approach are often implicit and unacknowledged, so the task dissociation approach has not been exposed to the explicit treatment of these issues. Despite, initial concerns, violations of the independence assumption and the invariance of the theoretical quantities between conditions has been shown to be less severe than first proposed.

A number of theorists have re-evaluated the process dissociation procedure, and have proposed derived variants that represent a useful synthesis of added capabilities (e.g., Brainerd et al., 1999; Buchner et al., 1995). These capabilities are derived from the need to include the base rate of responding to unstudied, control items (Brainerd et al., 1999) and extend the calculation of meaningful estimates of conscious and unconscious processes to formal models that do not apply the independence relational model (Buchner et al., 1995; Hirshman, 1998). Further, the independence assumption may be inappropriate when applied to some experimental conditions and
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indirect memory tests (Curran & Hintzman, 1995; Mecklenbrauker, Wippich, & Mohrusen, 1996, see also Chapters 5, 7, & 9; Russo, Cullis, & Parkin, 1998). Consequently, the potential for co-varying effects of experimental variables on the conscious and unconscious processes needs to be systematically investigated.

It is also important that the theoretical quantities described by the model represent substantive psychological content, this will involve the re-specification of conscious and unconscious processes. Such specification is likely to involve a more functional perspective. Nevertheless, such caveats and considerations do not detract from the basic principle underlying the opposition logic. Indeed, the evolution of the original process dissociation procedure demonstrates the theoretical and methodological utility of the model. Key issues that are currently being addressed include: (1) a richer outcome space in order to permit goodness-of-fit tests; (2) tests of between condition parameter invariance; and (3) the generation of response bias parameters. The provision of sufficient degrees of freedom within the computational model will allow testable hypotheses to be generated that assess the status of the core assumptions.

In summary, the strengths of the process dissociation framework are that it provides researchers with a model with explicitly defined empirical and theoretical quantities. These properties provide an important tool for advancing the study of dual process conceptions of memory. In order to appropriately evaluate the process dissociation framework, it is necessary to understand the distinction between evidence that supports the general validity of the formal model versus specific empirical support for any single assumption. In particular, the application of the process dissociation procedure to the paradigms employed in the experimental work presented in this thesis will contribute to the delineation of the boundary conditions of the process dissociation procedure.

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3. Theoretical Accounts of Conscious and Unconscious Memory Processes and Ageing: Towards an Integrated Framework

3.0 Introduction

Theories of age-related differences in cognition are distinguished by the need to include a developmental mechanism that explains the reasons and identifies the source of differences in performance (Salthouse, 1991). Given that the findings from research investigating cognitive ageing are diverse, it has proved difficult to formulate unified theories that articulate the relation between age and cognition. Nonetheless, a pervasive account that has been posited to account for cognitive deficits in older adults is the progressive and generalised slowing of information processing activities (Birren, 1974; Cerella, 1990; Salthouse, 1992). However, it is important to note that attempts at 'grand' cognitive theories are not without serious limitations (Dennett, 1992), therefore this has led to approaches that identify multiple processes/mechanisms to account for age-related differences in cognition.

A precursor for any account of age-related differences in memory is the basal distinction between two major taxonomic categories of theoretical interpretation: (1) distal interpretations; and (2) proximal interpretations. Distal interpretations address the factors that an individual engaged in earlier in life, such as changes in the quality of education and differential patterns of cognitive activity. In contrast, proximal interpretations address mediating factors at the time of assessment. The localisation of age-related effects within proximal interpretations often involves the use of analytical models to explain effects in particular component processes of cognition. Within these analytical models, distinctions are made among theoretical constructs in order to specify which entities are responsible for the age-related differences that are observed. These constructs have been operationalised in terms of differences in the efficiency of specific processing components, the selection and effectiveness of particular strategies, and alterations in the quantity of a specific processing resource (e.g., attention and working memory).

The ability of an analytical model to identify variables that demonstrate differential age sensitivity is the primary method for evaluating a proposed developmental mechanism. Accordingly, the current chapter will be limited to such analytic, proximal theoretical accounts of age-related
differences. Cognitive neuroscientific accounts of the neuroanatomical substrates of memory are also considered proximal interpretations, because the majority focus on the correlation between cognitive and neurobiological components, rather than speculate about the origins of the age-related differences in these components. Therefore, cognitive neuroscientific accounts of age-related differences in memory will be explicitly introduced in the current chapter because of the pivotal correlation that has been repeatedly reported between neurobiological and behavioural indices in ageing. This overall approach is a necessary bootstrapping procedure because the implications of distal processes for the interpretation of cross-sectional age-differences in memory are complex and, as yet, under specified (Neisser, 1997).

3.1 Chapter Overview

The current chapter is intended to identify the theoretical approaches that have a bearing on the relation between age and memory, in order to provide a context for the experimental work presented in this thesis. The discussion of the theoretical work is organised into three sections. In the first section, the major theoretical accounts proposed to explain the age-related decline in cognitive function will be summarised. The theoretical constructs identified by these accounts are widely regarded as major determinants of age-related differences in cognition, and more importantly have implications for the interpretation of the effect of ageing on memory. This section is organised in the terms of the experimental variables that were applied to investigate conscious and unconscious processes in the category exemplar generation and the perceptual associative word stem completion tasks; namely, divided attention, the item method directed forgetting paradigm, and the list method directed forgetting paradigm. In the second section, the general theoretical accounts proposed to interpret the functional and neurobiological distinction between explicit and implicit memory will be discussed. Particular attention will be devoted to the transfer appropriate processing framework because this has been variously formalised in terms of processing distinctions pertinent to understanding the effects of ageing on memory. It will become apparent that only a small amount of theoretical research has focused on the interpretation of age-related difference in conscious and unconscious memory processes, as compared to the theoretical work undertaken to account for the explicit-implicit memory distinction. In the third section, a brief discussion of cognitive ageing characterised within a cognitive neuroscientific framework is provided, because this approach highlights the importance of convergent sources of evidence when addressing the complex processes involved in cognitive ageing.
3.2 Cognitive Ageing: Theoretical Accounts

Age-related decline in cognition has been attributed to a large variety of mediating mechanisms such as dysfunctional inhibitory processing (Hasher & Zacks, 1988), limited processing resources (Craik & Byrd, 1982), age-related slowing (Salthouse, 1996). However, the attribution of poorer performance in memory and other cognitive tests to such mechanisms has only been partially successful. For example, the notion that age-related deficits in a variety of cognitive tasks reflects the slowing in cognitive operations such as the speed with which mental, perceptual and motor processes can be executed (Fisk, Fisk, & Rogers, 1992; Salthouse, 1996), or the rate of responding within dual-task conditions (Waugh, Fozard, & Thomas, 1978), has undergone considerable revision. Within this account, age-related impairment arises either because the later, relevant operations cannot be performed (the limited time account) or because the output of processing earlier in the time stream may no longer be available when the later processing is complete (the simultaneity account, Salthouse, 1996). There is evidence that slower coding speed correlates with impairment in a number of cognitive functions, and this is particularly acute with more complex mental operations (Salthouse, 1996). The general slowing was originally characterised as a linear function of young adults reaction times (the complexity hypothesis), but this has been superseded by non-linear functions that are capable of explaining a larger body of data (Cerella, 1990).

One fundamental concern with the general slowing account is the development of an adequate conceptualisation of the term slowing. Slowing can be characterised as a peripheral factor that limits the expression of ability, or an intrinsic component of the level of an individual's cognitive ability. However, from a neurological perspective, the locus of age-related slowing has been hypothesised to be at the level of increased neural noise that reduces the signal-to-noise ratio for information in the nervous system (Salthouse & Lichty, 1985) or an attenuation in neural connections (Cerella, 1990). Examples of more functional interpretations proposed to account for the generalised slowing observed in older adults include impaired attentional inhibition (Hasher & Zacks, 1988; Zacks & Hasher, 1994) and the notion of an increase in the amount of information lost at each processing stage (Myerson, Hale, Wagtstaff, Poon, & Smith, 1990). Independently of the manner in which the slowing is conceptualised, shared age-related variance across several memory measures and measures of speed (Salthouse, 1985), combined with persistent age-related differences in performance under conditions in which time constraints are removed (Myerson et al., 1990), and when the age effects in measures of memory are not accounted for by differences in speed (Salthouse, Kausler, & Saults, 1988), do not permit simple conclusions to be drawn.
Examples of approaches that localise age deficits in more specific attributes of cognition identify a decline in attentional processes (Plude & Hoyer, 1985), working-memory capabilities (Baddeley, 1986), and discourse comprehension (Light & Albertson, 1988). In addition, greater susceptibility to various forms of interference and impairment in the ability to spontaneously generate semantic elaborations have also been identified as potential determinants of age-related deficits in cognition (Hashtroudi et al., 1989; Rabinowitz et al., 1982). However, determining reliable age effects in some of these attributes of cognition has been particularly difficult. For example, despite the fact that increased susceptibility to various forms of interference is one of the earliest hypotheses proposed to account for age-related deficits in cognition, no definitive conclusions can be drawn with respect to age-related differences in proactive and retroactive interference, because preservation and impairment have both been reported (Craik, 1986; Worden & Meggison, 1984).

The limited success in obtaining reliable age effects in some component processes of cognition may reflect the tendency to report age-related differences in memory in concert with differences in other cognitive variables (Hultsch et al., 1991); whereby the age-related variance in a variety of cognitive measures is shared rather than independent. Consequently, it has been argued that the causal factors responsible for the age-related differences in memory, and more generally in cognition, may be small in number (Salthouse, Hancock, Meinz, & Hambrick, 1996). However, this position is not yet supported by sufficient experimental work to warrant its’ application across multiple measures of cognitive function. It is equally plausible that the difficulty associated with the identification of specific factors and understanding their mode of operation is due to application of measures that are not sufficiently sensitive to measure the constructs of interest.

The following subsections represent a selective review of four dominant interpretations of age-related differences in cognition that have been applied to memory: (1) the selection and utilisation of strategies; (2) deficits in inhibitory mechanisms; (3) the decline in the ability to spontaneously engage in elaborative processing; and (4) differences in the ability to divide attention. Both the hypothesised deficits in inhibitory mechanisms and in the ability to divide attention have been interpreted within a more general framework, the limited processing resource account. Nevertheless, for the purposes of the present discussion, these two interpretations will be treated separately. Each of these four interpretations will be referred to in the later experimental chapters presented in this thesis.
3. Conscious and Unconscious Memory Processes and Ageing

3.2.1 Strategy Differences

The characterisation of age-related differences in cognition in terms of the ineffective selection and application of strategies has been applied to a variety of different cognition domains (Salthouse, 1991). Typically, a strategy is characterised as a method of performing a particular cognitive task. Four factors are intrinsic to this basic definition of a strategy (Salthouse, 1991): (1) strategies are specific to a particular task; (2) all individuals being compared are equally capable of executing the hypothesised strategies; (3) strategy differences have direct consequences for the performance on the task; and (4) orthogonal measures are available to determine strategy use and task performance. If only the frequency or spontaneity with which strategies are used by young and older adults differs then, it follows that age-related differences would be absent in a performance measure when both age groups are using the same strategy. Nevertheless, the attribution of a causal role for a strategy difference between young and older adults is only valid to the extent that these differences do not actually reflect another, more fundamental mechanism (Salthouse, 1991).

The first factor was proposed as a prerequisite for the distinction between strategies that are associated with a specific task and metacognitive processes associated with monitoring strategy selection. Clearly, if the second factor is violated, the particular performance measure will be inappropriate for a between subjects comparison. It is assumed that the selection and use of strategies will either reflect a general optimal method for deploying abilities, or a subject specific adaptation. The third factor is necessary in order to understand the output transformation between strategies and performance, whereas the fourth factor relates to the attribution of differences in output performance to veridical differences in the use of strategies. Several procedures have been developed for providing independent measures of strategy use in order to compare performance in young and older adults who use the same strategies (Salthouse & Prill, 1987). At present, the evidence is inconclusive with respect to strategy analyses because it has been difficult to localise age effects in memory at the level of age-related differences in task-appropriate strategies, since both qualitative and quantitative differences in performance should be obtained (Light, 1991). Nonetheless, potential sources of strategic differences in memory task performance will be identified in the following experimental chapters, in order to facilitate discussion of the age-related differences obtained in the experiments presented in this thesis.

A related issue involves the distinction between performance and competence. Competence represents the capability of an individual under 'optimal' condition of evaluation, whereas
performance represents the context-dependent capability of an individual. A corollary to this distinction is that a performance deficiency can potentially be ameliorated by providing appropriate tasks and conditions (Arbuckle, Vanderleck, Harsany, & Lapidus, 1990; Brigham & Pressley, 1988; Burke & Light, 1981). This distinction is particularly relevant for research that examines age-related differences, because a disproportionate effect of age on the difference between performance and competence can lead to an inadequate interpretation of the data. However, there is only minimal experimental work evaluating the magnitude of the performance-competence difference as a function of age (Salthouse, 1991). The performance-deficiency hypothesis has been most extensively articulated in terms of the putative age-related deficiency in the ability to spontaneously engage in semantic processing (Burke & Light, 1981). However, the experimental evidence is equivocal in this regard, because similar effects have been obtained in young and older adults following the provision of semantic as compared to perceptual encoding and retrieval cues (Rankin & Hinrichs, 1983).

3.2.2 Ageing and Inhibition

Inhibition is one of the primary constructs that has been applied to interpret age-related differences in the ability to retrieve information from memory (Hasher, Stolzfus, Zacks, & Rypma, 1991; Hasher & Zacks, 1988; Zacks & Hasher, 1994). Hasher and Zacks (1988) proposed an influential framework in which inhibition was characterised in terms of its operation within selective attention; selective attention was argued to be supported by activation and inhibition processes. Typically, activation processes are characterised as largely unconstrained as compared to the intentional, controlled nature of inhibitory processes (Hasher & Zacks, 1988; Houghton & Tipper, 1996). Further, attentional inhibitory based processes are argued to allow selection among response alternatives (Arbuthnott, 1995). Inhibition has also been characterised as a more theoretically neutral construct, which is not deterministic (Anderson & Bjork, 1994). The primary locus of age deficits in cognition are assumed to be within attentional inhibitory processes (Hasher & Zacks, 1988). However, the precise nature of the attentional inhibition mechanism, as it relates to the identification and suppression of items, has not been specified with sufficient precision (Arbuthnott, 1995).

In terms of the framework proposed by Hasher and colleagues, inhibition is argued to suppress the activation of irrelevant, or selected-against, information that can potentially enter working memory, information already present within working memory that is no longer relevant, as well as focusing
3. Conscious and Unconscious Memory Processes and Ageing

attention on previously rejected information (Hasher & Zacks, 1988; May, Kane, & Hasher, 1995). One prediction arising from this view is that there should be reduction in the capacity of working memory, resulting from the inability to sufficiently suppress irrelevant forms of processing (Engle, 1996; Stoltzfus, Hasher, & Zacks, 1996), which will, in turn, have a larger effect in older adults because of the diminished attentional capacity associated with ageing. In addition, these effects are argued to lead to increased processing time and reductions in the conscious retrieval of relevant information (Hasher & Zacks, 1988).

Several different sources of experimental work are consistent with the attentional inhibition framework proposed by Hasher and Zacks (1988). These include a wide variety of complex tasks that involve language comprehension, speech production, and working memory. For example, negative priming and susceptibility to interference from distracting text when reading are both impaired in older adults relative to young adults (e.g., Kane, Hasher, Stoltzfus, Zacks, & Connelly, 1994; for a review, see McDowd & Birren, 1990). However, Kramer and Larish (1996) failed to find age-related impairment in tasks such as negative priming, the Wisconsin Card Sorting Test (WCST), and the stopping paradigm (Logan, 1994). Nonetheless, Kramer and Larish (1996) did report an impairment in stopping an overt response and adopting new rules in a categorisation task. Kramer and Larish (1996) argued that the selective pattern of age deficits suggests that inhibitory processing does not undergo a diffuse decline in older adults; rather, the nature of the decline is better characterised in terms of selective deficits within a subset of inhibitory processes (see also, Arbuthnott, 1995; Arbuthnott & Campbell, in press; Dempster, 1992).

In contrast to the conceptualisation of inhibitory processes proposed by Hasher and Zacks (1988), Jacoby and his colleagues have characterised ageing in terms of a loss of conscious control, accompanied by a preservation of unconscious, automatic processing (Hay & Jacoby, 1996; Jennings & Jacoby, 1997). Within this account, the deficit in consciously controlled processes is assumed to reflect a primary impairment in executive control, as conceptualised within the central executive component of working memory (Baddeley & Hitch, 1974); whereas, Hasher and Zacks (1988) proposed that the deficit in executive control was a secondary consequence of a decline in inhibitory processes. The impairment in executive control is assumed to be expressed by an increased role for automatic, unconscious processes in older adults. In the following experimental chapters, both the inhibitory deficit and loss of conscious control accounts will be discussed in a variety of different experimental contexts.
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3.2.2.1 Ageing and Inhibition: Evidence from List and Item Method Directed Forgetting

The current section addresses the role of inhibitory processes that are assumed to operate within the item and list method directed forgetting paradigms. Only a limited amount of experimental work has been conducted to investigate the nature of the inhibitory mechanisms in directed forgetting as a function of age (see Chapters 7 and 8). The emerging research examining the effect of designating an item at study as either to-be-remembered (R) or to-be-forgotten (F) has been the subject of a number of reviews (Bjork, 1972; Bjork, 1989; Epstein, 1972; Johnston, 1994; MacLeod, 1998). As discussed in Chapter 1, several interpretations of the list method directed forgetting effect have been proposed, however the predominant mechanism is retrieval based inhibition (Basden & Basden, 1996; Basden & Basden, 1998; Basden et al., 1993). In addition, inhibitory based processes have also been implicated in the item method directed forgetting effect, however these are argued to operate to terminate the rehearsal of F cued items (Zacks & Hasher, 1994; Zacks et al., 1996). Two studies presented in this thesis investigated the relationship between behavioural intentions and inhibition in terms of the ability to operate according to the list method paradigm (Experiments 4 & 6).

The theoretical motivation for applying the item and list method paradigm was the ability of these paradigms to invoke inhibitory based processing. Accordingly, the experimental work conducted was designed to extend the understanding of age-related differences in inhibitory processes to directed forgetting associated with conscious and unconscious processes, as defined within category exemplar generation and perceptual-associative word stem completion memory tasks. In particular, utilising the item and list method directed forgetting paradigm enabled the evaluation of two assumptions within framework posited by Hasher and Zacks (1988): (1) inhibition serves to suppress no longer relevant information; and (2) inhibitory processing is impaired in older adults. A decline in the magnitude of the list-method directed forgetting effect in older adults would be consistent with the original proposal by Hasher and Zacks (1988) relating to these two assumptions.

More specifically, older adults may be less able to accurately encode and retrieve the R or F cue designation associated with each item, because of the generalised slowing associated with ageing and lapses in registering the cue designation (Zacks et al., 1996). However, the attentional demands that are likely to lead to such conditions may be more acute in the item method paradigm, but the difficulty with attributing an age-related deficit in the magnitude of the item method directed forgetting effect to impaired inhibitory processing is that this effect is also supported by the
differential rehearsal of R and F cued items. Therefore, it is necessary to disentangle the contribution of inhibition and differential rehearsal based processes to the item method directed forgetting effect (cf. Zacks et al., 1996). This issue will be expanded in the Chapters 7 and 8. Similarly, an attenuated list method directed forgetting effect in older adults can also be attributed, in part, to age deficits in memory for spatiotemporal contextual information (Craik & Jennings, 1992; Spencer & Raz, 1995), since it cannot simply be assumed that strategic differences do not exist between young and older adults in the manner in which the task is performed (for additional discussion of this issue, see Chapters 7 & 8). Further, memory for spatiotemporal contextual information is potentially a particularly significant mediating factor at longer study and test intervals, because the effort required to inhibit the rehearsal of F items will increase as a function of time (Zacks et al., 1996).

In summary, to the extent that the list method (and to a lesser extent the item method) directed forgetting effect is mediated by the inhibition of the F items, older adults would be expected to be less able to comply with the instructions associated with F cues, since as discussed, a variety of paradigms that invoke intentional inhibitory processes have provided evidence of a decline in older adults (for a review of such paradigms, see Zacks & Hasher, 1994). However, the magnitude of the effects that indicate impaired inhibitory processes, although significant, have been relatively small (Hamm & Hasher, 1992; Hartman & Hasher, 1991; Zacks et al., 1996), and it may be that these age effects are contingent, in part, on the nature of the inhibitory processes that are being invoked (Kramer, Humphrey, Larish, Logan, & Strayer, 1994).

3.2.3 Elaborative Processing and Ageing

Craik and his colleagues proposed an interpretation of age-related decline in memory in terms of the efficiency with which elaborative, or semantic, processing is spontaneously performed at encoding and at retrieval (Burke & Light, 1981; Craik, 1977; Craik & Simon, 1980). The locus of the deficit in elaborative processing is assumed to be a generalised impairment in the ability to engage in effortful processing (Craik & Jacoby, 1996), rather than within the automatic activation of associative pathways involved in semantic elaboration. However, the extant experimental evidence does not support the view that there are age-related differences in semantic activation, when examined using measure such as a comparison in the response latencies to targets preceded by related and unrelated primes (Light, 1991).
According to the elaboration-deficit hypothesis, the age-deficits are also predicted to be expressed in measures of context-specific encodings and in the ‘depth’ of encodings; and more indirectly, these deficits will be expressed in dependent measures of memory that are mediated by such encoding. However, the findings are inconclusive in relation to age-related differences in the context-specificity of encodings. For instance, Rabinowitz, Craik, Ackerman (1982) argued that older adults form canonical encodings that access the core meanings of words, rather than encode distinctive, context-specific information. This hypothesis was based on the absence of an association-specific memory effect for paired-associates in older adults, whereas in young adults, memory performance was found to be mediated by association-specific memory rather than by the pre-experimental semantic relatedness between paired-associates. However, other studies have demonstrated age-invariance in other forms of this task (Park, Puglisi, Smith, & Dudley, 1987; Puglisi et al., 1988).

One approach to resolving these apparent inconsistencies is to characterise the deficit in effortful rehearsal as a production deficiency. Accordingly, it is plausible to assume that a manipulation that effectively induces older adults to engage in elaborative processing would be expected to reduce age-related differences (Craik & Simon, 1980). Only encoding that fosters the unconstrained, self-generation of precise elaborators at encoding appears to facilitate memory performance in older adults (Hashtroudi et al., 1989). However, this evidence primarily focused on conceptually-based, semantic elaborative encoding. In relation to the perceptual-associative word stem completion task that was utilised in the experimental work presented in this thesis, the provision of a line drawing at encoding and retrieval that corresponded to the context word in each word pair may be sufficient to attenuate age-related differences in the estimates of perceptual-associative unconscious memory because of the reduction in effortful, perceptually-based elaborative processing. The hypothesised operations at encoding and retrieval that are engendered by this paradigm are discussed in the appropriate sections in the experimental chapters.

3.2.3.1 Elaborative Processing: Evidence from Item Method Directed Forgetting

The discussion in Chapter 1 and the foregoing subsection established that the item and list method directed forgetting paradigms represent a means for fostering a task environment that will be sensitive to age-related differences in attentional inhibition. Nonetheless, as discussed earlier, an additional mechanism has been proposed to account for the item method directed forgetting effect: the differential rehearsal of R and F items (Basden & Basden, 1996; Basden & Basden, 1998;
Basden et al., 1993). Accordingly, if it is assumed that the item method directed forgetting effect is mediated by differential rehearsal at encoding, evidence of an age-related decline in the magnitude of the item method directed forgetting effect would be consistent with the notion that ageing is associated with a deficiency in elaborative processing. However, as discussed earlier, the ability of older adults to adopt a differential rehearsal strategy is also determined by the selective inhibition of the rehearsal of F cued items, which is likely to be particularly demanding because of the item-by-item change in retrieval instruction (Zacks et al., 1996).

One potential approach to disentangling the contributions of retrieval inhibition and differential rehearsal is to vary the amount and type of item-specific, differential rehearsal conferred on R and F items. This can be achieved by varying the type and temporal location of rehearsal opportunities. Indeed, such manipulations have been shown to have a differential effect on the retrieval of R and F cued items (e.g., Hauselt, 1998; see also, Chapters 1, 7, & 8). For example, Gardiner et al. (1994) demonstrated that F and R cued items can be held in abeyance at encoding until the directed forgetting cue is provided, before undergoing differential rehearsal. In particular, varying the interval between the critical item and the onset of the cue allows the systematic variation in the length of time R and F items undergo maintenance rehearsal; and following cue onset, critical items undergo elaborative rehearsal, in accordance with the cue designation (Bjork, 1972). Therefore, this particular manipulation was utilised with the category exemplar generation task in order to try and disentangle the contribution of differential rehearsal and inhibition to the item method directed forgetting effect (Experiment 3).

3.2.4 Attention and Memory: Evidence from Divided Attention

The concept of attention as a processing resource that changes with age, and so determines the way in which certain cognitive processes operate has been espoused by several authors (Craik & Byrd, 1982; Hasher & Zacks, 1979; Plude & Hoyer, 1985). Central to several theoretical accounts of cognitive ageing is the assumption that conscious, recollective memory processes are dependent on attention at encoding, whereas unconscious memory processes are only minimally dependent on attention at encoding (Bentin, 1994; Besson, Fischler, Boaz, & Raney, 1992a; Jacoby et al., 1993b; Jacoby et al., 1989; Parkin & Russo, 1990; Shallice et al., 1994; Szymanski & Macleod, 1996). This view is also consistent with the more general notion that only controlled or effortful, rather than automatic, processes are dependent on the allocation of attention (Hasher & Zacks, 1979; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). As discussed in Chapter 1, this position is
referred to as the attentional view.

The notion proposed by Jacoby and colleagues (Jacoby, 1991; Jacoby et al., 1989; Jennings & Jacoby, 1993) that ageing only impairs consciously controlled processes appears to conflate attentional control with attentional resources, thereby limiting the ability to interpret instances when resource demanding processes, such as self-initiated retrieval, operate automatically (Craik et al., 1996). Under such conditions, the cognitive effort expended is observed as impaired performance on the secondary task, rather than in impaired memory task performance (Craik et al., 1996; cf. Femades & Moscovitch, 2000). However, the difficulty with distinguishing between resource demands and cognitive control is that it is not easily accommodated by single-resource theories of attention, and for other reasons that are outside the scope this discussion, the notion of a global pool of processing resources has been the subject of much debate (Hirst & Kalmar, 1987).

The attentional view has also been articulated in terms of a neuropsychological model. In particular, Moscovitch and colleagues proposed a neuropsychological, component-process model in which two components, an associative, automatic modular component and an intentional strategic ('frontal') component, interact to determine encoding and retrieval in direct memory tests (Femades & Mosovitch, 2000; Moscovitch, 1994a; Moscovitch & Winocur, 1995). The strategic component operates to direct attention to the information that represents the input to the modular system. Dividing attention at encoding decreases the likelihood that information will be encoded adequately by the modular system, leading to impaired memory (Bentin, Moscovitch, & Nirhod, 1998), because of the localised effect on the strategic component (Moscovitch, 1994a). Clearly, when this model is framed in terms of the ‘frontal lobe deficit’ account of ageing (West, 1996), a disproportionate impairment in older adults under conditions of divided attention would be predicted (Moscovitch & Winocur, 1995).

The second approach that can be adopted for interpreting the effects of divided attention at encoding on memory retrieval is the transfer appropriate processing view. According to this framework, divided attention at study is expected to reduce the amount of conceptually based processing, but have little or no effect on perceptual processing (Broadbent, 1971; Craik, 1983; Mulligan, 1998). Therefore, the effect of divided attention at encoding should only be observed with conceptual direct and indirect memory tests, and not perceptual direct and indirect memory tests (Mulligan, 1998). Combining this distinction between perceptual and conceptual processing with the process dissociation procedure raises an important question with respect to the attentional
requirements for encoding of semantic information. There is evidence for automatic semantic activation during the course of word identification (Carr, 1992; Neely, 1991), but word identification is also attention demanding because it involves the elaboration and integration of words within a spatiotemporal context (Bentin, 1994). In contrast, the context-invariant features of words are longer lasting and are encoded automatically (Bentin, 1994). The conceptual encoding involved in category exemplar generation is primarily mediated by context-dependent, rather than core, semantic features because less typical category exemplars are normally selected for use in this memory task. Clearly, there is a need for experimental work investigating the effect of divided attention on conceptual conscious and unconscious processes in order to provide a better understanding of the role of attention at encoding for subsequent memory retrieval, when the effect of contamination by conscious retrieval has been excluded.

Other explanatory frameworks such as the response bottleneck view have been proposed (Pashler, 1994), however these appear to able to account for only a subset of the divided attention and memory data. Briefly, processing bottlenecks are hypothesised to arise because some operations are mediated by a single mechanism that cannot be shared between two tasks. Thus, a switching strategy is necessary under these conditions, rather than the sharing of a mechanism, as would be the case in the attentional resource capacity model. However, the limited amount of data investigating this conceptualisation as a means for interpreting age-related differences in dual-task performance precludes an examination of its explanatory power. Further, given the serial nature of the divided attention task that was employed in the experimental work presented in the thesis, this model cannot be directly evaluated. Thus, the studies to be reported were conceived and planned to address the sometimes competing predictions of the attentional view and the transfer appropriate view; accordingly, the following subsection is described primarily in terms of these two views.

3.2.4.1 Divided Attention, Memory, and Ageing

Craik (1982) proposed that the effect of divided attention at encoding parallels the effects of ageing on memory (see also, Jacoby, 1991; Jacoby et al., 1989; Jennings & Jacoby, 1993). The primary approach for evaluating this proposition has involved age contrasts under a variety of dual task paradigms (as identified in Chapter 1); age-related impairment is typically obtained under dual task conditions (for a review, see Hartley, 1992). However, as discussed in Chapter 1, the effects of divided attention at encoding on subsequent memory performance are less consistent. Further, there is a continuing debate regarding the mechanism responsible for a larger negative effect of divided
attention in older adults. The dominant interpretation is the reduced attentional resource view proposed by Craik and colleagues (Craik, 1983; Craik & Byrd, 1982; Rabinowitz et al., 1982). Specifically, the age-related decrement in attentional resources impairs the ability of older adults to engage in the mnemonic operations that demand resources. Accordingly, there is a differential demand on the absolute level of attention resources available for young and older adults under the same dual-task conditions. Within this model, the demand on attentional resources can be reduced by providing a supportive environment for mnemonic operations (Craik, 1986).

The nature of the resource demand has also been characterised in terms of a complexity hypothesis, which is largely descriptive, rather than explanatory, in character. Specifically, McDowd and Craik (1988, p. 267) argued that ‘division of attention is one of several equivalent ways to increase overall task complexity’. An increase in task ‘difficulty’ or ‘complexity’ would be expected to impair older adults relative to young adults because of the greater demand on the absolute level of attentional resources available for older adults (e.g., Crossley & Hiscock, 1992; Park et al., 1989; Salthouse et al., 1984). However, the hypothesis appears to be insufficient because large age-related differences have also been obtained in less complex, rather than more complex, tasks (Crossley & Hiscock, 1992; Rogers, Bertus, & Gilbert, 1994). Further, the presence of selective, rather than general, age-related differences in dual-task performance, such as an age-related difference in the effect of divided attention on a direct test but not on an indirect memory test (e.g., Light et al., 1999), cannot be accommodated within the hypothesis.

Cognitive resources have also been conceptualised in terms of working memory capacity (Baddeley & Hitch, 1974; Craik, 1977) and the rate of performing different mental operations (Cerella, 1985). Accordingly, age-related deficits have been obtained in dual-task paradigms that have a large working memory component, because it is argued that older adults have an impairment in the central executive component of working memory (Park et al., 1989). In addition, Wickens (1992) suggested that the age-related difference in dual task performance was determined by the extent to which each task is mediated by the same processing resources. However, this account has not been evaluated systematically, but it is nonetheless able to generate specific predictions regarding the nature of the interactions between resources and age. For the purposes of the experimental work presented in this thesis, the use of the divided attention manipulation applied by Mulligan (1997), whereby a digit-letter sequence is retained in short-term memory whilst concurrently performing an encoding task, is likely to cause substantial interference effects at encoding because both the primary and secondary task are mediated by the similar processing resources.
Difficulties with the resource metaphor have been identified both in terms of the methodology (Navon, 1984) and the limited domain of dual-task performance effects that can be accommodated (Hirst & Kalmar, 1987; Pashler, 1994). As a consequence, it has been necessary to propose alternative non-resource accounts to explain dual-task decrements in older adults. One such account locates the source of age deficits in outcome conflicts between parallel processes that arise because the same operations mediate both the primary and secondary tasks (Hirst & Kalmar, 1987; Korteling, 1994; Navon, 1984). The advantage of this conceptualisation is that a precise specification of the component processes that mediate performance is provided (Hirst & Kalmar, 1987). Another, related proceduralist account emphasises the difficulty older adults have coordinating multiple tasks (Korteling, 1991); that is, older adults lack attentional flexibility or control. One source of evidence that supports this hypothesis is that older adults are impaired relative to young adults when they are required to adopt a rapid, strategic switching strategy between the primary and secondary task (Korteling, 1991; McDowd, Vercruyseen, & Birren, 1991). However, this explanation is only pertinent when attentional flexibility is required on a trial-by-trial basis, rather than when strategic switching is block wise (Kramer & Larish, 1996). Experiments 1 and 2 employed a trial-by-trial manipulation of attentional load, therefore this protocol may expose age-deficits present in attentional flexibility.

In this thesis, the focus of the two experiments on memory, attention and ageing were limited to the effects of divided attention at encoding, namely: (1) the extent to which the encoding of conceptual conscious and unconscious information, as defined by category exemplar generation paradigm, is disrupted by a varying attentional load secondary task was investigated (Experiment 1); and (2) the extent to which conscious and unconscious processes that support the acquisition of unrelated word pairs under perceptual encoding instructions, defined by the perceptual-associative word stem completion task, was investigated as a function of the varying attentional load manipulation (Experiment 2). If older adults are able to exercise equivalent control at encoding as young adults under conditions of divided attention (as measured by the accuracy data obtained in the recollection of 3- and 5-item digit-letter strings), it will still be of interest to determine the pattern of effects relating to the content of conscious and unconscious information as a function of age and divided attention by contrasting the findings from the two experiments.

3.2.4.1.1 Summary

Explicating the role of mechanisms such as multiple resources, output conflict and bottleneck
accounts has been limited by a lack of experimental work in relation to ageing. These accounts differ in the manner in which processing resources are allocated to the primary and secondary task: in capacity accounts resources are allocated in a divided or graded manner, whereas in the bottleneck account resources are allocated in a binary, all-or-none fashion. Further, age effects may reside in the ability to switch between strategies or in the ability to utilise one or both of the strategies for performing the task.

3.3 Explicit-Implicit Memory: A Developing Theoretical Framework

The review of experimental work investigating the explicit-implicit taxonomy of memory provided in Chapter 1 highlighted the difficulty in providing an unequivocal localisation of age effects within each form of memory (cf. La Voie & Light, 1994; Light & La Voie, 1993b). Nonetheless, it does appear that age-related differences in memory are reduced when performance is mediated by automatic, unconscious processes (Dywan & Jacoby, 1990; Jacoby et al., 1993b), and when the environment support is high (Craik, 1986; Craik & McDowd, 1987). Hay and Jacoby (1996) argued that instances in which performance was mediated by unconscious processes reflected strong stimulus-response links of the form found in 'hardwired' functions or habitual responses. In contrast, age-related differences are expected to be greatest when memory performance is mediated by self-initiated, conscious processes because of the greater burden on cognitive resources.

Before articulating the theoretical issues that relate specifically to age-related differences in conscious and unconscious memory processes, a discussion of the theories that have been proposed to explain the cognitive architecture of explicit and implicit memory is necessary, since many of the issues addressed in the experimental chapters are based on this theoretical work. The discussion will be limited to the domain of theoretical work that attempts to explain the phenomenon of verbal priming. In this regard, four principal categories of theory can be identified, each of which concentrates on how the distinction between explicit and implicit memory can be conceptualised: (1) multiple independent memory systems (Moscovitch et al., 1993; Schacter, 1994b; Squire, 1994); (2) transfer appropriate processing framework, represented by multiple dichotomous process distinctions (Blaxton, 1989; Roediger, 1990b); (3) components-of-processing framework (Johnson, 1983; Tenpenny & Shoben, 1992; Witherspoon & Moscovitch, 1989); and (4), post-perceptual selection accounts (Masson & MacLeod, 1996; Ratcliff & McKoon, 1997; Ratcliff, McKoon, & Verwoerd, 1989).
At a basal level, the multiple memory system framework is modelled in terms of the ontology and emergent properties of neurological structures that give rise to memory (Schacter, 1992b), rather than as a primarily epistemological explanation of the mechanisms that mediate memory based information processing (Bower, 1996). The multiple memory systems framework represents a formalisation of the task dissociation approach for studying memory within a structural, cognitive neuroscientific perspective, where a dissociation between memory tasks is interpreted as evidence of discrete ‘Fodor-type’ memory systems with dissociable neural correlates. Each empirically independent memory system, of which at least four are widely recognised (Schacter & Tulving, 1994b), is characterised by distinct properties and attributes. In contrast, the transfer appropriate processing framework is derived from hypothesised mental procedures, such as levels of processing and perceptual and conceptual processing (Blaxton, 1989; Craik & Lockhart, 1972; Roediger, 1990b). The component-of-processing framework identifies the processes that mediate task performance, which are determined by an analysis of the nature of the task and the strategies that are adopted (Johnson, 1983; Moscovitch, 1994b; Tenpenny & Shoben, 1992; Witherspoon & Moscovitch, 1989). The components-of-processing processing framework developed tangentially from the processing dichotomies based on the transfer appropriate processing framework. The most recent development has been the post-perceptual selection theories that locate repetition priming effects at the level of bias effects that occur in response selection (Light & Kennison, 1996a; but see, Light & Kennison, 1996b; e.g., McKoon & Ratcliff, 1996; Ratcliff & McKoon, 1997).

Three of these four primary theoretical approaches are described in the following subsections. The process and multiple memory systems approaches are not mutually exclusive approaches to the explicit-implicit memory distinction (Hayman & Tulving, 1989a; Tulving, 1999), since a degree of convergence is inevitable (Kelley & Lindsay, 1996). Further, the dialogue between proponents of these two approaches should not be characterised as that between multiple memory systems and a unitary mnemonic system (Foster & Jelicic, 1999; Masson & Graf, 1993; cf. Tulving, 1999). Therefore, a levelling treatment is not required for the integration of process and system approaches. Post-perceptual selection theories are not addressed because they do not have a direct bearing on the experimental work included in this thesis, and these theories are at present under specified, and are not yet able to account for a large domain of the data in implicit memory. In addition, the forced-choice cueing procedure adopted to evaluate this class of theory may be responsible for the bias effects reported by the advocates of this theory (Masson & MacLeod, 1996; Ratcliff & McKoon, 1997), and also may contaminate indirect tests with conscious processes because the explicit choice component is not present in the canonical form of indirect memory tests.
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(see also, Bowers, 1999; Light & Kennison, 1996b; but see, McKoon & Ratcliff, 1996). Thus, a detailed treatise of the post-perceptual selection theories is beyond the scope of the present chapter.

The multiple memory systems view will be discussed first, with emphasis given to the perceptual representation system (Tulving & Schacter, 1990), posited to mediate perceptual item-specific priming, and the recently proposed conceptual representation system (Gabrieli, 1999), posited to subserve conceptual item-specific priming. The process approaches represent a collection of dichotic distinctions between types of processing; each of these will be examined individually, with particular emphasis given to accounts that are directly relevant to experimental work presented in this thesis. Finally, the components-of-processing approach will be discussed, since this approach represents an important rapprochement between the process and system approaches. However, it will eventually be necessary to specify an intermediate, more specific neural network based accounts in which the operation of distinct, interlocked brain processes operate as a functional system.

3.3.1 Multiple Memory Systems: Mechanisms of Explicit and Implicit Memory

The multiple memory systems approach is designed to relate performance on a behavioural task to the underlying neural structures and processes, in order to provide a detailed morphology of memory. However, a general criticism of this approach is that the functional relation between task demands and prior encoding does not really represent a substantive unit of analysis on which to base a theoretical framework that seeks to explain the neural substrate of memory, nor is it sufficient to provide empirical falsification or confirmation of discrete memory systems (Ratcliff & McKoon, 1996; Toth & Hunt, 1999; Weldon, 1999). Specifically, these functional categories of description are not isomorphic with the neural structures that are inferred from them (Luria, 1973). A further difficulty with using memory tasks as the unit of analysis (as extensively discussed in Chapter 2) is that they can be performed in multiple ways, since each instance of a particular response can reflect a quite different instantiation of processes (Tulving, 1985c).

An additional failing of this class of approach is that it is sometimes unclear whether the postulated memory systems represent a taxonomic classification of memory, a descriptive construct, or a formal theory (Eichenbaum, 1994; Nadel, 1994). This may, in part, reflect the fact that the mechanisms that mediate memory and other forms of cognitive processing are often assumed to be independent at every level, which excludes the occurrence of a shared mechanism between other...
cognitive processes and other memory systems. Nonetheless, none of these concerns are restricted to the multiple memory systems approach, since they are also equally relevant to the interpretation of task performance within process accounts.

3.3.1.1 Memory Architecture: Structural Dichotomy

Most of the current memory system proposals have their origins in two principal dichotomies: (1) episodic and semantic memory (Tulving, 1972; Tulving, 1983; Tulving, 1985a); and, (2) declarative and procedural memory (Cohen, 1984; Cohen & Squire, 1980; Squire, 1987). Both of these dichotomies have included specific statements about the relation between states of consciousness, performance, and intentionality. For example, Tulving (1985a) fractionated consciousness to create a taxonomy that corresponded to the multiple memory systems within the framework; therefore, consciousness is not conceptualised within a unitary system (cf. Schacter, 1989; Schacter, 1990). In particular, procedural memory is not amenable to conscious reflection (anoetic consciousness), whereas episodic memory was argued to be supported by autonoetic (self-referential) consciousness, which is the basis for the phenomenological experience associated with recollection. Declarative memory has been characterised as a store of factual knowledge and events that can be consciously retrieved and the output verbalised (Cohen, 1984; Cohen & Squire, 1980; Squire, 1987). The parallels with episodic and semantic memory led to the reconceptualisation of these memory systems as subsystems of declarative memory (Schacter & Tulving, 1994a; Squire, 1994). Nondeclarative memory is largely equivalent to procedural memory in Tulving's scheme, because it cannot be accessed consciously and the output cannot be verbalised, and contains the skills and rules that guide the processing of declarative memory. The distinction between explicit and implicit memory has also been explicitly stated as co-extensive with that between declarative and procedural memory (Squire, 1994). Nevertheless, the declarative-nondeclarative distinction differs from the model of memory proposed by Tulving (1985a) principally in terms of the parallel operation of the declarative-nondeclarative memory systems, as opposed to the serial interaction between episodic, semantic and procedural memory.

In order to account for dissociations between tasks such as cued recall and free recall and within tasks such as word fragment completion that supposedly belong to the same memory system (Blaxton, 1989; Hayman & Jacoby, 1989; Ratcliff & McKoon, 1996), one solution has been to further fractionate the memory system under investigation. For example, procedural memory has been fractionated in order to enable the specification of tasks within four subsystems (Squire,
1987): (1) simple associative learning; (2) non-associative forms of learning such as habituation and sensitisation; (3) skills and habits; and, (4) the perceptual representation systems (PRS) responsible for priming, consisting of a collection of pre-semantic subsystems used in the perception of objects and words (Schacter & Tulving, 1994b; Squire, 1994). An alternative approach to within-system dissociations has been to decompose task performance into the multiple memory systems engaged by the task, which is embodied in the concept of co-determination introduced by Tulving (1991).

Obviously, some of the informational processing demands and supporting neural circuitry will be common to memory tasks. For example, distributed, overlapping patterns of neural activation that are both shared and distinct among tasks are often reported across functional neuroimaging studies (cf. Sherry & Schacter, 1987). In such instances, a processing, or a components-of-processing view, in which neural processes are assembled online, is more consistent with the data, since it is the neural implementation that varies between memory tasks such as recall and recognition (Cabeza et al., 1997), rather than the memory system.

Considerable attention has been focused on the PRS, which is a subsystem of a more general presemantic representation system (Tulving & Schacter, 1990). The information represented in the PRS is assumed to be independent of associative and functional properties, and access is hyperspecific (inflexible) because the PRS does not contain abstract focal traces. Specifically, the PRS contains a multitude of distributed representations, which includes the visual word form system that mediates item priming effects for written words, the structural representation systems for objects, and the auditory word form system for spoken words (Schacter & Church, 1992).

However, several difficulties have arisen that cannot be easily accommodated within the PRS model. For example, evidence of residual perceptual priming in young and older adults following a modality change violates the property of hyperspecificity attributed to the PRS (Light et al., 1992). Also, the pre-semantic nature of the PRS implies that conceptual processing should not affect performance mediated by PRS, however there is considerable evidence against this assumption (e.g., McCauley et al., 1996).

A more fundamental problem is that conceptual priming is argued to depend on the modification or addition of new information to semantic memory, since it is assumed to be equivalent to semantic priming. However, there are multiple sources of evidence suggesting that conceptual priming is functionally, and potentially neuroanatomically, distinct from semantic memory and from perceptual item-specific priming (Blaxton et al., 1996; Fleischman et al., 1995; Gabrieli et al., 1994; Gabrieli et al., 1996c). Accordingly, Gabrieli (1999) proposed a conceptual representation system.
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(CRS) that operates to represent a current state of structure and content for conceptual knowledge, and is responsible for the conceptual priming effects obtained in tasks such as category exemplar generation. Alternatively, the PRS could be modified to include higher-order conceptual processes (McCauley et al., 1996), or argued to interact with declarative knowledge modules that support semantic information (Rybash, 1996).

It is not clear whether the PRS or CRS can be extended to account for the acquisition and retention of new associations. The difficulty with the processing of associative information within a system designed to deal with presemantic structural information is that such information can be either structural or semantic. More generally, there appears to be little separation between item-specific and association-specific priming in most of the multiple memory systems accounts, despite the importance of this distinction in the basic experimental work (cf. Rybash, 1996). This is a symptom of the tendency of the multiple memory systems approach to be based on general, rather than specific task analyses (cf. Moscovitch, 1994b). Typically, the multiple memory systems approach does not provide sufficient detail to predict the performance of specific tasks under specific experimental conditions. Future development in this regard may come from the specification of functionally incompatible, content specific memory systems, the most prominent of which are knowledge modules that represent unitised information; for example, conceptual, spatial, and facial modules that feed into a central consciousness system (Moscovitch, 1992a; Rybash, 1996). At present, this approach is limited to a descriptive level of specification when related to the explicit-implicit memory distinction, because it is not clear how to extend the conceptualisation to explain the manner in which different informational content is expressed in the neural correlates that correspond to explicit and implicit memory.

From the perspective of ageing, it is an oversimplification to argue that any particular memory system is wholly spared or impaired in older adults. Nonetheless, there are several implications that arise from the memory architecture proposed by Tulving. For example, differential age-related sensitivity is predicted, with more specialised systems being the most affected by factors detrimental to memory. Thus, any negative effects of ageing should be selective rather than diffuse, having the greatest impact on episodic memory and the least on procedural memory. Consistent with this view, Mitchell (1993; 1990) argued that only episodic memory is impaired in old age, whereas both semantic and procedural memory are intact. However, the evidence is not entirely consistent with this position. It is not clear that tasks supported by semantic memory are entirely preserved or that all aspects of episodic memory are impaired in old age (Light & Burke, 1988).
relation to the distinction between declarative and nondeclarative memory, it has been argued that older adults acquire nondeclarative representations as rapidly as young adults, but they are poor at acquiring declarative knowledge (Squire, 1992a). However, this position fails to explain why older adults find it more difficult to learn declarative as opposed to procedural knowledge. Further, in a review of memory and ageing research, the four forms of nondeclarative memory were not all found to be spared in old age (Light, 1991).

3.3.2 Process Approaches

The intrinsic concept that underscores the majority of process approaches is the transfer appropriate processing framework, discussed in Chapter 1. This view is also embodied by the proceduralist views that emphasise the role of the operations and activities engaged at encoding and retrieval in order to define the memory acquired (Kolers, 1973; Kolers & Roediger, 1984), and by the encoding specificity hypothesis proposed by Tulving (1973). All of these process approaches are predicated on the notion that memorial activity involves processes (Roediger, 1990b), procedures (Kolers, 1973; Kolers & Roediger, 1984), or records (Kirsner & Dunn, 1985) that can be accessed at a later time. However, these approaches, like the multiple memory systems framework, suffer from the problem of being rather vague in terms of the level of theoretical specification, since the principles of function, rather than the precise specification of the causal sequences of mechanisms and procedures responsible for task performance, have been formulated (Brent, 1984; Toth & Hunt, 1999).

The application of process approaches to understanding age-related differences typically involves seeking differences in the types of processing operations carried out on encoded events, in the extent to which context influences the specificity of encoding, and in the ability to recapitulate original processing operations at the time of retrieval. This overall approach is embodied within two dominant processing dichotomies: perceptual versus conceptual processing and self-initiated versus environmental support. Each of these will be addressed in the following subsections. In addition, the distinction between activation and elaboration based processes and the components-of-processing view will be discussed.

3.3.2.1 Transfer Appropriate Processing: Perceptual versus Conceptual Processes

One of the most widely applied dichotomic processing contrasts is that between perceptual and
conceptual processing, which originates from research conducted in the reading literature (McClelland & Rumelhart, 1981), and has been extended to memory processing (Blaxton, 1989; Jacoby, 1983b; Roediger, 1990b; Roediger et al., 1989b). There is also now evidence of the functionally distinct neurological structures that subserve perceptual and conceptual memory processes (Blaxton et al., 1996; Gabrieli et al., 1994; Schacter, 1994a). In particular, cognitive neuroimaging has revealed that perceptual priming of verbal materials is correlated with activity in the visual regions of the occipital cortex and left frontal cortex, whereas the neural correlates of conceptual priming appear to be located in the left frontal and temporal-parietal cortical regions (Blaxton et al., 1996; Gabrieli et al., 1996a; for a review, see Schacter & Buckner, 1998). Similarly, neurological dissociations have been obtained in adults diagnosed with Alzheimer’s disease, since evidence of preserved perceptual priming but impaired conceptual priming has been reported (for a review, see Fleischman & Gabrieli, 1998; Monti et al., 1996; Russo & Spinnler, 1994).

Despite the relative success of the basic four-cell process-based framework that was described in Chapter 1, violations have been obtained that highlight two basic difficulties with the framework: (1) the lack of a consistent taxonomy classifying memory tasks as perceptually or conceptually driven; and (2) the difficulty in measuring these processes without confounding the findings with differences in retrieval intentionality. For example, associative word stem completion is argued by some to require semantic elaboration at encoding, as would be expected if it were a conceptually driven task (Srinivas & Roediger, 1990), although this is certainly not universally accepted (Light et al., 1995; Reingold & Goshen-Gottstein, 1996a; Reingold & Goshen-Gottstein, 1996b). These issues will need clarification if progress is to be made. In this regard, the experimental work presented in the thesis that evaluated age-related differences in perceptual-associative word stem completion applied two variables, divided attention and item method directed forgetting, in order to provide additional data concerning the functional properties associated with this form of memory for new associations.

Additional assumptions may be necessary to increase the inductive power of the perceptual-conceptual processing distinction. For example, it has been argued that perceptual priming is supported by dissociable form-specific and modality-specific processes (Gabrieli, Fleischman, Keane, Reminger, & Morrell, 1995; Tulving & Schacter, 1990), whereas multiple, dissociable forms of conceptual unconscious processes may mediate performance on conceptual indirect memory tests (Cabeza, 1994; Vaidya et al., 1997; Vriezen, Moscovitch, & Bellos, 1995; Woltz,
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1996). For example, Vaidya et al. (1997) proposed a largely descriptive model of two dissociable routes to the retrieval of conceptual information dependent on whether or not the conceptual retrieval cue instantiates competitive and non-competitive memorial access. Competitive access refers to the relatively unconstrained retrieval processes instantiated when alternatives compete in response to a retrieval cue, whereas non-competitive access refers to the retrieval of a single semantic entry because the relevant item is directly activated. Further, it was argued that only those conceptual memory tasks that instantiate competitive access are sensitive to conceptual elaboration and divided attention. Accordingly, given that category exemplar generation fosters the competitive retrieval of items, an effect of divided attention would be predicted by this model. The experiment reported in Chapter 6 directly addressed this issue.

For the present purposes, the relation between the perceptual-conceptual distinction and conscious-unconscious processes is also of particular relevance. As discussed in Chapters 1 and 2, the relation between the ‘content’ of mnemonic processes and conscious and unconscious processes has been characterised as orthogonal (Jacoby, 1996; Jacoby et al., 1997b). However, the attribution of a greater role for conceptual processes in direct memory tests relative to indirect memory tests, independent of the informational demands of the test cues (Craik et al., 1994; Roediger, Weldon, Stadler, & Riegler, 1992; Weldon, Roediger, Beitel, & Johnston, 1995), is not able to account for dissociations between conceptual direct and indirect memory tests in any simple manner. By extension, although a role for perceptual processing in indirect memory tests has been established, the specification of how indirect memory tests utilise conceptually based information is less clear (Challis & Brodbeck, 1992).

In addition to the availability of consciousness, a criterial feature separating the nature of the information that supports direct and indirect memory tests is the availability of the spatiotemporal context in which an item occurred (Bower, 1996; Jacoby & Hollingshead, 1990). This condition is able to account for the effects of divided attention (Mulligan, 1998). Specifically, there is substantial evidence to suggest that divided attention disrupts conceptual and contextual encoding (Cowan, 1995; Craik, 1989; Rabinowitz et al., 1982), rather than perceptual processes. Therefore, an effect of divided attention on perceptual and conceptual direct memory tests would be predicted, because these tests are supported by contextual encoding. Similarly, conceptual direct and indirect memory tests would be expected to be impaired by divided attention because these tests are mediated by conceptual processing (cf. with the attentional view). Nonetheless, the preponderance of dissociations along the direct-indirect task distinction, rather than the perceptual-conceptual
processing distinction (Roediger, 1990a), demonstrates the importance of determining the nature of perceptually- and conceptually-driven processing, since the utility of the distinction will be, in part, dependent on understanding the context-dependent nature of these processes (cf. Craik, 1991; Kolers, 1975).

Specific predictions emerge from the converging operations provided by the perceptual and conceptual processing dichotomy in relation to ageing. For example, conceptual rather than perceptual processing is expected to be impaired in old age (Rabbitt, 1979; Rabbitt, 1982; Rybash, 1996, see also Chapter 1). Understanding the dissociations in performance in older adults as a function of direct and indirect memory tests will reflect, at a minimum, the interaction between the perceptual-conceptual and the conscious-unconscious processing dichotomies, rather than that between conscious and unconscious retrieval alone. As will become apparent shortly, it is in the context of the environmental support hypothesis that the conceptual-perceptual processing distinction has been most clearly applied to ageing and memory.

3.3.2.2 Environmental Support Hypothesis

The environmental support hypothesis refers to two variables that determine the amount of information available at encoding and retrieval. The first, refers to the effects of context afforded by the memory environment, termed environmental support, and the second, the need for self-initiated, constructive operations (Craik, 1983; Craik & Byrd, 1982). The locus of age-related deficits in memory is assumed to be in self-initiated operations (Craik, 1983; Craik, 1986). In the original account, these two factors were originally considered to be negatively correlated (Craik, 1986; Craik & McDowd, 1987), therefore deficiencies in self-initiated processing could be compensated for by increasing the available environmental support. Accordingly, age-related differences in memory will be pronounced on memory tasks such as free recall that require self-initiated operations and offer little environmental support for retrieval, whereas age-related differences should be minimal on tasks that provide substantial environmental support such as perceptual identification (Craik, 1986; Craik & McDowd, 1987). In addition, older adults are expected to benefit to a greater extent than young adults from an increase in environmental support (Craik, 1983).

There are studies showing the amelioration of age-related differences when environmental support is increased, however there are also a number of studies reporting either equal or stronger
improvements following increased environmental support in young adults relative to older adults (Craik & Jennings, 1992; Light, 1991; Park & Shaw, 1992). In the original proposal, Craik (1983; 1986) argued that the effect of environmental support was limited to the effects of context on conscious recollection; however more recent accounts have proposed that environmental support also modulates the amount of automatic, ‘habitual’ processes (Jacoby, 1994). This is a necessary addition to the original hypothesis in order to account for evidence of equivalent age effects in young and older adults, since this may reflect automatic influences, whereas greater enhancement may reflect the operation of consciously mediated processing that occurs in young adults when environmental support is impoverished (Craik, 1992).

It is possible to hold environmental support constant across tasks while varying the processing requirements of the memory tests. For example, the test cue constraint imposed by the retrieval intentionality criterion would be expected to equate the amount of environment support across direct and indirect memory tests (Schacter et al., 1989), locating the primary difference between the memory tasks at the level of self-initiated operations. Under these conditions, age effects reflect differences in the ability to engage the necessary self-initiated operations, which are presumed to be due to the demanding and effortful nature of this form of processing exceeding the limited processing resources available in older adults. However, Light (1991) argued that primary mediating factor that accounts for the dissociation between direct and indirect memory tests as a function of age is the process of deliberate recollection, because recollection based remembering also involves the retrieval of the original spatiotemporal context, which is more demanding for older adults than young adults (Spencer & Raz, 1995).

The distinction between environmental support and self-initiated processing can also be reconceptualised in terms of the distinction between perceptual and conceptual processing: performance in conceptual indirect memory tests should be affected by ageing to a greater extent than performance in perceptual indirect memory tests, whereas performance in conceptual direct and indirect memory tests should be largely equivalent. Further, a category verification task should offer more environmental support than a category exemplar generation task (cf. Light & La Voie, 1993b), because the dependent measure is the decision time to categorise an exemplar as a member of a particular category, which is presented as the retrieval cue. However, thus far, age differences, if any, do not appear to be in evidence to a greater extent for the conceptual priming in the category exemplar generation task (Light et al., 1999, see also, Chapters 5 & 7).
Evidence for the environmental support hypothesis is equivocal. Nevertheless, larger differences are found on tasks that demand certain kinds of self-initiated constructive operations, namely, conscious recollection or the provision of multiple completions in response to a single retrieval cue. However, this does not provide any information on the nature of the processes associated with conscious recollection.

3.3.3.3 Activation and Elaboration Processes: Item-Specific and Association-Specific Representations

According to the activation-elaboration processing distinction, two mechanisms contribute to stimulus encoding: one based on activation, or perceptual-fluency, and one based on elaborations between events experienced together, or between these events and the context in which they occur (e.g., Gillund & Schiffrin, 1984; Humphreys, Bain, & Pike, 1989; Mandler, 1980). Activation and elaboration are assumed to occur in parallel when two mental representations first become related (Graf & Mandler, 1984; cf. Phaf & Wolters, 1996). Activation processes reflect the automatic, unconscious activation that spreads along associative pathways of existing representations corresponding to the stimulus presented. In contrast, elaboration processes are attention demanding, accompanied by conscious awareness, and are involved in encoding inter-stimulus relations and stimulus-context associations. All of these functional properties are a necessary prerequisite for explicit memory.

More recently, Phaf and Wolters (1996) proposed that activation causes long lasting strengthening of the existing intra-item associations, which is sufficient to support repetition priming because faster access and response generation is available when the same stimulus is re-presented. The strengthening of the intra-item associations is restricted though, which accounts for the rapid, asymptotic acquisition of priming. In addition, activation processes have been characterised as capable of initiating a complete processing route that preserves specific stimulus and encoding characteristics (Masson & MacLeod, 1992). In contrast, once the slower, elaborative processes begin to operate, a more complex, distinctive representation of novel associations among stimuli, other existing knowledge, and the spatiotemporal context of stimulus presentation is created. In relation to ageing, the hypothesised deficits in elaborative processing are argued to be manifested in tasks that involve the retrieval of spatiotemporal contextual information, such as source monitoring and intentional recollection (Craik & Jennings, 1992; Spencer & Raz, 1995). In contrast, the relative sparing of item-specific priming in old age may support the contention that activation processes are
However, the activation-elaboration distinction cannot account for the priming of new associations for which there are no pre-existing memory representations; additional operations need to be posited to deal with the formation of new representations. For instance, activation is said to involve unitisation of newly juxtaposed elements. Unitisation may occur either as a result of perceiving coherence among individual stimulus elements, as dictated by Gestalt principles of perception, or as a consequence of elaborative processing during encoding. Unitisation of previously associated items can occur fairly automatically, but unitisation of unrelated word pairs does not take place automatically because mere conjunction of the words at encoding is not sufficient to support associative priming (see Chapter 1). Therefore, elaborative processing is assumed to be necessary to establish the new connections tapped by associative priming tasks. However, it was argued in Chapter 1 that it is possible to obtain associative priming in young adults and patient populations when the dependent measure is perceptual identification under conditions that do not encourage semantic elaborative encoding, since encouraging perceptual encoding appears to be sufficient (Gabrieli et al., 1997a; Moscovitch et al., 1986; Musen & Squire, 1993; Paller & Mayes, 1994). However, this has not been demonstrated for associative priming in an associative word stem completion task, in either patient populations or older adults (for exceptions to the latter, see Experiments 2, 5, & 6).

In addition, there is evidence for a more consistent age-related deficit in association-specific priming as compared to item-specific priming (see Chapter 1). This differential sensitivity has been attributed to the larger role that conceptual, elaborative processing plays in association-specific priming relative to item-specific priming (Craik et al., 1994). However, it is plausible to assume that associative priming mediated by perceptual, elaborative processing may be age-invariant, although, it remains to be specified why one form of these processes should be age sensitive and the other preserved. This had led to the development of a distinction between acquisition and modification mechanisms (as conceptualised by Bowers, 1994). Acquisition mechanisms are hypothesised to construct novel memory representations from events that have been encoded. In contrast, modification mechanisms involve the above baseline activation or modification of established mnemonic representations, and are therefore assumed to support item priming (Bowers, 1994; Graf & Mandler, 1984; Mandler, 1980; Morton, 1979). A concept common to all modification accounts is that implicit memory should be limited to paradigms that access pre-existing representations, although other forms of modification are thought to be possible (Burt & Humphreys, 1993).
Findings demonstrating priming of both new associations (Howard et al., 1991) and nonwords (Light et al., 1995) in young and older adults, have been integrated within revised versions of the modification mechanism account (Bowers, 1994; Dorfman, 1994). Specifically, the priming of nonwords is assumed to operate on the word-like, letter grouping by the modification of familiar sublexical representations. However, there are several data sets that cannot be easily accommodated in this form of modification mechanism. For example, one implication of the modality specific nature of perceptual priming is that implicit memory is dependent on novel traces of individual hyperspecific events, rather than on the modification of abstract amodal units (but see, Coltheart, 1989). Further, the theoretical implications of the priming of new associations between unrelated word pairs are sufficiently important that modification theories of priming have undergone decline, because in order to explain the priming of new associations there is a need to posit additional mechanisms that go beyond the access of established mnemonic representations. More generally, the progressive deterioration of the conceptual distinction between activation and elaboration processes has led to rapprochement with the transfer appropriate processing framework (Roediger & McDermott, 1993).

3.3.2.3 Components-of-Processing Approach

Proponents of the components-of-processing approach argue that it represents the most effective method for providing convergence between the multiple memory systems and processing frameworks, since the nature of the processes that mediate performance on a memory task are combined with an understanding of the neural correlates of these processes (Roediger et al., 1999). At the task level, it has been proposed that the components-of-processing are assembled online in an interactive process. However, only a partial specification of the component-processes that comprise memory tasks has been achieved, since this requires considerable information regarding the functional nature of these processes, their relative significance, and the interaction between the processes. Nonetheless, the fractionation of components-of-processing that are hypothesised to support memory tasks performance has received support from neuroimaging studies. For example, tasks mediated by the activation of presemantic representations of words and objects are correlated with neural activity in posterior cortical areas such as the extrastriate occipital cortex (Fleischman et al., 1995; Gabrieli et al., 1995; Schacter, 1994b), whereas priming tasks mediated by access to semantic information are correlated with neural activity in more anterior neural regions in the temporal-parietal cortex (Gabrieli et al., 1994).
The component processes are typically conceptualised as modules that operate as computational devices applying propositional content. In addition, three properties are often attributed to the modules, which are derived from the proposal by Fodor (1983): (1) informational encapsulation, which refers to the impenetrable nature of the modules in relation to the effects of higher-order knowledge on the processing; (2) domain specificity, which refers to the constraint on the type of input to the modules; and (3) shallow output, which refers to the aspect of the output from the modules that is available for conscious inspection; namely, it is ahistorical and only contains structural features of the processed stimulus and perceptual level contextual information. The functional interpretation and integration of the output from the modules is assigned to more central systems (such as the medial temporal lobe) that are subject to top down influences (Moscovitch & Umlita, 1990; Moscovitch & Umlita, 1991).

Within the components-of-processing approach, item-specific priming is mediated by the reactivation of records produced in perceptual and semantic input modules and semantic central systems (Kirsner & Dunn, 1985; Moscovitch et al., 1994). Information is initially encoded along a structural and presemantic dimension, in perceptual input modules, and then the shallow output undergoes semantic interpretation in the central systems (Moscovitch, 1992a; Moscovitch, 1992b). This conceptualisation represents a structural model of the principles of transfer appropriate processing (Moscovitch et al., 1994). However, the modular nature of the input modules precludes conscious awareness accompanying the processing operations, but the enhanced perceptual processing fluency that is associated with the presentation of the same or similar stimulus material can result in a sense of familiarity (Jacoby, 1983a; Johnston, Dark, & Jacoby, 1985; cf. Watkins & Gibson, 1988). Moscovitch and his colleagues argued that the locus of conscious memory formation is a component process system within the hippocampus and related structures in the medial temporal lobe and diencephalon (Moscovitch, 1992a; Moscovitch, 1992b; Moscovitch, 1994c). Reciprocal pathways have been specified that connect the hippocampal complex to the neocortex, which serve to create a memory trace that is capable of being appended with conscious awareness. This process has been termed consolidation (Moscovitch et al., 1994; cf. Schacter, 1989).

The benefits of this approach are that functional dissociations between direct and indirect memory tests can be accommodated without the need to posit separate memory systems. Nonetheless, additional assumptions are necessary in order to account for functional dissociations between indirect memory tests; namely, different components of processing are instantiated in the performance of dissociated tasks. In contrast, the conscious retrieval from long-term memory is
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argued to be mediated by a process termed, registration, whereby representations are transformed into long-term records (Moscovitch, 1992a). Determining the component processes that mediate a task enables the nature of ageing to be investigated without recourse to assumptions about the content and representational format of the information that is stored. Therefore, the component process approach emphasises the need to analyse task demands and the strategies that a participant adopts. Nonetheless, if a memory task is to represent the unit of analysis for memory systems 'converging dissociations....of different kinds, observed with different tasks, in different populations, and using different techniques' will be necessary (Schacter & Tulving, 1994b, p.18). In the same way, in order to distinguish between different processes at a substantive level of specificity, more stringent criteria will need to be developed and adhered to. The process approach has yet to fully articulate the concept of a process.

3.4 Comparison of Normal Ageing and Memory-Impaired Populations

Central to neuropsychological models of cognitive ageing is the charting of memory function in neurological impaired patients and relating these data to the parallels that exist in older adults. One dominant hypothesis is based on the functional parallel between older adults and amnesic disorders, whereby item-specific priming appears to be relatively well preserved in both groups compared to direct memory test performance (Craik, Anderson, Kerr, & Li, 1995; cf. Squire, 1994). Further, since ageing and amnesia are accompanied by neuropathological changes in the temporal and/or diencephalic regions of the brain (which correlates with impaired direct memory test performance, Moscovitch & Umlita, 1990; Moscovitch & Umlita, 1991) and relative preservation of the primary sensory and association cortices (which correlates with preserved item priming, Ivy, MacLeod, Petit, & Markus, 1992; Squire, 1992b), it is not surprising that functional parallels should be obtained.

An alternative neuropsychological account of cognitive ageing involves relating the functional deficits found in patients with "frontal lobe deficits" to older adults (Albert & Kaplan, 1980; Craik & Jacoby, 1996; Moscovitch & Winocur, 1995; Raz, Gunning-Dixon, Head, Dupuis, & Acker, 1998; Stuss, Craik, Sayer, Franchi, & Alexander, 1996). The principal behavioural evidence for this model is the poorer performance of older adults, relative to young adults, on tests of frontal lobe function such as the WCST and various verbal fluency tests (but see, Mountain & Snow, 1993, for the difficulties associated with interpreting performance on neuropsychological tests as directly reflecting processing in a specific brain region). Patients with frontal lobe deficits have been
characterised as experiencing a generalised impairment in consciously controlled processing, which leads to a greater dependence on features of the mnemonic environment such as environmental support (Albert & Kaplan, 1980; Lhermitte, 1983). In addition, patients with frontal lobe deficits exhibit poorer performance on recall than on recognition memory tasks (Wheeler, Stuss, & Tulving, 1995), mirroring the pattern of deficits observed in older adults, discussed in Chapter 1. This differential impairment in direct memory tests suggests that strategic and organisational task components mediated by the frontal lobes are sensitive to age-related impairment (Moscovitch & Winocur, 1995). Clearly, this generalised pattern of functional symptomatology has direct parallels with the accounts of age-related cognitive decline in memory that were discussed earlier (e.g., Hasher & Zacks, 1988; Hay & Jacoby, 1996; Jacoby & Hay, 1998).

There is also extensive functional neuroscientific evidence in the form of neuroimaging studies that indicate significant age-related differences in prefrontal cortical regions compared to medial temporal regions (e.g., Raz et al., 1998; Schacter, Savage, Alpert, Rauch, & Albert, 1996). Nevertheless, age-related impairment is likely to be a function of both hippocampal and frontal systems deterioration. Moscovitch (1995) extended this hypothesis to argue that age-related deficits will be restricted to memory tests that are mediated by these two major systems. Therefore, priming on tasks such as word fragment completion, picture naming, lexical decision, and perceptual identification would not be expected to be impaired in older adults, because they are not mediated by the hippocampus (because they are primarily perceptually-based) or the frontal lobe system (because they do not involve a significant semantic search component). In contrast, priming tasks that involve either a substantial frontal component such as reading transformed text have been found to be impaired in those impaired frontal function (Moscovitch et al., 1986) and older adults (Hashtroudi et al., 1991). By extension, associative word stem completion and category exemplar generation both involve organisational and semantic processes, which are associated with larger strategic retrieval demands as compared to perceptual item-specific priming tasks. Therefore, these tasks would be expected to be associated with larger age-related deficits than tasks that are mediated by neural regions that are less prone to age-related deterioration. The functional and structural properties of the two basic memory paradigms that were employed in the experimental work are discussed in Chapter 9.

3.5 Conclusions

Considerable research effort has been focused on trying to localise age-related differences in
memory within a tripartite framework: encoding, storage, and retrieval. However, these efforts have been frustrated by the considerable integration among the processes that support these mnemonic stages, and the variation in manner in which each stage has been conceptualised. It was argued that a basal requirement for an account of the effects of age on memory is the identification of impaired operations that are conceptualised in terms of the distinction between conscious and unconscious processes. Despite the multiple sources of evidence that demonstrate a greater age-related decrement in performance in direct tests than in indirect memory tests, the theories that have been proposed to account for this partial dissociation are not sufficiently integrated. This may, in part, reflect the failure to adequately consider differences in the salient properties of explicit and implicit memory, and the discriminating power of the dependent measures. These concerns have been endorsed with slightly different emphasis by the proponents of each framework. Nonetheless, it was assumed that the processing invoked when performing a memory task is limited by relatively general processing constraints, in addition to variations in the efficiency of specific processes. For example, it is thought that conscious retrieval requires a change in the focus of attention from using memory as a tool to treating it as an object (Dywan & Jacoby, 1990). Older adults may be less able to complete such shifts, possibly because of the decreased processing capacity in working memory (Russo & Parkin, 1993).

A prerequisite for continued theoretical development will be more empirical data that develops our understanding of the relationship between task performance, retrieval strategies, and states of awareness. Within the task dissociation methodology, it has been difficult to objectively measure the contribution of conscious and unconscious processes. There has also been minimal effort explicating the relation between the conscious and unconscious processes and other processing dichotomies. In general, the processing constructs, such as perceptual processing, could not be operationally defined independently of memory performance in a particular test. It also seems unlikely that direct and indirect memory tests only differ along one dichotic distinction, because the factors that are expected to influence performance in one test are likely to also effect performance on another. In this regard, there a number of different subcomponents of the memory system that can be regarded as processors, rather than systems (stores) of information. Hence priming that arises because of reinstatation of a particular kind of processing is not incompatible with an interpretation of implicit memory in terms of separate subcomponents of the memory system (Roediger & McDermott, 1993).

The experimental research reported in this thesis was not designed to present a formal model of age-
related differences in explicit and implicit memory; rather, the utility of three theoretical constructs proposed to account for age-related differences in memory were evaluated. Specifically, the current chapter focused on three dominant accounts of cognitive ageing: (1) older adults experience dysfunctional inhibitory processing (Hasher & Zacks, 1988); (2) divided attention at encoding is particularly disruptive for older adults (Craik, 1977), which reflects a more fundamental cognitive resource deficit in older adults; and (3) conscious processes undergo a decline with ageing, whereas unconscious processes are largely preserved (Hasher & Zacks, 1979; Hay & Jacoby, 1996).

The experimental research included several changes from foregoing research in order to obtain new data concerning memory for conceptually-based item-specific processing information and memory for perceptually-based association-specific information. First, the category exemplar generation task and the perceptual-associative word stem completion task were specified in terms of the process dissociation procedure. In all previous studies that have addressed conceptual priming and memory for new associations in older adults, along with many of the studies addressing conceptual priming and memory for new associations in young adults, participants have responded to test cues specified in accordance with the task dissociation approach. Thus, in these studies, indirect memory test performance is potentially contaminated by conscious processes, whereas direct memory test performance is potentially contaminated by unconscious processes (Bowers & Schacter, 1990; Cabeza, 1994; Rybash, 1996). Second, the use of directed forgetting and divided attention as the two primary encoding manipulations enabled theoretically important constructs to be operationalised. These constructs have not been evaluated in this way in foregoing ageing studies. Third, the systematic application of the process dissociation procedure to investigate of age-related differences in conscious and unconscious processes is important because it directly addressed the utility of the process dissociation procedure, as defined by the boundary conditions under which the underlying process dissociation model can be successfully applied.

Age-related differences were expected in the estimates of conscious processes for both category exemplar generation and the memory for new associations in all of the experiments. In particular, the category exemplar generation task involves a strong retrieval component and organisational, strategic, and semantic processes that are mediated by anterior cortical loci (Moscovitch & Winocur, 1992). Similarly, associative word stem completion draws on computationally complex processes such as the activation of semantic memory and anterior cortical loci (Schacter, 1994a), but given the emphasis on perceptual encoding operations, this task ought to respond in a similar manner as perceptual memory tasks to divided attention and directed forgetting. Nonetheless,
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relational, contextual processing is an important component of this task because of the role the context word serves at retrieval. An additional important goal of the research conducted was to determine the nature of the age-related differences in the unconscious processes that support category exemplar generation and perceptual-associative word stem completion.
4. General Methods

The experimental methods that were common to more than one of the six experiments described in the chapters 5, 6, 7 and 8 are specified in the following sections. Specific exceptions and additions to these paradigms are provided in the procedure section in each of the experimental chapters. Verbatim instructions for each experiment are provided in the Appendix, Chapter 11.

4.1 Participants

The younger adults were undergraduate and postgraduate students at University College London who responded to advertisements that were placed around the University campus calling for volunteers. All of the older adults were recruited from branches of the University of the Third Age based within the central and greater London area. The University of the Third Age is an organisation that provides educational courses in a variety of academic and non-academic subjects. Older adults responded either to advertisements or announcements at branch meetings informing them of the need for volunteers to take part in an experiment investigating memory and ageing. Both the young and older adults who responded to the request for volunteers reported that they had no diagnosed neurological or psychiatric impairments, and were not taking any psychoactive medication. Specific background and demographic information for the young and older participants is described separately for each experiment in the appropriate section of the experimental chapters.

Clearly, it is possible that any age-related differences in the performance observed might be attributable to the fact that the young adults were students and older adults were not; rather than age per se. However, such effects are likely to be ameliorated by the continuing educational status of the older adults and the fact that they were community-dwelling and not institutionalised. The status of older adults with respect to this latter demographic variable has been shown to effect performance on word stem completion priming, since only institutionalised older adults were found to be impaired in word stem completion priming (Winocur et al., 1996). Prior to inclusion in an experiment, group matching was conducted on the basis years of educational level. The means for age and educational level obtained from the responses provided on a short questionnaire (presented

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*In each experiment, a small number of participants were excluded for various reasons such as the failure to understand the task instructions and achieving an MMSE score that was lower than the criterion. In each case, additional participants were tested in their place.*
to the participants) at the beginning of each experiment are presented in the appropriate section of each experimental chapter. In addition, the scores obtained by administering the Mini-Mental State Exam (MMSE, Folstein, Folstein, & McHugh, 1975) to the older adults are provided in the relevant section of each experimental chapter. The MMSE is a mental status scale sensitive to early stages of dementing illness. It is a particularly powerful assessment scale for discrimination between normal ageing and dementia (Christensen, Hadzi-Pavlovic, & Jacomb, 1991). The exclusion criterion was an MMSE score of 27 or lower. Participants were also assessed for sensory impairment sufficient to impede the perception of experimental stimuli. Matching on the basis of sex ratio was not possible because of the difficulty with obtaining a sufficient number of male older adults.

All participants claimed to be native speakers of English, and had corrected or normal vision and hearing. All participants were remunerated at the departmental rate, which was £3.00 per hour during the first year of the experimental work and rose to £5.00 per hour during the final two years of experimental work. No participant was tested in more than one experiment at an interval of less than six months.

4.2 Materials

In each experiment, the presentation of experimental stimuli and instructions was implemented and controlled by utilising an Apple Macintosh PowerBook 5300cs computer running PsyScope v1.1 (Experiments 1-3), and PsyScope v1.2.1 (Experiments 4-6, Cohen, MacWhinney, Flatt, & Provost, 1993). The only difference between these two versions of PsyScope was that the latter version of the software was a PowerPC™ processor native application, whereas the former version was compiled to run on a Motorola 68040™ processor based Apple Macintosh. The integrated computer screen on the PowerBook 5300cs was a 10.4" LCD colour dual-scan screen. All instructions and experimental stimuli were presented on the computer screen in 18-point Times New Roman.

The space bar on the keyboard of the Apple Macintosh PowerBook and a Carnegie Mellon University Button Box were used to record the input from the required buttons presses, as specified in the experimental instructions. At test, all responses were hand written by the participant on a response form that was specific to each experiment. For all verbal responses, a Sony Tape Cassette Recorder was used to record the responses of the participants during the divided attention task. The divided attention task performance was analysed by listening to the tape recording made for each participant.
4.3 Procedure

In all of the experiments, each participant was tested individually in a purpose built experimental room. Participants were initially provided with an information sheet detailing the basic procedures, the purpose of the experiment, and approximate length of the experiment. This stage was followed by a brief spoken introduction provided by the experimenter to consolidate the details of the experiment. After the participants indicated that they understood the information contained within the introduction, they completed a consent form and a brief demographic questionnaire. The contents of the advertisements for volunteers, information sheets containing the basic procedural details, and consent forms were designed and implemented in accordance with the regulations provided by the Joint UCL/UCH Committee on the Ethics of Human Research: Committee Alpha. The MMSE was administered prior to beginning the cognitive-behavioural part of the experiment.

Each phase of the experiment was introduced individually, thereby minimising task requirement expectations. In both the study and test phases, each participant was seated in front of the computer screen at a distance of 50 to 60cm. The participants received written study and test instructions presented on the computer screen. The experimental period began once it was determined that the participants understood the task described in the instructions.

4.3.1 Encoding Tasks

Two primary categories of encoding task were used: divided attention (Experiments 1 and 2); and directed forgetting (Experiments 3, 4, 5, and 6). The following subsections describe the similarities and differences in the implementation of these two encoding tasks across the category exemplar generation task and perceptual-associative word stem completion tasks that were utilised in the studies reported in the following experimental chapters.

4.3.1.1 Divided Attention Task

To facilitate comparison across experiments, both Experiment 1 (category exemplar generation task) and 2 (associative word stem completion task) employed the same divided attention task. The divided attention task was modelled after an experiment by Mulligan (1997, 1998), as discussed in Chapter 1. Thus, the divided attention task involved the retrieval of a digit-letter sequence of varying length from short-term memory. The digit-letter sequence was either three or five items in length. The one-item and seven-item loads employed by Mulligan (1997) were not included because
these loads were not shown to be necessary in order to obtained a dissociation between category cued-recall and conceptual priming. The digit-letter sequences comprised of digits (1-9) and a set of letters (B, C, D, F, G, H, J, K, L) that were subject to two constraints designed to minimise chunking: (1) digits and letters occupied alternating positions, with a digit in the first position; and (2) not more that one instance of each digit or letter occurred within a sequence.

The study trial sequence under divided attention task was fixed as follows. The presentation of each study trial was initiated by the participant pressing the centre key on the Carnegie Mellon University Button Box prompted by the message "Press Button to Continue" on the computer screen. A fixation point appeared in the centre of the screen for 500ms. Then, for the attentional load trials, participants were instructed to read the digit-letter sequence aloud (that appeared on screen for 2.5 seconds) and retain the sequence until a prompt to 'RECALL' appeared on the screen. For the zero load trials, participants were instructed to say the word 'blank' in response to dashes that appeared on the screen for 2.5 seconds instead of the digit-letter sequence. An exemplar or word pair, depending on the experiment, was presented immediately afterwards. Participants were instructed to read the exemplar or word pair out aloud and try to retain the word(s) for a later memory test. Finally, either the word 'RECALL' (in the attentional load trials) or the word 'BLANK' (in the zero load trials) was presented on the computer screen for 2.5 seconds. Participants then either recalled the digits and letters (in the attentional load trials) or said the word 'blank' (in the zero load trials) in response to the retrieval cue. Each participant was initially provided with six practice trials. If an error was made when reading the digit-letter sequence, the experimenter prompted the participant by saying 'you made an error'. Participants were instructed to concentrate on remembering the digit-letter sequence until they received the recall prompt. In this way, the divided attention task instructions equally emphasised the allocation of attentional resources to the primary and secondary task.

As explained in Chapter 1, the divided attention task was selected for various theoretical considerations. In particular, it was assumed that the divided attention task reduced between-participant variance in terms of task switching because of the serial nature of the relation between divided attention task and the encoding of critical items. Moreover, the duration of each stage of the divided attention task was experimentally-determined. Of course, although plausible, this analysis of the strategy necessary to perform the divided attention task is speculative, because task switching was not evaluated empirically; participants could have still operated strategically despite these design features. Clearly, the magnitude of the divided attention costs would depend partly on the particular strategy adopted by participants: some strategies such as elaboratively rehearsing the digit-letter sequence, are probably more resource demanding than are more superficial (and less...
4. General Methods

effective) strategies, such as thinking about the first letter of the digit-letter sequence. Thus, in retrospect, it would probably have been better to instruct all participants to use the same strategy in order to facilitate the interpretation of the divided attention costs.

4.3.1.2 Directed Forgetting Task

Both the list-method and item-method directed forgetting cueing procedures were applied to the category exemplar generation and the perceptual-associative word stem completion tasks. In the item-method cueing procedure, participants were informed that the purpose of the experiment was to see how well they could remember words following an intermixed presentation of words that were designated to-be-remembered (R) or to-be-forgotten (F). The instruction to either remember or forget a category exemplar or word pair took the form of a 'RRR' or 'FFF' cue that appeared after the presentation of the critical item at study. In addition, the effect of a second variable, the time between the critical item and the onset of the R and F cue, was fully crossed with the presentation of the cue for the category exemplar generation task. Two levels of cue onset were employed: immediate and delayed. In the immediate cue onset condition, the R and F cues were presented immediately after the presentation of each word. In the delayed cue onset condition, the presentation of the R and F cues was suspended for a period of 5 seconds after the word had been presented. Across both levels of cue delay, the duration of each study trial was constant. The presentation of the study list was experimentally paced in order to ensure that the intervals in the immediate and delayed cue conditions were constant.

The initial encoding instructions explained the significance of the R and F cues and the format of cue presentation. These instructions were followed by a practice session that was comprised of six words or six word-pairs, three of which were cued RRR and three were cued FFF in a single random sequence. The purpose of the practice phase was to familiarise the participants with the format of presentation of the study trials, and to reinforce the purpose of the item cue instructions. At the end of the practice session, participants were instructed to recall only those words that had been associated the RRR cue, and were provided with feedback on their performance.

The list-method directed forgetting cueing procedure initially involved the presentation of half of the list of critical study words. Following the presentation of the first half of the study list, participants were informed that the list was 'just for practice', and that it was the following list of words that they should remember. In addition, encoding instructions appropriate to the premise of the experiment were provided, and these are specified in the appropriate section in the experimental chapters.
4.3.2 Memory Tasks

After the study phase, participants performed an inclusion and exclusion memory test, with the order of test cues counterbalanced across participants and presented in a different random order for each participant. In all of the experiments, six buffer items were inserted into the test lists, three at the beginning and three at the end of the test list. In addition, in all of the experiments except Experiment 1, the presentation of the inclusion and exclusion test items was randomly intermixed in order to equate the period between the presentation of the items at study and the two classes of test instructions. An additional rationale for this change in the structure of the test phase is provided in Chapters 6 and 7.

4.3.2.1 Category Exemplar Generation

The stimuli for the category exemplar generation task were category exemplars drawn from the Battig and Montague (1969) category norms. Category exemplars ranged from three to eight letters in length, and were selected according to two criteria: (1) they were not in the ten most frequent instances or three least frequent instances; and (2) each exemplar had been produced by at least 10 participants. The exemplars were drawn from populations of non-exhaustive categories. The average rank of the category exemplars was 31. For all levels of the divided attention manipulation and cue designation in directed forgetting, the assignment of the experimental conditions honoured the semantic categories. The presentation of category exemplars at study was pseudorandom, such that no two category exemplars from the same category were presented consecutively.

The relationship between the study and test was explained at the beginning of the test phase. This approach was adopted in order to minimise the spontaneous use of a retrieval strategy at variance with retrieval instructions of the inclusion and exclusion tests. At test, category names were presented that corresponded to the category exemplars used in the study condition and an equal number of category names that corresponded to the category exemplars that did not appear at study. Category names were presented individually, and participants were instructed to write down up to eight category exemplars for each category name, in accordance with the inclusion and exclusion test instructions. Participants were instructed to provide up to eight exemplars to ensure that exemplars other than the most common were produced (Rappold & Hashtroudi, 1991).

4.3.2.2 Perceptual-Associative Word Stem Completion

The basic elements of the word stem completion paradigm, employed to assess memory for new
associations, closely followed the paradigm developed by Graf and Schacter (1985), and then subsequently modified by Reingold and Goshen-Gottstein (1996a; 1996b) to satisfy the boundary conditions of the process dissociation procedure. At study, the participants were instructed to remember a series of word pairs presented for a subsequent memory test. In the word stem completion task, the participants were instructed to complete the target word stems in each context-target word pair with a five-letter word in accordance with the inclusion and exclusion test instructions. Participants were also informed that they should avoid proper names, plurals and declensions of verbs.

For all of the experiments that investigated associative word stem completion, 144 word pairs were selected, and these were divided into three groups of 48 triads. Each triad was comprised of three pairs of unrelated words. The counterbalancing of triads was applied by observing three constraints on the word pairs: (1) all of the words were five letters in length, and their three-letter stems had more than two or more possible completions with a five-letter word; (2) context and target words did not share the same stem; and (3) within each triad, all combinations of the context and target words were semantically unrelated. The latter constraint was assessed by subjective inspection of each word pair for semantic relatedness.

The context words were the names commonly given to line drawings in a study by Snodgrass and Vanderwart (1980). Therefore, each word pair consisted of at least one noun in a unique combination with a target word, and these 144 unique pairs represented the word pairs that were presented to participants. The mean word frequencies were 48 and 52 occurrences per million for context and target words, respectively (Kucera & Francis, 1967). In addition to presenting the context word at study and test, the corresponding line drawing from Snodgrass and Vanderwart (1980) was displayed in the same central position, relative to the entire screen, above each word pair, for both the study and test conditions.

For the sake of economy of description, the words that made up the word pairs are referred to as A-B, C-D, and E-F pairs, where the A, C, and E words served as context words for the B, D, and F words that represented the target words. An extra word (labelled X, in Table 4.1) was assigned to each triad, which represented the target word in the study phase, but these words were replaced at test with the stem of an unstudied target word (the control condition). Therefore, these extra words were only presented once at study in the intact, recombined, and control conditions. At both study and test, the context words were presented to the left of the target word. For each triad at test, all participants received the identical pairing of context words and target word stems, namely, A-B, C-D, and E-F.
The pairing of the 144 context and target words at study determined the test condition assignment for each pair, and each context word only appeared once in the study list. Specifically, the assignment of words to the 144 context words was constrained by the 48 triads, and within each triad, words were counterbalanced according to the scheme detailed in Table 4.1. The triads were rotated through six permutations so that each target word was equally likely to be represented in an intact, recombined or control test condition. This was achieved by dividing the 48 triads into six groups comprised of eight triads, and assigning each of the six groups of triads to six permutation conditions constrained by a Latin Square design. Therefore, at test, all participants were presented with the same 144 context and target word stems that were equally likely to be presented as an intact, recombined, or control word pair.

<table>
<thead>
<tr>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-D</td>
<td>C-B</td>
<td>C-X</td>
<td>C-X</td>
<td>C-D</td>
<td>C-F</td>
</tr>
<tr>
<td>E-X</td>
<td>E-X</td>
<td>E-F</td>
<td>E-B</td>
<td>E-F</td>
<td>E-D</td>
</tr>
</tbody>
</table>

**Test List 1**

- A-B (I), old A-B (R), new A-B (I), new A-B (R), old A-B (C), old A-B (C), new
- C-D (I), old C-D (R), new C-D (C), old C-D (C), new C-D (I), new C-D (R), old
- E-F (C), new E-F (C), old E-F (I), old E-F (R), new E-F (I), new E-F (R), old

**Test List 2**

- A-B (I), new A-B (R), old A-B (I), old A-B (R), new A-B (C), new A-B (C), old
- C-D (I), new C-D (R), old C-D (C), new C-D (C), old C-D (I), old C-D (R), new
- E-F (C), old E-F (C), new E-F (I), new E-F (R), old E-F (I), old E-F (R), new

Table 4.1 Permutations used to create context-target word assignment at study and rest. The letters I, R, and C refer to the intact, recombined, and control test conditions, respectively. ‘New’ and ‘Old’ refers to the exclusion and inclusion test conditions of the process dissociation procedure. The two version of the test list (labelled Test List 1 and Test List 2) ensure that a context-target word pair is equally likely to appear in the inclusion and exclusion test condition.

Memory for new associations is mediated by conscious processes if the estimates of conscious processes are greater in the intact relative to the recombined condition, whereas a larger estimate of unconscious processes in the intact relative to the recombined condition memory provided the measure of associative unconscious processes. Item-specific priming was measured as the contrast
4. General Methods

between the context-control and context-recombined word pairs, where better performance in the context-recombined as compared to context-control word pair represented an index of item-specific priming. Although, this measure of item-specific priming was not equivalent to that derived from the comparison between studied and unstudied single items (Goshen-Gottstein & Moscovitch, 1995b; Schacter & McGlynn, 1989), the inclusion of context-control word stem pairs was still warranted given the need for a relativistic baseline for item-specific priming as compared to association-specific priming.

4.3.2.3 Process Dissociation Test Instructions

In all six experiments, the inclusion and exclusion tests of the process dissociation procedure were manipulated within participants. The inclusion and exclusion tests were cued on an individual basis using the words ‘OLD’ and ‘NEW’, respectively; with the exception of Experiment 1. These cues appeared below the critical items that were presented at test. Further, all of the cues at test were counterbalanced across inclusion and exclusion tests, thereby minimising interference and crossover effects across the test cue employed in each experiment.

Canonical versions of the inclusion and exclusion test instructions were provided to participants. In the inclusion test, participants were instructed to respond with items that were compatible with the test cue from the studied list, and if they were unable to provide a completion from the studied list, they were to provide the first completion(s) that came to mind that was compatible with the test cue. In the exclusion test, participants were instructed to provide compatible items in response to the test cues using items that were not presented at study (i.e., avoid any of the items presented at study). For both the inclusion and exclusion tests, participants were encouraged to use the test cues as cues for the direct-retrieval of studied items (Jacoby et al., 1997b), and were instructed to avoid using a generate-recognise strategy for the retrieval of studied items. The distinction between these two modes of retrieval was explained to participants by providing examples.

These canonical instructions were supplemented with additional instructions determined by the demands of the specific memory task. For the category exemplar generation task, participants were asked to write down up to eight exemplars for each category name from the words that were studied earlier. If they could not do this, they should provide the first word that comes to mind, or leave it blank if unable to think of any suitable word. The participants were instructed that a response should be made within 30 seconds, after which time they should continue onto the following item. In the exclusion test, participants were told that they should provide, as fast as they could, eight exemplars for the category names using words that had not been presented earlier in the study.
phase. For the perceptual-associative word stem completion task, the only addition made to the canonical instructions was that participants should only provide completions to each target word stems using a five-letter word.

For the experiments that employed item- and list-method directed forgetting, the inclusion task assessed the ability of participants to retrieve both R and F cued items, whereas the exclusion test condition assessed the ability of participants to avoid completing test cues with either R or F cued items.
5. The Effect of Age and Varying Attentional Load on Category Exemplar Generation

5.0 Introduction

The foregoing introductory chapters revealed that until recently conceptual priming has received relatively little attention in relation to ageing, despite the important theoretical implications of it. The studies that have examined the effects of age on conceptual priming have reported both age-related invariance and impairment (Grober et al., 1992a; Isingrini et al., 1995; Jelicic et al., 1996; Light & Albertson, 1989; Light et al., 1999; Monti et al., 1996), whereas in conceptual direct memory tests the evidence largely indicates age-related impairment (Craik & Jennings, 1992; Isingrini et al., 1995; Light & Albertson, 1989; Light et al., 1999; Monti et al., 1996). The current experiment sought to investigate the effects of age in conceptual conscious and unconscious processes, as conceptualised within the category exemplar generation task (Hamann, 1990; Rappold & Hashtroudi, 1991; Srinivas & Roediger, 1990), and constrained within the retrieval environment of the process dissociation procedure (Jacoby, 1991).

Several limiting properties were identified in Chapter 1 with regard to the research that has investigated conceptual priming. Most notably, the studies that have investigated conceptual priming are based on paradigms that do not preclude the possibility of contamination by conscious processes (Schmitter-Edgecombe, 1999; Toth & Reingold, 1996). Consequently, the advantages conferred by the process dissociation procedure are particularly important for experimental work investigating conceptual priming and ageing, because contamination in conceptual indirect memory tests has been found to disproportionately facilitate the performance of young adults relative to older adults (e.g., Light & Albertson, 1989).

In addition to determining the effects of ageing on conceptual conscious and unconscious processes, the effect of divided attention at encoding was investigated. The results from studies that have explored the effects of divided attention on conscious and unconscious processes have been subject to two different interpretations (see Chapter 3). Specifically, the transfer appropriate processing view emphasises the sensitivity of conceptual conscious and unconscious processes to the reactivation of conceptual and lexical operations necessary for encoding items at study (Mulligan, 1998; Mulligan & Hartman, 1996). Conceptual encoding operations are expected to be attenuated
5. Age, Varying Attentional Load, and Category Exemplar Generation

by dividing attention (Craik, 1983; Craik & Byrd, 1982), independently of whether the operations are associated with conscious or unconscious processes. According to the attentional view, unconscious processes are mediated automatically, whereas conscious processes are attention demanding (e.g., Besson, Fischler, Boaz, & Raney, 1992b; Jacoby et al., 1993b; Jacoby et al., 1989; Parkin & Russo, 1990).

The research that has examined the effect of divided attention on conceptual priming is relatively consistent (see Chapter 1). Briefly, several other studies have demonstrated that conceptual priming is dependent on attention and may, in fact, be more dependent on attention than comparable direct memory tests under conditions of a 'strong' division of attention (Gabrieli et al., 1997b; Mulligan, 1997; Mulligan, 1998; Mulligan & Hartman, 1996; Schmitter-Edgecombe, 1996; Schmitter-Edgecombe, 1999). Further, Light et al. (1999) reported that divided attention impaired an indirect category exemplar generation task, but not an indirect category exemplar verification task, in both young and older adults. The only exception is a study by Isingrini et al. (1995), which reported little or no effect of divided attention on conceptual priming (see also, Jacoby et al., 1989; Koriat & Feuerstein, 1976). However, given that all but one of these studies employed a task dissociation approach, it can be argued that the effect of divided attention on conceptual priming reflects contamination by conscious processes.

More generally, a factor that may contribute to the differences in the effect of divided attention at encoding across different conceptual indirect memory tests may be the operation of two dissociable modes of accessing conceptual information. This position is based on evidence suggesting that several variables are able to dissociate conceptual indirect memory tests (Cabeza, 1994; Vaidya et al., 1997; Weldon & Coyote, 1996). In relation to the effect of divided attention, a task that invokes competitive retrieval access of response candidates (such as category exemplar generation) is predicted to be sensitive to the effects of divided attention, whereas tasks that involve the non-competitive access of response candidates (such as semantic verification) are predicted to be relatively immune to the effects of divided attention (Vaidya et al., 1997). However, conceptual priming tasks that invoke multiple competitive response alternatives may also be more disposed to contamination by conscious processes than tasks that involve non-competitive retrieval access, consequently, it is important to obtain a veridical measure of conceptual unconscious processes to ensure that the locus of an effect of attention is unequivocally determined.

In the current experiment, the amount of attention available at encoding was varied parametrically by utilising the short-term memory load task applied to conceptual memory tests by Mulligan.
5. Age, Varying Attentional Load, and Category Exemplar Generation

(1997; 1998). Importantly, extending the application of this divided attention paradigm to the investigation of age effects was motivated by the notion that attention can be manipulated parametrically as a scalar dimension. In particular, a more fine-grained analysis of the region between attention and memory will approach the degree of specificity necessary to truly evaluate the nature of any age-differences that may be present. An additional benefit associated with this particular divided attention paradigm is that it does not truncate the perceptual or lexical analysis, but it is still capable of providing the strong division of attention that appears to be necessary in order to impair conceptual priming (Mulligan, 1997; Mulligan, 1998; Schmitter-Edgecombe, 1999).

To the extent that the divided attention paradigm employed in the current experiment operates in accordance with the analysis provided, it was hypothesised that divided attention would impair the encoding of items at study. Further, if it is assumed that unconscious processes primarily mediate conceptual indirect memory tests, and conscious processes are dominant within conceptual direct memory tests, then it follows from the findings reported by Mulligan (1997, 1998) that there will be an incremental decline in the estimates of conscious processes as a function of increasing attentional load, whereas unconscious processes will only be impaired at the maximum 5-item attentional load.

As discussed in the introductory chapters, the locus of age-related impairment is argued to reside in conscious processes and not unconscious processes (Hay & Jacoby, 1996; Jacoby, 1991; Jennings & Jacoby, 1993). As discussed in Chapter 3, this interpretation does not take into account the content of memory, as conceptualised within the perceptual-conceptual processing distinction. Several sources of evidence lend support to the position that age-related impairment will be obtained, at least under some conditions, in conscious and unconscious processes associated with conceptual processing (see Chapter 3, Craik & Rabinowitz, 1985; Howard, 1988a). In particular, conceptual unconscious processes may involve additional cognitive resources relative to perceptual unconscious processes, as suggested, for example, by the evidence of an effect of divided attention on conceptual priming, but not perceptual priming.

Nonetheless, when age-related cognitive resource deficits are operationalised in terms of divided attention task performance, the effect of ageing has been less than conclusive (for reviews, see Hartley, 1992; Salthouse, 1991). This is, in part, due to differences across studies in the interaction between the memory paradigm and the task used to modulate attention. The discussion of these issues in Chapters 1 and 3 led to the conclusion that the divided attention task implemented in the current experiment shares domains of processing with the memory task and places significant demands on working memory; both of these factors are known to expose age-deficits in cognitive resources (Chapter 3). An additional consequence of the putative reduction in attentional resources
available to older adults may be that the encoding effort required to perform the divided attention task is greater for the older adults. This deficit should be manifested by a greater primary task cost for the older adults relative to the young adults. However, this deficit in older adults may only be observed under the processing demands found in the maximum attentional load.

As discussed in Chapter 2, the process dissociation procedure requires that three assumptions are met in order to calculate conscious and unconscious parameter estimates. These three assumptions are assumed to be satisfied by ensuring that several boundary conditions are maintained (Jacoby, 1998; Jacoby et al., 1997a; Toth et al., 1995, see also, Chapter 2). Until recently, there have been no studies that have been explicitly designed to investigate the experimental protocols under which boundary conditions are sustained. Therefore, an additional goal of the current experiment, and the other experimental work presented in this thesis, was to define the conditions under which the assumptions of the process dissociation procedure are met in terms of tasks, variables, and experimental protocols employed. The most notable, for the purposes of the current experiment, was that retrieval instructions oriented participants to employ a direct retrieval strategy in both the inclusion and exclusion tests. The adoption of a direct-retrieval strategy by participants is intended to ensure that equivalent baseline guessing rates operate across the inclusion and exclusion tests, and that conscious and unconscious processes operate independently (Jacoby, 1998).

Two aspects of the design implemented in the current experiment warrant particular attention with regard to the issue of boundary conditions. First, since young and older adults were compared directly, it was particularly important to ensure that the baseline rates for both age groups were sufficiently high to avoid zero scores in the exclusion test, because this is known to produce artifactually low estimates of unconscious processes. Indeed, even when the selection of stimulus items and the experimental protocols are designed to ensure task performance operates according to the direct retrieval model, zero scores in the exclusion test can still occur, which then necessitates the application of correction procedures, or the removal of these participants' data prior to analysis (e.g., Curran & Hintzman, 1997). Second, the category exemplar generation task may, under some circumstances, be performed using a generate-recognise retrieval strategy (Mecklenbrauker et al., 1996; cf. Schmitter-Edgecombe, 1999), despite instructions that direct participants to employ a direct retrieval strategy.
5. Age, Varying Attentional Load, and Category Exemplar Generation

5.1 Method

5.1.1 Participants

The participants were 24 young adults (Mean = 23.5 years of age; Range = 18-30 years of age; N males = 10; N females = 14) and 24 older adults (Mean = 69.0 years of age; Range = 61-78 years of age; N males = 9; N females = 15). The young adults had a mean of 16.1 years of education, whereas the older adults had a mean of 16.4 years of education. The mean MMSE score for the older adults was 28.7.

5.1.2 Design and Materials

The design comprised a 2 (age: young and old) x 2 (test instruction: inclusion and exclusion) x 3 (attentional load: 0-item load, 3-item load, and 5-item load) mixed factorial design. Age was a between-participants factor, with attentional load and test instructions manipulated within-participants. Thus, each participant received two types of memory test (inclusion and exclusion), and these memory tests were presented in a blocked design.

Items were counterbalanced so that they served in all study and test conditions equally often across participants. Twenty-four category names were selected, each with 6 exemplars per category. Therefore, there were 144 critical category exemplars. Eight additional category exemplars from four categories were used as buffers to avoid primacy and recency effects. The 24 categories were divided into two study base sets (A & B) consisting of 72 category exemplars, each comprising three lists of 24 category exemplars from four categories (A1, A2, A3, B1, B2, B3). The three lists of each base set corresponded to one of the three attentional loads. Exemplars within each category belonged to the same attention-load condition and the study lists were rotated through each of the three attentional load conditions. There were two test lists. List α comprised the two category names per attentional load condition from Set A, two category names per attentional load condition from Set B, and two filler category names. List β comprised the remaining two category names per attentional load condition from Set A, the remaining two category names per attentional load condition from Set B, and two additional filler category names. The category exemplars that corresponded to category names of unstudied items were used as a measure of baseline response rate. For the attentional task, there were 48 digit-letter sequences and 24 0-item sequences presented randomly, corresponding to 72 category exemplars presented at study, constrained by the study list pairing, across each of two base study lists. In addition, four digit-letter sequences and four 0-item
sequences were assigned to the category exemplars that served as buffer items.

5.1.3 Procedure

At study, category exemplars and the divided attention task were presented in accordance with the procedure outlined in the General Methods Chapter. Each category exemplar was presented for 3 seconds. In all conditions of the test phase, the presentation of the category names was self-paced. Each category name was presented by pressing the centre key on the button box prompted by the message "Press Button to Continue" on the computer screen. A fixation point appeared in the centre of the screen for 500ms. Then, a category name appeared and remained on the computer screen for 10 seconds. The General Methods Chapter details the inclusion and exclusion test instructions that were provided. In both inclusion and exclusion tests, the participants were provided with practice test cues to ensure familiarity with the test requirements.

5.2 Results

The mean proportion of digit-letter sequences that were correctly recalled for the 0-item, 3-item, and 5-item attentional load was .97, .98, and .95 for the young adults, respectively, and .97, .99, and .94 for the older adults, respectively. Thus, young and older adults were able to recall digit-letter sequences, and this did not vary as a function of attentional load and age, ps > .05. Similarly, the identification of category exemplars did not vary as a function attentional load and age, ps > .25.

The mean proportion of correctly completed exemplars for each experimental condition are shown in Table 7.1. A 2 (age: young vs. old) x 2 (test instruction: inclusion vs. exclusion) x 3 (attentional load: 0-item vs. 3-item vs. 5-item) mixed factors ANOVA was performed on the proportions of correctly generated category exemplars. The only significant main effect was that of test instruction, $F(1, 46) = 5.36, p < .05$. A significant interaction was obtained between age and test instruction, $F(1, 46) = 30.15, p < .001$, which indicates the differential effect of age on the inclusion and exclusion tests. In addition, the interaction between test instruction and attentional load was significant, $F(2, 92) = 19.35, p < .001$, which reflects the differential effect of attentional load on the inclusion and exclusion tests.
**Table 5.1. Mean proportion of studied category exemplars generated in response to category names in each experimental condition.**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Inclusion</th>
<th>Exclusion</th>
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<tbody>
<tr>
<td></td>
<td>Attentional load</td>
<td>Attentional load</td>
</tr>
<tr>
<td>0</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Young</td>
<td>0.31</td>
<td>0.25</td>
</tr>
<tr>
<td>Old</td>
<td>0.20</td>
<td>0.14</td>
</tr>
</tbody>
</table>

In the young adults, there was a decline in the retrieval of exemplars as a function of increasing attentional load in the inclusion test, as indicated by the significant differences between the 0- and 3-item load, $F(1, 46) = 3.91, p < .05$, and 0- and 5-item load, $F(1, 46) = 17.37, p < .001$. In contrast, the retrieval of exemplars in the exclusion test increased as a function of increasing attentional load, as demonstrated by the significant difference between the 0- and 5-item load, $F(1, 46) = 8.77, p < .01$. Performance in the inclusion test exceeded the exclusion test at the 0-item load, $F(1, 46) = 51.86, p < .001$, whereas at the 5-item load, performance between the inclusion and exclusion tests did not differ significantly, $F(1, 46) = 2.86, p = .09$.

In the older adults, there was a decline in the retrieval of exemplars as a function of increasing attentional load in the inclusion test, as indicated by the significant differences between the 0- and 3-item load, $F(1, 46) = 3.90, p < .05$, and 0- and 5-item load, $F(1, 46) = 14.38, p < .001$. In contrast, but consistent with the young adults, the retrieval of exemplars in the exclusion test increased as a function of increasing attentional load, as demonstrated by the significant difference between the 0- vs. 5-item load, $F(1, 46) = 4.69, p < .05$. Performance in the inclusion test did not differ significantly from the exclusion test at the 0-item load, $p > .25$, whereas at the 5-item load, performance in the exclusion test exceeded the inclusion test, $F(1, 46) = 14.82, p < .001$.

In relation to the age effects, there was a significant age-related difference that favoured the young adults in the inclusion test at the 0-item, 3-item, and 5-item attentional loads, $F(1, 46) = 7.24, p < .01$, $F(1, 46) = 5.46, p < .05$, and $F(1, 46) = 8.99, p < .01$, respectively. In the exclusion test, the intrusion rate differed significantly at each level of attentional load as a function of age, and this
difference favoured the older adults at the 0-item, 3-item, and 5-item attentional loads, \( F(1, 46) = 21.32, p < .001 \), \( F(1, 46) = 17.90, p < .001 \), and \( F(1, 46) = 8.00, p < .01 \), respectively. Both the direction and magnitude of the effect of divided attention on the inclusion and exclusion tests, between the 0- and 5-item load, was the same for the young and older adults, \( ps > .50 \).

The baseline rate of responding in the inclusion and exclusion tests differed significantly for both young and the older adults, suggesting that participants did not use equivalent criteria when completing the category names in the inclusion and exclusion tests. Under such circumstances, it is normally necessary to derive a parameter estimate of response bias (Jacoby, 1998; Yonelinas & Jacoby, 1996a). However, the lower baseline rate for the exclusion test than the inclusion test suggests the adoption of a generate-recognise retrieval strategy in the experiment. Therefore, the difference in the baseline rate of responding could not be corrected, because correction models of response bias have been developed to address response bias differences that arise when a direct-retrieval model is employed (Jacoby, 1998). In addition, zero exclusion scores, for at least one level of attentional load, were obtained in 12 young adults. The inclusion of these zero exclusion scores in process dissociation analyses have been shown to artifactually lower the estimates of unconscious processes, therefore the proponents of the process dissociation procedure have argued that these data need to be excluded from the analyses (but see, Curran & Hintzman, 1997; Jacoby, 1991).

The estimates for conscious and unconscious parameters were calculated in accordance with the computational expressions for the process dissociation procedure outlined in Chapter 2, and are shown in Table 5.2. In both the young and older adults, a paradoxical crossed interaction between the conscious and unconscious parameters was obtained as a function of increasing attentional load. In addition, the unconscious parameter estimates did not exceed those for the baseline rate of responding. Therefore, taken together, the overall pattern of data suggests that the locus of the paradoxical dissociation in the parameter estimates appears to be the adoption of a generate-recognise retrieval strategy (Jacoby, 1998; Russo & Andrade, 1995, see also Chapter 9). Consequently, the core assumptions of the process dissociation procedure were violated, because the two verification procedures proposed by Jacoby (1998) suggested that a generate-recognise retrieval strategy was adopted by the young and older adults.
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Table 5.2 Estimates of conscious and unconscious parameters for each experimental condition.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Conscious Attentional Load</th>
<th>Unconscious Attentional Load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Young</td>
<td>0.27</td>
<td>0.16</td>
</tr>
<tr>
<td>Old</td>
<td>0.04</td>
<td>-0.08</td>
</tr>
</tbody>
</table>

0 = 0-item load, 3 = 3-item load, and 5 = 5-item load

5.3 Discussion

In the young adults, inclusion test performance exceeded the performance in the exclusion test under full attention, whereas in the older adults similar values were obtained in the inclusion and exclusion tests. Age-related deficits only appeared in the inclusion test. Therefore, on the basis of these data, it is plausible to assume that a large component of task performance in the category exemplar generation task is attributable to conscious processes, at least in young adults. One implication of this finding is that the functional dissociations obtained between direct and indirect forms of category exemplar generation are potentially attributable to the differential involvement of conscious and unconscious processes within each form of the task, rather than the process pure dissociation of implicit and explicit memory. For both age groups, an increase in the intrusion of studied items in the exclusion test was accompanied by a decrease in completion of category names in the inclusion test as a function of increasing attentional load.

One of the primary questions addressed was whether a factorial manipulation of the amount of attention available at encoding has an effect on both conceptual conscious and unconscious processes. However, the failure to obtain veridical estimates of conscious and unconscious processes precluded an evaluation of this research question. Nonetheless, the effect of divided attention on conceptual priming reported in several studies is unlikely to represent an artefact mediated by conscious processes (Mulligan, 1997; Mulligan, 1998; Mulligan & Hartman, 1996). In particular, an effect of divided attention on conceptual unconscious processes, as conceptualised in a category exemplar generation task implemented in accordance with the process dissociation
procedure, has recently been reported. Specifically, Schmitter-Edgecombe (1999) reported an effect of divided attention on the parameter estimates of conceptual conscious and unconscious processes (the secondary task was a digit monitoring task). Critically, the direction of these effects were hypothesised for the current experiment; namely, there was a decline in the contribution of conceptual conscious and unconscious processes under divided relative to full attention.

In contrast, previous process dissociation analyses that have utilised word stem completion, recognition memory, memory for paired-associates, and fame judgement as a function of a divided attention manipulation have obtained invariance in the unconscious parameter estimates (Jacoby, 1996; Jacoby, 1998; Jacoby et al., 1993b; Jacoby et al., 1989; Jennings & Jacoby, 1993). Interestingly, it is plausible to assume that least two of these paradigms, memory for paired-associates and fame judgements, were mediated by conceptual unconscious processes. Therefore, the evidence from task dissociation studies, and that reported by Schmitter-Edgecombe (1999), are at variance with the majority of the foregoing process dissociation findings, and the view that automatic, unconscious processes should be unaffected by variations in attention at encoding (e.g., Besson et al., 1992b; Jacoby et al., 1993b; Jacoby et al., 1989; Parkin et al., 1990).

As discussed earlier, a potential determinant of the reversed effect of divided attention on the estimates of unconscious processes is the adoption of a generate-recognise retrieval strategy, where all of the exemplars that were recognised are a subset of automatically generated words (Jacoby, 1998; Jacoby et al., 1993b). Consistent with the findings obtained here, Jacoby (1998) reported a crossed interaction as function of divided attention in a word stem completion task, when inclusion and exclusion test instructions encouraged the adoption of a generate-recognise retrieval strategy for responding to test cues. In contrast, canonical process dissociation findings were obtained under task instructions that fostered a direct-retrieval strategy in the inclusion and exclusion tests. Thus, it appears to be possible to decompose the effects on inclusion and exclusion tests, and by extension, the parameters estimates, of systematically eliciting a direct-retrieval strategy and a generate-recognise strategy (Curran & Hintzman, 1995; Curran & Hintzman, 1997; Jacoby, 1998, but see Chapter 9). However, given that an independent assessment of the mode of retrieval was not utilised, these interpretations are only based on indirect evidence, in much the same way that process purity is inferred within the task dissociation approach.

The increase in the intrusion of studied items in the exclusion test accompanied by a decrease in the inclusion test as a function of increasing attentional load has been obtained elsewhere, and has been interpreted as evidence that divided attention decreases the availability of conscious recollection to
exclude items in the exclusion test and recollect items in the inclusion test (Jacoby, 1994). However, the offset between the inclusion and exclusion tests led to a crossed interaction between the parameter estimates (see, Hirshman, 1998). Several studies have also reported crossed interactions between the conscious and unconscious parameter estimates (Curran & Hintzman, 1995; Russo & Andrade, 1995; Toth et al., 1994). For example, Curran and Hintzman (1995) reported a crossed interaction between conscious and unconscious parameter estimates, whereby the estimates of conscious processes increased with presentation duration, whereas the estimates of unconscious processes decreased. Similarly, Russo and Andrade (1995) reported a crossed interaction when applying the process dissociation procedure to investigate the effect of the item-method directed forgetting cueing paradigm on word fragment completion. Unconscious processes were greater for F items than for R items, whereas conscious processes were greater for R items than for F items (the canonical item method directed forgetting effect). In both of these studies, these findings were interpreted as evidence that violations of the independence assumption produce spurious dissociations between conscious and unconscious processes.

Nonetheless, the interpretation of crossed interactions arising from the application of the process dissociation procedure have been the subject of debate. For example, Jacoby et al. (1997b) reasoned that a crossed interaction arising from a read versus generate manipulation represented evidence in support of the independence assumption. This interpretation is indeed consistent with that applied in the task dissociation literature, since crossed interactions have been considered as evidence of independence between dual processes, in the manner that double dissociations are interpreted in the clinical literature (Jones, 1987). In the context of process dissociation analyses, the reason for interpreting a crossed interaction as evidence of independence is that unconscious processes will not be invariant across all variables. However, in order to support this argument, it is necessary to contend that a variable has a simultaneously opposing effect on conscious and unconscious processes. In addition, when applied to a single variable, each level needs to be reconceptualised as two distinct variables (Russo & Andrade, 1995). Although, this is implausible for a variable such as divided attention, since this would require conceptualising each level of the divided attention manipulation as a distinct variable.

There were three factors in the experimental protocol that could have precipitated the adoption of a generate-recognise retrieval strategy, and thereby would have negated the instructions to retrieve exemplars directly: (1) excluding items on the basis of a discrete recognition judgement is generally less effortful than directly recollecting items, particularly in a completion task (Richardson-Klavehn & Gardiner, 1995); (2) the instruction to retrieve up to eight category exemplars per category name
is likely to lead to the generation of multiple legitimate response alternatives, which undergo response competition and then selection by a discrete recognition judgement; and (3) the blocked, rather than item-by-item, cueing of the inclusion and exclusion test instructions could have led to a response set that fostered the adoption of a generate-recognise retrieval strategy.

It is plausible that the mechanism underlying the retrieval of exemplars is less likely to operate according to a generate-recognise retrieval strategy when the number of response solutions required is reduced. In particular, in a study that also required up to eight exemplars for each category name following encoding under a levels of processing manipulation, Mecklenbrauker et al. (1996) also found evidence to suggest that a generate-recognise retrieval was utilised by participants. In contrast, Schmitter-Edgecombe (1999) employed a category exemplar generation task in which only two category exemplars per category name were required at test, and inclusion and exclusion tests were cued using an item-by-item procedure. However, the instruction to generate only two exemplars for each category name potentially reduces the contribution of unconscious processes, and therefore inflates the contribution of conscious processes, because it is less difficult to exclude only two exemplars. This facilitation is likely to be expressed by a high incidence of low and zero exclusion scores. Further, the requirement to respond with two exemplars per category name is likely to increase the role of strategic processes, as opposed to mnemonic retrieval (for a discussion of these issues, see Chapter 9).

With respect to the theoretical implications of an effect of divided attention on conceptual conscious and unconscious processes, it would be reasonable to assume that the component processes that mediate conceptual conscious and unconscious processes share at least some component processes, or conceptual processing mechanisms, which are different from the component processes that mediate perceptual indirect memory tests (Mulligan, 1997; Mulligan, 1998; Wagner, Gabrieli, & Verfaellie, 1997). Therefore, in addition to variables that primarily influence conceptual priming (and only minimally influence perceptual priming) such as levels of processing, organisation, and generation (Hamann, 1990; Jacoby et al., 1993b; Parkin et al., 1990; Srinivas & Roediger, 1990), divided attention may also be capable of dissociating perceptual and conceptual memory indirect memory tests (Mulligan, 1998; Schmitter-Edgecombe, 1999).

The notion that the magnitude of the effect of divided attention will differ for conceptual conscious and unconscious processes has been interpreted within a sensitivity framework (Mulligan, 1998; Mulligan & Hartman, 1996). Specifically, conceptual conscious processes are assumed to be more sensitive to variations in the amount of prior conceptual processing than conceptual unconscious
5. Age, Varying Attentional Load, and Category Exemplar Generation

processes. The sensitivity account is based on the assumption that conceptual processing operates differently when associated with conscious and unconscious processes. Although this position could not be evaluated in the current experiment, other studies that have utilised a polarised, rather than a parametric, manipulation of divided attention have found that conceptual unconscious processes are only impaired when the division of attention is particularly ‘strong’ (Gabrieli et al., 1997b; Mulligan & Hartman, 1996; Schmitter-Edgecombe, 1999). An alternative to the sensitivity account is based on hypothesised differences in the influence of spatiotemporal contextual information in conscious and unconscious processes (Humphreys et al., 1989; Jacoby & Dallas, 1981; Jacoby & Hollingshead, 1990; Schwartz, Rosse, & Deutsch, 1993). According to this view, conceptual direct memory tests are sensitive to both prior conceptual processing and contextual encoding, whereas conceptual indirect tests are primarily sensitive to prior conceptual processing. Accordingly, a conceptual direct memory test would continue to demonstrate retention after conceptual priming is at zero, because direct memory tests are also supported by contextual encoding. Although there is evidence that both conceptual and contextual processing have attentional requirements, the relationship between the memorial effects of these processes and attention are not well understood (Cowan, 1995).

As discussed in Chapters 1 and 2, the results from several studies investigating age-related differences in attention have provided only partial support for the proposal that attentional resources decline as a function of age, when measured under conditions of divided attention (e.g., Baddeley, Logie, Bressi, Della Sala, & Spinnler, 1986; Park et al., 1989). Nevertheless, an age-related decline as a function of attentional load was hypothesised for attention-demanding conscious retrieval processes, but the attentional deficit was expected to be confined to the maximum attentional load in the estimates of unconscious processes. Differential effects as a function of divided attention on conscious processes can be interpreted as evidence that there is a qualitative change in the manner in which older adults are able to divided attention at encoding. An age-related deficit was only obtained in the inclusion test under divided attention, whereas there was no significant age-related difference in the exclusion test under each attentional load. However, the magnitude of the effect of divided attention did not differ as a function of age.

It can be argued that the category exemplar generation task simply reflects the tendency to respond with studied items (Toth & Reingold, 1996), and this does not involve a significant role for conceptual processing. Consequently, age-related impairment in conceptual unconscious processes in the category exemplar generation task may only occur when conceptual processing is emphasised at encoding; however, explicitly inducing semantic elaboration at encoding is likely to increase the
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incidence of floor effects in the exclusion test. Although this position is hard to reconcile with the reliable effect of divided attention on conceptual unconscious processes in the category exemplar generation task, since this suggests that there was a role for conceptual processing. Alternatively, age-related deficits in conceptual unconscious processes may only emerge under resource demanding tasks that involve the integration, co-ordination, and monitoring of multiple sources of information (Salthouse, 1985; Welford, 1986). Additional work will be necessary to determine whether conceptual unconscious memory makes demands on cognitive resources in the same way as conceptual conscious memory, since it is clear from the effect of divided attention on conceptual conscious and unconscious (reported recently by others) that these processes are resource demanding. Therefore, it is premature to conclude that conceptual unconscious processes are immune to the effects of ageing.

In relation to the boundary conditions of the process dissociation procedure, the data do appear to be better explained in terms of the redundancy model under a generate-recognise retrieval strategy (Joordens & Merikle, 1993). Nevertheless, the findings from the current experiment do not undermine the value of the process dissociation procedure, rather they underscore the need to ensure that the appropriate boundary conditions are maintained (see also, Chapter 7).
6. Consequences of Varying Attentional Load and Ageing on Memory for New Associations: Limits on Loss?

6.0 Introduction

The early experimental work that investigated the formation of new associations between unrelated word pairs was designed to determine the conditions under which these associations could be reliably demonstrated in young adults (e.g., Graf & Schacter, 1985; Graf & Schacter, 1987; Schacter & Graf, 1989). However, as discussed in Chapter 1, associative priming tasks do not represent process pure measures of unconscious association-specific memory (e.g., Bowers & Schacter, 1990; Gooding et al., 1999; Kinoshita, 1998; McKone & Slee, 1997; Reingold & Goshen-Gottstein, 1996b). This consideration illustrates the utility of applying the process dissociation procedure to investigate memory for new associations. In addition, the conceptualisation of memory for new associations within the perceptual-conceptual processing framework has elucidated some of the principles of operation that describe the formation of new associations between unrelated word pairs (Goshen-Gottstein & Moscovitch, 1995a; Goshen-Gottstein & Moscovitch, 1995b; Reingold & Goshen-Gottstein, 1996a; Reingold & Goshen-Gottstein, 1996b; Schacter & Graf, 1989).

In particular, emphasising perceptual or conceptual encoding operations has been shown to have implications for the proportion and nature of conscious and unconscious processes that contribute to the associative word stem completion task (e.g. McKone & Slee, 1997; Reingold & Goshen-Gottstein, 1996a; Reingold & Goshen-Gottstein, 1996b). In the current experiment, the perceptual encoding paradigm developed by Reingold and Goshen-Gottstein (1996a) was employed, because in the strong cue condition of this paradigm, in which a line drawing depicting the context word at study is re-presented at test along with the corresponding context-word stem pair, associative memory for word pairs is mediated by conscious and unconscious processes. In addition, the estimates of unconscious processes are well above baseline.

As discussed in Chapter 1, although perceptual operations are encouraged by the perceptual encoding paradigm, the encoding of the word pairs is not exclusively located at a pre-semantic level, since, for example, the reading out aloud of a word pair requires access to the semantic properties of the words (Seidenberg & McClelland, 1989). In addition, it has been argued that unrelated word pairs undergo storage and reactivation in semantic memory (Schacter, 1994a), and
may also undergo semantic, elaborative processing as a consequence of an encoding strategy that may develop spontaneously at encoding (Goshen-Gottstein & Moscovitch, 1995b). Therefore, the functional properties that distinguish the perceptual and conceptual associative word stem completion task have not, as yet, been specified with sufficient detail.

One approach that has been employed to provide a more precise theoretical specification of the processes that mediate perceptual- and conceptual-associative memory tasks is the functional dissociation strategy. For example, Goshen-Gottstein and Moscovitch (1995a) reported that the magnitude of associative priming in a perceptual-associative lexical-decision task was not influenced by a levels of processing manipulation, but was impaired by a cross-modal manipulation of stimulus form between study and test (see also, Moscovitch, 1994b; Schacter & Graf, 1989). If it is assumed that the findings from item-specific memory tasks can be abstracted as a conceptual analogue to interpret the effect of the same variables on association-specific memory tasks, these results suggests that the role of conceptual processes in the perceptual-associative lexical decision task are minimal, because perceptual item-specific priming is also only slightly influenced by a levels of processing manipulation (Thapar & Greene, 1994), and largely eliminated by a cross-modal manipulation between study and test (Rajaram & Roediger, 1993).

The current experiment investigated the effect of a parametric manipulation of attentional load at encoding on the perceptual-associative word stem completion task. The manipulation of attention utilised was identical to that employed in Experiment 1. One of the primary motivations for conducting this experiment was to obtain data to describe the function between attention at encoding and memory for new associations. From the perspective of the transfer appropriate processing view, the perceptual encoding operations and perceptually related retrieval cues are expected to foster perceptually-driven processes, which are sensitive to the amount of attention available at encoding when associated with conscious processes (e.g., Craik et al., 1994; Mulligan, 1998; Roediger et al., 1992, for a discussion of this interpretation and experiments that support this position, see Chapters 1 and 3).

Nonetheless, if it is assumed that there is a significant involvement of conceptual processing in 'perceptual-associative' unconscious processes (Rybash, 1996), an effect of divided attention on these processes would still be compatible with the transfer appropriate processing framework, because a determinant of the operation of conceptual processing is the availability of attention (Mulligan, 1997; Mulligan, 1998). A theoretically more principled approach to the interpretation of the effect of divided attention on perceptual-associative unconscious processes is the interactive activation model, in which orthographic, phonological and semantic components dynamically
interact with one another (Micco & Masson, 1991). However, this model is less able to explain some of the findings that have been explained by the transfer appropriate processing framework, such as the relative immunity of perceptual priming to conceptual variables (e.g., Schacter, 1992a).

As discussed in Chapters 1 and 3, the attentional view assumes that only those processes that are associated with conscious retrieval are attention demanding (Besson et al., 1992b; Jacoby et al., 1993b; Jacoby et al., 1989, discussed in Chapters 1, 3 and 5). Therefore, in order to interpret an effect of divided attention on automatic, unconscious processes, the notion of context-dependence needs to be invoked (Jacoby, Ste Marie, & Toth, 1993a; Neumann, 1984; Toth, 1996); that is, the demands of the memory task modulates the nature of processes that mediate unconscious retrieval. This more relativistic perspective can sustain, at least in principle, an effect of divided attention on perceptual-associative unconscious processes. However, process dissociation theorists would not extend this perspective to interpret an effect of attention on unconscious processes, because these processes are assumed, by definition, to be automatic, and are consequently not sensitive to the availability of attention (Jacoby, 1994).

Evidently, the two principle frameworks available to interpret the effects of divided attention at encoding on memory require additional assumptions to interpret an effect of divided attention on perceptual unconscious processes. Therefore, on the basis of the convergence between the transfer appropriate processing framework and attentional views in relation to the effect of divided attention on perceptual unconscious processes, it was predicted that the estimates of perceptual-associative unconscious processes would be invariant across each level of attentional load, whereas the increasing attentional load would lead to a decline in the estimates of perceptual-associative conscious processes.

From the perspective of cognitive ageing, it was argued in Chapter 1 that older adults are particularly impaired in direct memory tests that involve the formation of new associations (La Voie & Light, 1994; Light, 1991; Rybash et al., 1998). These findings are consistent with hypothesis that older adults experience transmission deficits in the nodes that constitute a network representation of a newly formed association (MacKay & Burke, 1990), as well as an impairment in the ability to engage in self-initiated constructive operations (Craik, 1983). In contrast, associative priming appears to be preserved in older adults under conditions of self-paced, elaborative encoding, or following two or more study opportunities (Howard et al., 1991; Howard et al., 1986; Rabinowitz, 1986). However, all of these experimental conditions increase the probability that the associative priming task will be compromised by conscious retrieval (Roediger & McDermott, 1993; Rybash, 1994; Rybash et al., 1998). For example, Rybash et al. (1998) reported that a conceptual-associative
word stem completion task was mediated by conscious retrieval in both young and older adults, and age-related deficits were obtained in the conscious parameter estimates when the age-group analyses excluded young adults with zero exclusion scores. However, the application of conceptual encoding instructions and a low baseline rate of performance precluded an analysis of age-related effects that may have been present in the unconscious parameter estimates.

In the current experiment, the application of the process dissociation procedure to the perceptual-associative word stem completion task provided a basis for rapprochement between the notions that age-related impairment in associative priming reflects contamination by conscious processes or encoding instructions that are conceptually-oriented. Specifically, age-related impairment in single-trial conceptual associative priming has been attributed to deficits in semantic, elaborative processing (Howard, 1988a; Howard et al., 1991), but associative priming also appears to be inextricably linked under conceptually-oriented encoding conditions to conscious processes (Rybash et al., 1998). In contrast, as discussed earlier, the 'strong cue' perceptual encoding paradigm leads to association-specific memory mediated by conscious and unconscious processes (Reingold & Goshen-Gottstein, 1996a), rather than conscious processes alone (Reingold & Goshen-Gottstein, 1996b; Rybash et al., 1998). Therefore, the perceptual encoding paradigm provided the conditions necessary to investigate whether or not age-related deficits are present in veridical estimates of unconscious processes that are invoked following perceptually-oriented encoding.

It was hypothesised that the conscious parameter estimates would be impaired in older adults given the negative effect of ageing on conscious retrieval (Craik & Jennings, 1992; Light, 1991; Rybash, 1996). In contrast, age-related deficit in unconscious processes were hypothesised to be eliminated under perceptually-oriented encoding conditions, because it has been argued that perceptual processing is not as prone to an age-related decline as conceptual-semantic processing (Light, 1991; Rybash, 1996). One source of evidence to support this position is that the provision of a perceptually-oriented encoding environment reduces age-related deficits that may be present in indirect item-specific memory tests, but not in direct memory tests (Mitchell, 1993). In contrast, MacKay and Burke (1990) argued that older adults are impaired in their ability to form new associations, and this deficit would be expressed for new associations retrieved using both conscious and unconscious processes.

Several boundary conditions for the appropriate application of the process dissociation procedure have been identified (Jacoby, 1998; Jacoby et al., 1997a). For the present purposes, the most fundamental condition is the adoption of a direct-retrieval strategy for the completion of test cues, since this is intended to ensure that the independence assumption and an equivalent response
6. Age, Varying Attentional Load, and Perceptual-associative Word stem Completion

criterion between test conditions are maintained. Accordingly, the adoption of a direct-retrieval strategy was encouraged by providing explicit instructions explaining the distinction between a direct-retrieval strategy and a generate-recognise retrieval strategy, in addition to an opportunity to practice a direct-retrieval strategy at test. The adoption of a generate-recognise retrieval strategy was also potentially curbed by the instruction to complete each word stem with a five-letter word, since this limits the number of legitimate solutions and the corresponding response competition that the retrieval candidates undergo. Indeed, under these circumstances a generate-recognise retrieval strategy is not less effortful. An additional consequence of limiting the number of legitimate response solutions is that the opportunity to operate strategically, as opposed to relying on mnemonic processes, is reduced (for a discussion of this issue, see Chapter 9). For example, participants would not be able to adopt a strategy that involves completing word stems with low frequency words in the exclusion test in order to avoid intrusion errors, as would be the case with test instructions that do not constrain the length of the response word (e.g. Rybash et al., 1998).

6.1 Method

6.1.1 Participants

The participants were 48 young (Mean = 21.5 years of age; Range = 18-30 years of age; N males = 17; N females = 31) and 48 older adults (Mean = 68.9 years of age; Range = 61-78 years of age; N males = 14; N females = 34). The young adults had a mean of 15.3 years of education, whereas the older adults had a mean of 16.9 years of education. The mean MMSE score for the older adults was 29.1.

6.1.2 Design and Materials

A 2 x 3 x 3 x 2 mixed factorial design was employed, whereby age (young and older adults) was a between participants factor, and attentional load (0-load, 3-item load, and 5-item load), test trial type (intact, recombined, and control), and test instruction (inclusion and exclusion) were within participants factors.

One hundred and forty-four context-word stem pairs were assigned to one of three main study lists, with each main study list comprised of 48 words. In each of the three study lists, all of the words were assigned to one of the three attentional load conditions: 0-item load, 3-item load, and 5-item load. 16 of the 48 study words were assigned to the intact test trials, 16 to the recombined test trials, and 16 to the control test trials. Two base test lists were generated. In each test list, half of the
intact, recombined, and control word pairs were cued with inclusion test instructions, whereas the remaining half of the intact, recombined, and control word pairs were cued with exclusion test instructions.

6.1.3 Procedure

All of the participants performed the divided attention task in accordance with the procedure described in the General Methods Chapter. At study, the presentation of each word pair and line drawing was initiated by pressing the space bar in response to the prompt, 'Press the Spacebar to Continue'. A fixation point remained on the screen for 250ms and was then replaced with a word pair and line drawing, which remained on the screen for 5 seconds. All participants were instructed to read each word pair out aloud while the words remained on the screen and also direct their attention to the line drawing that appeared above the word pair. The participants were informed of the relation between the line drawing and the context word.

After the presentation of the study list, participants performed the associative word stem-completion task. The presentation of each context-word stem pair was initiated by pressing the space bar on the computer, prompted by the appearance of the message, 'Press Spacebar to Continue', on the screen. A fixation point appeared in the centre of the screen for 500ms. Then, a context-word stem pair appeared and remained on the screen for 10 seconds. The test status and retrieval instructions associated with each context-target word stem pairs was indicated by the presence of the word 'OLD' or the word 'NEW' below each word pair, in accordance with the procedure presented in the General Methods Chapter. No explanation was provided in relation to the function of the context word. For both the inclusion and exclusion tests, the participants were provided with practice test sessions in order to ensure familiarity with the task requirements.

6.2 Results

The mean proportion of digit-letter sequences that were correctly recalled for the 0-item, 3-item, and 5-item attentional load was .97, .95, and .96 for the young adults, respectively, and .97, .99, and .95 for the older adults, respectively. Thus, young and older adults were able to recall digit-letter sequences, and this did not vary as a function of attentional load and age, ps > .25. Similarly, the identification of word pairs did not vary as a function attentional load and age, ps > .05.

The mean proportions of word stems completed with studied words in each experimental condition are presented in Table 6.1. The data from the inclusion and exclusion tests were submitted to a 2
(age: young vs. old) x 2 (test instruction: inclusion vs exclusion) x 3 (attentional load: 0-load, 3-item load, and 5-item load) x 2 (test trial type: intact vs recombined) mixed factors ANOVA. The main effects of age, $F(1, 70) = 10.30, p < .01$, test instruction, $F(1, 70) = 60.93, p < .001$, and test trial type, $F(1, 70) = 183.24, p < .001$, were all significant. Significant interactions were obtained between age and test instruction, $F(1, 70) = 7.30, p < .01$, age and test trial type, $F(1, 70) = 14.49, p < .001$, test instruction and attentional load, $F(2, 140) = 22.42, p < .001$, and test instruction and test trial type, $F(1, 70) = 25.56, p < .001$. In addition, significant interactions were obtained between age, test instruction, and test trial type, $F(1, 70) = 19.07, p < .001$, and among test instruction, attentional load, test trial type, $F(2, 140) = 16.34, p < .001$.

Table 6.1. Mean proportion of studied target words generated in response to word stems in the experimental conditions.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Attentional Load</th>
<th>0</th>
<th>3</th>
<th>5</th>
<th>0</th>
<th>3</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inclusion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>0-item load</td>
<td>0.53</td>
<td>0.52</td>
<td>0.41</td>
<td>0.31</td>
<td>0.30</td>
<td>0.35</td>
</tr>
<tr>
<td>Old</td>
<td>0-item load</td>
<td>0.42</td>
<td>0.37</td>
<td>0.31</td>
<td>0.28</td>
<td>0.31</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>3-item load</td>
<td>Intact Condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>0.32</td>
<td>0.31</td>
<td>0.28</td>
<td>0.26</td>
<td>0.27</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>Old</td>
<td>0.30</td>
<td>0.30</td>
<td>0.29</td>
<td>0.25</td>
<td>0.26</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5-item load</td>
<td>Recombined Condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>0.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old</td>
<td>0.19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 = 0-item load, 3 = 3-item load, and 5 = 5-item load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the young adults, a significant association-specific memory effect was obtained in the inclusion test for the 0-item load, $F(1, 70) = 101.49, p < .001$, 3-item load, $F(1, 70) = 123.04, p < .001$, and 5-item load, $F(1, 70) = 41.19, p < .001$. Similarly, a significant association-specific memory effect was obtained in the exclusion test for the 0-item load, $F(1, 70) = 5.94, p < .05$, and 5-item load, $F(1, 70) = 11.39, p < .001$, but the effect did not reach significance for the 3-item load, $F(1, 70) = 3.47, p = .07$. In the older adults, a significant association-specific memory effect was obtained in the inclusion test for the 0-item load, $F(1, 70) = 34.53, p < .001$, 3-item load, $F(1, 70) = 13.67, p < .001$, but not for the 5-item load, $F(1, 70) = 1.47, p = .23$. For the exclusion test, there was evidence of a significant association specific memory effect for the 3-item load, $F(1, 70) = 7.82, p < .01$, and the
5-item load, \( F(1, 70) = 19.01, p < .001 \), but not for the 0-item load, \( F(1, 70) = 1.48, p = .23 \). In relation to the age effects, there was a significant age-related difference in the association-specific memory effect in the inclusion test for the 0-item, 3-item, and 5-item attentional loads, \( F(1, 70) = 8.80, p < .01 \), \( F(1, 70) = 27.34, p < .001 \), and \( F(1, 70) = 13.54, p < .001 \), respectively. In contrast, in the exclusion test the association-specific memory effect did not differ significantly at each level of attentional load as a function of age, \( F_s < 1 \).

The results of the analyses performed on the inclusion and exclusion test data in order to evaluate the effect of attentional load are presented in Table 6.1. Briefly, it is apparent that there were significant effects of attentional load in both the young and older adults. In the inclusion test, there was evidence of an incremental decline in performance as a function of increasing attentional load in the older adults, whereas in the young adults the effect of attentional load was restricted to the contrasts between the 0- vs. 5-item loads and 3- vs. 5-item loads. In the exclusion test, a significant effect of attentional load was obtained between the 3- vs. 5-item loads in the young adults, whereas, in the older adults, a significant effect of attentional load was obtained between the 0- vs. 5-item loads and 3- vs. 5-item loads.
Table 6.2. Results of the analyses performed on the proportion of studied words correctly generated in response to word stems to evaluate the effect of attentional load.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Inclusion</th>
<th></th>
<th>Exclusion</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Attentional Load Contrast</td>
<td>Attentional Load Contrast</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 vs. 3</td>
<td>0 vs. 5</td>
<td>3 vs. 5</td>
<td>0 vs. 3</td>
</tr>
<tr>
<td>Young</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F(1,70) =</td>
<td>0.28</td>
<td>27.04</td>
<td>36.48</td>
</tr>
<tr>
<td></td>
<td>p =</td>
<td>.60</td>
<td>.001</td>
<td>.001</td>
</tr>
<tr>
<td>Old</td>
<td>F(1,70) =</td>
<td>6.89</td>
<td>25.42</td>
<td>11.71</td>
</tr>
<tr>
<td></td>
<td>p =</td>
<td>.01</td>
<td>.001</td>
<td>.001</td>
</tr>
<tr>
<td>Young</td>
<td>F(1,70) =</td>
<td>0.24</td>
<td>2.60</td>
<td>1.27</td>
</tr>
<tr>
<td></td>
<td>p =</td>
<td>.62</td>
<td>.11</td>
<td>.26</td>
</tr>
<tr>
<td>Old</td>
<td>F(1,70) =</td>
<td>0</td>
<td>0.42</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>p =</td>
<td>1.00</td>
<td>.52</td>
<td>.52</td>
</tr>
</tbody>
</table>

Contrasts that reached significance are indicated in bold.

The conscious and unconscious parameters estimates were calculated in accordance with the computational expressions for the process dissociation procedure outlined in Chapter 2. The parameter estimates of conscious and unconscious processes for each experimental condition are shown in Table 6.3. A 2 (age: young vs. old) x 2 (memory parameter: conscious vs. unconscious) x 3 (attentional load: 0-item vs. 3-item vs. 5-item) x 2 (test trial type: intact vs. recombined) mixed factors ANOVA was performed. The main effects of age, $F(1, 70) = 18.74$, $p < .001$, memory parameter, $F(1, 70) = 281.57$, $p < .001$, attentional load, $F(2, 140) = 25.65$, $p < .001$, and test trial type, $F(1, 70) = 152.34$, $p < .001$, were all significant. Importantly, the interaction between attentional load and memory parameter was significant, $F(2, 140) = 10.44$, $p < .001$, indicating the differential effect of attentional load across the memory parameter estimates. In addition, the interaction between age and test trial type, $F(1, 70) = 38.23$, $p < .001$, and between attentional load and test trial type, $F(2, 140) = 16.88$, $p < .001$, were also significant. Finally, the interactions among age, memory parameter, and test trial type, $F(1, 70) = 4.0$, $p < .05$, and memory parameter, attentional load, test trial type, $F(2, 140) = 9.18$, $p < .001$, were also significant.
Table 6.3. Conscious and unconscious parameter estimates for each experimental condition.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Conscious Attentional Load</th>
<th>Unconscious Attentional Load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Intact Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>0.22</td>
<td>0.21</td>
</tr>
<tr>
<td>Old</td>
<td>0.15</td>
<td>0.06</td>
</tr>
<tr>
<td>Recombined Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>0.06</td>
<td>0.04</td>
</tr>
<tr>
<td>Old</td>
<td>0.05</td>
<td>0.05</td>
</tr>
</tbody>
</table>

0 = 0-item load, 3 = 3-item load, and 5 = 5-item load.

In the young adults, there was a significant conscious association-specific memory effect for the 0-item load, \( F(1, 70) = 32.38, p < .001 \), 3-item load, \( F(1, 70) = 40.22, p < .001 \), but not the 5-item load, \( F(1, 70) = 2.07, p = .15 \). In addition, there was evidence of a significant unconscious association-specific memory effect for the 0-item load, \( F(1, 70) = 31.23, p < .001 \), 3-item load, \( F(1, 70) = 41.32, p < .001 \), and 5-item load, \( F(1, 70) = 26.01, p < .001 \). In the older adults, a significant conscious association-specific memory effect was obtained for the 0-item load, \( F(1, 70) = 11.96, p < .001 \), and 5-item load, \( F(1, 70) = 7.07, p < .01 \), but not for the 3-item load, \( F(1, 70) = 0.53, p = .40 \). Further, there was a significant unconscious association-specific memory effect for the 0-item load, \( F(1, 70) = 7.92, p < .01 \), 3-item load, \( F(1, 70) = 14.69, p < .001 \), and 5-item load, \( F(1, 70) = 16.70, p < .001 \).

In relation to the effects of age at each attentional load, the age-related difference in the conscious association-specific memory effect was significant at the 3-item and 5-item loads, \( F(1, 70) = 16.29, p < .001 \), \( F(1, 70) = 8.41, p < .01 \), respectively, but not at the 0-item load, \( F(1, 70) = 2.47, p = .12 \). Although the unconscious association-specific memory effect was significant in the older adults, there was evidence of an age-related difference for the 0-item load that approached significance, \( F(1, 70) = 3.84, p = .053 \). There was no evidence of an age-related difference in the unconscious association-specific memory effect for the 3-item load, \( F(1, 70) = 3.36, p = .07 \), and 5-item load, \( F(1, 70) = 0.51, p = .48 \).

The manipulation of attentional load in the young adults led to a significant difference between the 0-item and 5-item load, \( F(1, 70) = 8.41, p < .01 \), and between the 3-item and 5-item load, \( F(1, 70) = 12.52, p < .001 \), for the conscious association-specific memory effect, whereas none of the contrasts
between each level of attentional load was significant for the unconscious association-specific memory effect, \( F_s > 1 \). In the older adults, the manipulation of attentional load led to a significant difference between the 0-item and 3-item load, \( F(1, 70) = 4.18, p < .05 \), between the 3-item and 5-item load, \( F(1, 70) = 7.69, p < .01 \), and between the 0-item and 5-item load, \( F(1, 70) = 20.89, p < .001 \), whereas none of the contrasts between each level of attentional load was significant for the unconscious association-specific memory effect, \( F_s > 1 \). Finally, there was no evidence for a significant age-related difference in the effect of attentional load in the conscious and unconscious association-specific memory effect, \( ps > .05 \).

Table 6.4 presents the results of the analyses performed on the conscious and unconscious parameter estimates in order to evaluate the effect of attentional load in the intact and recombined conditions. Briefly, it is apparent that the effect of attentional load in the young and older adults was restricted to the conscious parameter estimates in the intact condition. However, as observed for the inclusion tests, there was an age-related dissociation as a function of increasing attentional load, since there was an incremental decline in the conscious parameter estimates across each attentional load in the older adults, whereas in the young adults only the contrasts between 0- vs. 5-item load and 3- vs. 5-item load were significant.

### Table 6.4. Results of the analyses performed on the memory parameter estimates to evaluate the effect of attentional load.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Conscious Attendance Load Contrast</th>
<th>Unconscious Attendance Load Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 vs. 3</td>
<td>0 vs. 5</td>
</tr>
<tr>
<td><strong>Intact Condition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>( F(1,70) = 0.06 )</td>
<td>( F(1,70) = 24.96 )</td>
</tr>
<tr>
<td></td>
<td>( p = .81 )</td>
<td>( p = .001 )</td>
</tr>
<tr>
<td>Old</td>
<td>( F(1,70) = 8.24 )</td>
<td>( F(1,70) = 37.29 )</td>
</tr>
<tr>
<td></td>
<td>( p = .01 )</td>
<td>( p = .001 )</td>
</tr>
<tr>
<td><strong>Recombined Condition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>( F(1,70) = 0.56 )</td>
<td>( F(1,70) = 1.72 )</td>
</tr>
<tr>
<td></td>
<td>( p = .45 )</td>
<td>( p = .19 )</td>
</tr>
</tbody>
</table>
6. Age, Varying Attentional Load, and Perceptual-associative Word stem Completion

<table>
<thead>
<tr>
<th>Old</th>
<th>3.16</th>
<th>0.11</th>
<th>0.06</th>
<th>0</th>
<th>0.30</th>
<th>0.34</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F(1,70) =</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p =</td>
<td>0.09</td>
<td>0.74</td>
<td>0.80</td>
<td>0.98</td>
<td>0.59</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Significant contrasts are indicated in bold.

### 6.3 Discussion

Given that conscious and unconscious parameter estimates in the intact condition exceeded the recombined condition in both young and older adults, for at least two levels of attentional load, it was inferred that the reinstatement of associative context led to association-specific memory that was mediated by conscious and unconscious processes. In both the young and older adults, the association-specific memory effect was more robust when mediated by unconscious processes, as a function of increasing attentional load. Furthermore, the locus of the age-related deficit was limited to the conscious parameter estimates, since age-invariance was obtained in the estimates of unconscious processes. The extant experimental findings, and those reported by Rybash et al. (1998), support the notion that ageing and divided attention effect the contribution of conscious processes for association-specific information. In particular, the conscious parameter estimates declined as a function of the increasing attentional load, whereas the unconscious parameter estimates remained invariant. More generally, these data are consistent with the claim made by Craik and Byrd (1982) that dividing attention at study can mimic the effects of ageing.

Under the five-item attentional load condition, task performance was primarily, or entirely in the older adults, mediated by unconscious processes, which replicates the findings reported in previous process dissociation analyses and suggests that these processes did not demand attentional resources (e.g., Jacoby et al., 1993b). Similarly, Jacoby and colleagues have reported invariance as a function of divided attention at encoding for unconscious parameter estimates in a word-stem completion task (Jacoby et al., 1993b), a recognition memory task (Jacoby et al., 1993b), a paired-associates memory task (Jacoby, 1994; Jacoby, 1996), and a fame judgement task (Jacoby et al., 1989). In the older adults, the varying attentional load described a linear function across the region that was sampled for the conscious parameter, whereas in the young adults only the 5-item load impaired the conscious parameter estimates relative to the estimates obtained in the full attention condition. Importantly, the presence of an effect of divided attention on the conscious parameter estimates excludes the possibility that the invariance in the unconscious parameter estimates was due to an ineffective manipulation of attention.

As discussed in the introduction, one approach that has been adopted to the interpret the effects of a
variable on an association-specific memory task is to compare the findings with those obtained in an item-specific memory task. For example, Schacter and Graf (1989) reported that the cross-form presentation of materials between study and test impaired priming in conceptual-associative word stem completion; this effect has also been demonstrated in perceptual item-specific priming (Roediger & Blaxton, 1987). Schacter and Graf (1989) and Schacter and McGlynn (1989) argued that these findings can be reconciled with the transfer appropriate processing framework if it is assumed that the processes that support the retrieval of the association-specific information are perceptually-based, whereas the encoding and storage of the associations require deeper relational processing. However, evidence of an unconscious associative-specific memory in the current experiment, independent of the amount of attention available at encoding and under encoding operations that emphasised perceptual encoding operations, suggests that this explanation may be insufficient.

Evidence that the reinstatement of context led to association-specific memory mediated by conscious and unconscious processes is consistent with the tenets of the transfer appropriate processing framework and the encoding specificity principle. In the current design, unitisation may occur as a result of the formation of a perceptually distinctive representation (Reingold & Goshen-Gottstein, 1996a), or reflect the formation representations in two different codes (Paivio, 1971). The introduction of the distinction between conceptually and perceptually-oriented associative-specific memory represented an important advance in understanding age-related differences in memory for new associations. The direct implication of these findings is that older adults may be able to generate veridical single-trial associative priming, when the encoding operations are perceptually-oriented and provide considerable environmental support. The superior recall of pictures relative to words has been shown to only occur in older adults when pictures are named, whereas in young adults it is sufficient to present the pictures in order to obtain superior recall relative to words presented in isolation (Rissenberg & Glanzer, 1986). Further, Backman (1989) posited a compensatory role for the dual encoding of pictures and words, whereby age-related differences are smaller under such dual encoding conditions relative to words alone. In addition, varying the reinstatement of associative context in the intact as compared to the recombined condition reflected a systematic manipulation of environment context that influenced both the estimates of conscious and unconscious processes.

The absence of a deficit in the estimates of perceptual-associative unconscious processes in older adults, coupled with the dissociative effect of divided attention, suggests that perceptual-associative memory processes are functionally distinct from those that are encoded under conceptual encoding. However, in order to fully evaluate this position, it will be necessary to replicate the current
experiment with an associative word stem completion task modified to emphasise conceptual encoding operations. The two studies that have examined the effect of divided attention on conceptual-associative word stem completion are only of limited relevance because attentional load was varied at retrieval. Briefly, Kinoshita (1998) reported that the magnitude of conceptual-associative word stem completion priming was impaired under divided attention; this effect was mediated by a decline in the retrieval of the intact word pairs and an increase in the retrieval of recombined word pairs. In contrast, Gooding et al. (1999) reported that divided attention did not have an affect on conceptual-associative word stem completion priming, whereas the corresponding direct conceptual-associative word stem completion task was impaired under divided attention. The discrepant effects of divided attention on the conceptual-associative priming obtained in these two studies may reflect the greater opportunity to switch between the primary and secondary tasks in the Gooding et al. (1999) study.

As discussed in the introduction and Chapter 3, the transfer appropriate processing view predicts an effect of divided attention only when a memory task is mediated by a strong conceptual component. In addition, the current findings were also consistent with the attentional view, because unconscious processes are conceptualised as automatic, and therefore immune to the effects of varying attentional load at encoding. Nonetheless, given that even a canonical perceptually-based task such as perceptual identification involves conscious retrieval mediated by conceptual processes (Richardson-Klavehn et al., 1994b), it is plausible to assume that the effect of attention on the conscious parameter estimates obtained in the current experiment reflected the contribution of conceptual processes, despite prior perceptual, elaborative processing. Similarly, it has been argued that despite canonical perceptual encoding and cueing conditions, perceptual indirect memory tasks may also be mediated by a conceptual and/or lexical access component (Masson & MacLeod, 1992; Weldon, 1991; Weldon & Jackson-Barrett, 1993).

Overall, the magnitude of the effect of divided attention on the conscious parameter estimates did not differ as a function of age. Further, the fact that older adults were equally capable of performing the retention of the digit-letter sequence and identifying the critical items at encoding eliminates the possibility that the equivalent levels of association-specific unconscious memory in young and older adults were due to different levels of secondary task performance between the two age groups. It is possible that the age-related deficit in the estimates of conscious processes that accompanied the incremental increase in attentional load may reflect a reduction in the amount of elaborative processing necessary to instantiate a new association. Further, the extant data is inconclusive regarding the locus of the age-related deficits in memory for new associations in relation to whether the encoding and/or retrieval processes are impaired.
From a broader theoretical perspective, the evidence of intact single-trial associative unconscious memory is particularly interesting. In particular, the encoding and storage processes that mediate the formation of new associations are presumably equivalent for items that undergo conscious and unconscious retrieval, although it is still possible that the association strength necessary for an item to become available for unconscious retrieval may be less than that for conscious retrieval (Anderson, 1983). Association strength has also been applied to interpret age-related differences in the formation of new associations. For example, MacKay and Burke (1990) argued that older adults experience weakened linkages between connections that support formation of new representations, which result in impairment in the conscious and unconscious retrieval of associative information. However, the current findings do not support this position either. Therefore, there is a need to replicate these findings and identify the differences or associations between perceptual-associative conscious and unconscious processes. Accordingly, two additional experiments were conducted using the basic perceptual-associative word stem completion paradigm. These experiments are presented in Chapter 8.

Several features of the experimental protocols that were utilised warrant further attention in relation to the boundary conditions of the process dissociation procedure. Firstly, the completion of the target word stems was restricted to the same length as the words at study. However, this feature of the design departs from the canonical procedure utilised in foregoing studies that have investigated associative word stem completion, since target word stems can be typically completed with at least five different words that are not constrained by word length. The implications of this departure for the magnitude of the response competition among the retrieval candidates and the demands imposed by the task instructions have not been articulated within the process dissociation framework (for additional discussion of these issues, see Chapter 9).

As discussed in Chapter 2, the retrieval strategy employed by participants is a critical determinant for applying the appropriate relational model to describe the data. It is unlikely that the completion of target word stems in the inclusion and exclusion tests reflected the operation of a generate-recognise retrieval strategy, which would violate the core independence assumption of the process dissociation procedure. Apart from the two verification criteria suggested by Jacoby (1998), the only other method available to evaluate inclusion and exclusion test compliance are low estimates in conscious processes (Jacoby et al., 1997a); however, this is of limited value given the between age groups design. Nonetheless, in the absence of data to the contrary, it was assumed that a direct retrieval strategy was employed by the participants in the current experiment.
7. Category Exemplar Generation: A Contrast of Item and List Method Directed Forgetting

To further dissociate the contributions of conceptual conscious and unconscious processes, the two basic directed forgetting paradigms, item method and list method cueing (Basden & Basden, 1998), were investigated in two experiments. To date, there have been no published studies that have investigated the effect of either item or list method directed forgetting on the category exemplar generation task. The theoretical implications of the findings obtained in the following two experiments relate to the two principle mechanisms that are generally accepted to support the item and list method directed forgetting effect, the differential rehearsal of to-be-remembered (R) and to-be-forgotten (F) items and retrieval inhibition of a to-be-forgotten study list (e.g., Allen & Vokey, 1998; Basden & Basden, 1996; Basden & Basden, 1998; Bjork & Bjork, 1996), respectively. A condition for the operation of both of these mechanisms is the differentiation between R and F items (Bjork, 1989), which is, in part, supported by item-specific and relational processing (Basden et al., 1993).

As discussed in Chapter 3, the two basic mechanisms of directed forgetting, differential rehearsal and inhibition, have direct implications for the evaluation of at least two of the principle accounts of cognitive ageing. Further, although the primary mechanism for the item method directed forgetting effect is differential rehearsal, it has been proposed that inhibition may operate as an ancillary mechanism in the item method to terminate the rehearsal of individual F cued items (Zacks et al., 1996). In contrast, in the canonical, between-participants implementation of the list method paradigm, an inhibition based mechanism occupies a central role in the inhibition of a list of F cued items following the onset of the mid-list instruction (Bjork et al., 1998; Zacks & Hasher, 1994; Zacks et al., 1996). Accordingly, the primary determinant of the magnitude of the list method directed forgetting effect is assumed to be the efficiency of attentional inhibition. Thus, evidence of an age-related impairment in the list method directed forgetting effect may reflect a deficit in the inhibition acting on a F study list, whereas evidence of an age-related decline in the item method directed forgetting effect may reflect an inability to differentially rehearse R and F cued items at encoding that results, in part, from an impaired ability to inhibit the item-specific rehearsal of F cued items.

Given that indirect memory tests that are mediated by semantic, strategic or organisational cognitive operations are susceptible to age-related deficits (Jelicic, 1996; Rybash, 1996), additional research
using the basic category exemplar generation paradigm is warranted in order to establish whether or not the age-related invariance in conceptual priming is a reliable finding, when a veridical measure of conceptual unconscious processes is obtained. A potential determinant of the failure to obtain evidence of an age-related impairment in conceptual priming is that the explicit, conceptual encoding of category exemplars is not always encouraged, which may lead to a minimal role for conceptual unconscious processes. Thus, an additional motivation for employing the item method paradigm was that the differential encoding strategy engendered by this paradigm encourages the elaborative, conceptual encoding of R cued exemplars and shallow encoding of F cued exemplars, as an analogue of a levels of processing manipulation.

7.1 Category Exemplar Generation: Boundary Conditions for the Measurement of Conceptual Unconscious Processes

The experimental protocols employed in the following two experiments are also relevant for evaluating the boundary conditions under which conceptual unconscious processes can be investigated using the process dissociation procedure. In this regard, the principle issue that arose in Experiment 1 was that the parameter estimates appeared be biased by the adoption of a generate-recognise strategy, which led to the violation of the core assumptions of the process dissociation model (see also, Russo et al., 1998). Consequently, some aspects of the design and instructions that were utilised in Experiment 1 were changed for Experiments 3 and 4. Specifically, the retrieval instructions were changed in order to reduce the likelihood that the retrieval orientation would again result in the adoption of a generate-recognise retrieval strategy. This involved providing the participants with explicit examples of a generate-recognise and direct-retrieval strategy within the context of the retrieval demands of the category exemplar generation task. In studies that have applied the process dissociation procedure, the test instructions have not conformed to a canonical template, since the instruction to adopt a direct-retrieval strategy has been explicitly mentioned in some studies (e.g., Jacoby et al., 1993b, Experiments 1 and 2), but not in others (e.g., Jacoby et al., 1993b, Experiments 3 and 4; Toth et al., 1994). The requirement to provide multiple solutions for each category name was maintained, because the alternative approach of instructing participants to only respond with two exemplars is likely to invoke strategic methods for completing the inclusion and exclusion tests, rendering the findings equivocal with respect to the examination of memory effects, per se (for a more detailed discussion of this issue, see Chapters 5 & 9). Finally, the inclusion and exclusion tests were presented using a mixed design, rather than a blocked design, in order to reduce the likelihood that the participants would adopt a response set that favoured a generate-recognise retrieval strategy.
However, it may not be possible to ensure that participants operate in accordance with the direct-retrieval strategy in the context of a category exemplar generation task that requires more than two responses to each retrieval cue (cf. Schmitter-Edgecombe, 1999). One plausible explanation for the inability to retrieve items in accordance with the direct-retrieval instructions under these conditions may be that conceptual conscious and unconscious processes are inextricably linked with conscious awareness, as conceptualised within the construct of involuntary conscious memory (Richardson-Klavehn et al., 1994a; Richardson-Klavehn et al., 1996). This difficulty may not be limited to conceptual memory tasks, since performance in inclusion and exclusion tests of perceptual memory tasks may also reflect the adoption of a generate-recognise strategy (e.g., Richardson-Klavehn & Gardiner, 1998), despite instructions designed to preclude the use of this retrieval strategy and in the absence of the two identifiers of a generate-recognise retrieval strategy (Bodner, Masson, & Caldwell, 2000). Further, Reder, Wibble, and Martin (1986) demonstrated that the direct-retrieval strategy cannot always be engaged by older adults. Therefore, the following two experiments provided a formal assessment of the ability to implement the category exemplar generation memory task in accordance with the core assumptions of the process dissociation procedure.
7.2 Experiment 3: Category Exemplar Generation: Item Method Directed Forgetting Effect

7.2.1 Introduction

The item method directed forgetting effect is a product of the individual cueing of a critical item with either a cue to forget (F) or to remember (R), and has been explained in terms of differential rehearsal at encoding (e.g., Basden & Basden, 1998; Basden et al., 1993). The primary ancillary mechanism that has been proposed to support the item method directed forgetting effect is inhibition at encoding. However, since these processes operate alone on a subset of individual targets, they are not sufficient to support the item method directed forgetting effect (Basden & Basden, 1998; Basden et al., 1993). Similarly, the encoding of contextual information does not appear to be sufficient to account for the item method directed forgetting effect (MacLeod, 1975), because memory for spatiotemporal contextual information is not predictive of the magnitude of the effect (Gilliland, McLaughlin, Wright, Basden, & Basden, 1996, cited by Basden and Basden, 1998).

In relation to indirect memory tests, the item method directed forgetting effect has been obtained in word fragment completion (Allen & Vokey, 1998; Basden & Basden, 1996; MacLeod, 1989b) and in general knowledge fact completion (Basden & Basden, 1996, Experiment 2). However, contrary to their predictions, Basden et al. (1993) failed to obtain evidence of an item method directed forgetting effect in a word association task; although the floor effect obtained in the task does not permit a substantive conclusion to be drawn from this finding (Basden & Basden, 1998). Further, evidence of a directed forgetting effect in the indirect general knowledge task does not necessarily imply that a similar effect will be obtained in category exemplar generation, because conceptual priming can be dissociated into at least two functionally distinct mechanisms (Cabeza, 1994; McDermott & Roediger, 1996; Vaidya et al., 1997). One of the attributes of the category exemplar generation task that distinguishes it from the indirect general knowledge task and indirect word association task is that it does not involve item-by-item retrieval cueing. This difference is potentially important for the production of an item method directed forgetting effect, because Basden and Basden (1996) proposed that indirect memory tests that involve item-by-item cueing are intrinsically more sensitive to the effects of differential processing. Nonetheless, category exemplar generation may be sensitive to the item-specific, differential rehearsal fostered by the item method paradigm because several of the variables that foster differential rehearsal (e.g., levels of processing) have been shown to have facilitatory effects on indirect category exemplar generation.
7. Category Exemplar Generation: Item and List Cueing

As discussed in Chapter 1, it is necessary to detect whether or not a directed forgetting effect reflects contamination by conscious processes (Hauselt, 1998; Russo & Andrade, 1995). This issue has been addressed using a post-experimental questionnaire (Hauselt, 1998) and by applying the process dissociation procedure (Allen & Vokey, 1998; Russo & Andrade, 1995). Both of these methods have revealed that perceptual priming is compromised by conscious retrieval following item method cueing (Allen & Vokey, 1998; Russo & Andrade, 1995; Vokey & Allen, 1993). The issue of process purity is particularly relevant to the interpretation of directed forgetting in measures of conceptual unconscious processes, given the association between conscious retrieval and conceptual processing in conceptual memory tasks (Craik et al., 1994). Therefore, the evidence of an item method directed forgetting effect in an indirect general knowledge task reported by Basden and Basden (1996) needs to be tempered with caution. Consequently, in order to evaluate the sensitivity of conceptual unconscious processes to differential rehearsal engendered by the item method paradigm, it is necessary to obtain an objective measure of unconscious processes using the process dissociation procedure.

In addition to examining the effect of the item method paradigm on category exemplar generation, the current experiment also varied the contribution of maintenance and elaborative rehearsal at encoding. Maintenance rehearsal (also called, Type I or primary rehearsal) refers to the maintenance of an item in short-term memory using rote, nonassociative rehearsal, whereas in elaborative rehearsal (also called, Type II, secondary, or semantic rehearsal) an item undergoes grouping, or associative rehearsal that facilitates long-term retrieval (Craik & Lockhart, 1972; Woodward, Bjork, & Jongeward, 1973). Both of these rehearsal strategies are subject to control by a conscious, attentional mechanism, which may be subject to an age-related effect. The distinction between maintenance and elaborative rehearsal is supported by extensive experimental evidence consistent with the notion that these two forms of rehearsal have dissociable effects on memory task performance (Phaf & Wolters, 1993; Wixted, 1991).

The distinction between maintenance and elaborative rehearsal underwent parallel development with directed forgetting research (Bjork, 1972; Craik & Watkins, 1973; Epstein, 1972; Wetzel & Hunt, 1977; Woodward et al., 1973). In particular, this parallel development involved experiments in which the item method paradigm was combined with a delayed onset for the R and F cues. The delay is hypothesised to directly influence the contribution of maintenance or elaborative rehearsal conferred on R and F cued items (Wetzel, 1975; Wetzel & Hunt, 1977). As discussed in Chapter 1, several studies have obtained large effects on recall and recognition when the time available for
rehearsal is varied following the presentation of the R and F cue. For example, Wetzel and Hunt
(1977) reported that recognition memory, immediate recall, and final free recall performance all
increased as a function of the time for elaborative rehearsal, and this effect was larger for R items
than for F items, but only when the onset manipulation occurred within a blocked design. Similarly,
Gardiner et al. (1994) reported an effect of maintenance and elaborative rehearsal on recognition
memory using the remember-know (R-K) paradigm. Specifically, elaborative rehearsal increased
the proportion of recollection based retrieval, and maintenance rehearsal increased the proportion of
familiarity based retrieval (see also, Mandler & Boeck, 1980). In addition, an item method directed
forgetting effect was obtained for remember responses, but not for know responses.

The current experiment employed the cue onset protocols utilised in the study conducted by
Gardiner et al. (1994). Specifically, R and F cues were presented either immediately (followed by a
5 second post-cue interval) or after a delay (5 second). In the delayed cue condition, the amount of
maintenance rehearsal conferred on the exemplars is assumed to be greater than in the immediate
cue onset condition. Further, maintenance rehearsal was assumed to operate on both R and F cued
exemplars in the same way until cue onset, with only R cued exemplars subject to an elaborative
rehearsal strategy following cue onset, which can continue until the final memory task (Bjork, 1972;
Wetzel & Hunt, 1977). In the immediate cue condition, the 5 second post-cue interval was designed
to provide a greater opportunity (relative to the delayed condition) for elaborative rehearsal to be
conferred on R cued exemplars. Overall, the stimulus onset asynchrony (SOA) for study trials was
constant across the immediate and delayed cue conditions, so that any differences between these
conditions could be attributed to the trade-off between maintenance and elaborative rehearsal
(Gardiner et al., 1994; Wetzel & Hunt, 1977; Woodward et al., 1973).

Given that the item method paradigm primarily fosters item-specific, rather than relational
processing (Basden et al., 1993; Johnston, 1994), the effect of the manipulation of elaborative and
maintenance rehearsal was expected to operate at the level of individual items. Therefore, one
motivation for applying the manipulation of maintenance and elaborative rehearsal in an item
method paradigm was to provide additional convergent evidence that item method directed
forgetting reflects simple rehearsal differences. Accordingly, a facilitatory effect of elaborative
rehearsal on the conscious and unconscious parameter estimates was hypothesised, with a greater
effect for R relative to F cued exemplars. Further, since perceptual priming does not appear to be
facilitated by maintenance rehearsal at encoding (Greene, 1986; Phaf & Wolters, 1993; Richardson-
Klavehn & Bjork, 1988a), it could be argued that the unconscious retrieval of R and F cued items
will not be facilitated by maintenance rehearsal. Nonetheless, it was hypothesised that unconscious
processes would be influenced by maintenance rehearsal because of the similarities in the functional
properties of familiarity-based retrieval and conceptual unconscious processes (Toth, 1996).

In relation to ageing, only a small number of studies have investigated age-related differences in the item method directed forgetting effect. The findings from these studies are equivocal. One of the earliest studies reported involved the presentation of words that were either cued with a R or F cue, and the frequency of presentation of R cued words in the study list was varied between one and three (Kausler & Hakami, 1982). In addition, the R cued words appeared with one or two F cued words. At test, memory for the frequency of occurrence of R cued words was examined. Age-invariance was reported when R cued words appeared with one F cued word, but in those trials in which two F words were presented, older adults attributed a lower frequency of occurrence to the R cued words than young adults. This pattern of findings was interpreted as evidence of the inability of older adults to differentially process the R and F words to the same extent as young adults. Two other studies have reported an attenuated item method directed forgetting effect in older adults relative to young adults; however, these studies did not contain sufficient information to allow an evaluation of their findings, since both were conference reports (Camp & McKitrick, 1989; Giambra & Howard, 1994, cited in Zacks et al., 1996).

Zacks and her colleagues conducted several experiments that employed the item and list method paradigms to examine the effects of ageing on attentional inhibition (Zacks & Hasher, 1994; Zacks et al., 1996). The findings obtained using the item method paradigm are reported here, whereas the results obtained using the list method paradigm will be reported in Experiment 4. In the first two experiments (Experiments 1a and 1b), the effect of item method cueing on memory for semantically related category exemplars was examined. The two experiments differed in terms of whether the designation of R and F cues was within or between semantic categories. In immediate recall, within category cueing increased the intrusion of F items and impaired the retrieval of R items compared to between category cueing. It was argued that the semantic relatedness between R and F cued exemplars within a category reduced the distinctiveness necessary for operations to be applied separately to each class of item (see also, Horton & Petruk, 1980). Therefore, in the current experiment, the cueing of R and F cues was between categories, in order to maximise the item method directed forgetting effect. In addition to the immediate recall test, participants performed a final recall (Experiment 1a and 1b) and a recognition (Experiment 1b) memory task following the presentation of six study-test list blocks. The data from these final direct memory tests revealed that the directed forgetting effect was attenuated in older adults relative to the young adults, and this effect was mediated by the lower recollection of R items.

As discussed earlier, conceptual parallels can be drawn between the mechanisms proposed to
account for the item method directed forgetting effect and two general accounts of cognitive ageing. Firstly, the inhibition of the rehearsal of an item following the onset of the F cue is assumed to impose demands on conscious, attentional resources (Zacks & Hasher, 1994). Despite significant evidence consistent with the notion of age-related impairment in inhibitory processing (Hasher et al., 1991; Kane et al., 1994, for a review, see McDowd and Birren, 1990), a more accurate representation of the extant data is that the nature of the decline in attentional inhibition is better characterised in terms of selective deficits within a subset of inhibitory processes (Arbuthnott, 1995; Arbuthnott & Campbell, in press; Kramer & Larish, 1996, see also, Chapter 3). Therefore, in relation to attentional inhibition, the current experiment investigated whether or not the inhibitory processes that support the item method directed forgetting effect are subject to an age-related impairment. More specifically, it was hypothesised that the putative diminished working memory capacity for task relevant information in older adults will result in an impaired ability to instantiate the differential encoding of R and F items; namely, the failure to terminate the rehearsal of F cued items cued will attenuate the ability to differentially rehearse R and F items at encoding. Further, on the basis of the results reported by Zacks et al. (1996), the retrieval of R items was expected to be lower in older adults relative to the young adults.

The implications of the second principle mechanism of directed forgetting, the differential rehearsal of R and F cued items, relate to the hypothesised age-deficit in the ability to spontaneously engage elaborative or semantic, processing at encoding (Burke & Light, 1981; Craik, 1977). Specifically, such a deficit would be expected to influence the ability of older adults to elaboratively rehearse R cued items. Therefore, given that both elaborative rehearsal and attentional inhibition can mediate the item method directed forgetting effect, the age-deficit reported by Zacks et al. (1996) may reflect an impairment in one or both of these mechanisms. The maintenance versus elaborative rehearsal manipulation can go some way to disentangling the role of these two mechanisms. In particular, it can be argued that age-related impairment in the immediate cue condition represents an age-deficit in the ability to engage in elaborative rehearsal and/or an inability to inhibit the rehearsal of F items. In contrast, an age-related deficit in the delayed cue condition would be more likely to reflect differences in inhibition, rather than differences in the ability to engage in elaborative rehearsal, because the maintenance rehearsal conferred on R and F cued items in this condition will reduce the opportunity to engage in a differential elaborative rehearsal strategy. This approach is at variance with the series of studies conducted by Zacks and her colleagues in which the item and list method directed forgetting paradigms were used to examine the effect ageing on attentional inhibition, because the role of age-related differences in differential rehearsal were not addressed (Zacks & Hasher, 1994; Zacks et al., 1996). Overall, this argument is based on the logic underlying the manipulation of maintenance and elaborative rehearsal that was discussed earlier, and the
assumption that maintenance rehearsal is age-invariant.

7.2.2 Method

7.2.2.1 Participants

Sixteen young and 16 older adults participated in the experiment. The mean age of the young adults was 24.7 years (Range = 17 - 30 years of age; N males = 6; N females = 10), whereas the mean age of the older adults was 66.5 years (Range = 61 - 75 years of age; N males = 4; N females = 12). The young adults had a mean of 15.8 years of education, whereas the older adults had a mean of 14.5 years of education. Older adults scored a mean of correct responses on the MMSE 28.7.

7.2.2.2 Design and Materials

The design comprised a 2 (age: young or old) x 2 (test instruction: inclusion and exclusion) x 2 (cue onset: immediate and delayed) x 2 (cue type: R or F) mixed factors design. Age was a between participants factor, whereas test instruction, cue onset, and cue type were within participants factors. The cue onset manipulation was blocked, with half of the participants being presented with the immediate cue condition first and the remainder receiving the delayed cue condition first. Category name retrieval cues were accompanied with either inclusion or exclusion test instructions, and these two tests were presented in a mixed design.

The materials were the same as those utilised in Experiment 1. The 16 categories were divided into two lists of 48 category exemplars. For each participant, 48 category exemplars were assigned to the inclusion test and the other 48 to the exclusion test. Within each of the sets, 24 of the category exemplars were assigned to the immediate cue condition and the other 24 were assigned to the delayed cue condition. Of the exemplars within each of the cue conditions, 12 category exemplars were assigned to the to-be-remembered condition and the other 12 exemplars were assigned to the to-be-forgotten cue condition. Exemplars within each category belonged to the same directed forgetting condition and the same cue onset condition. The semantic categories were rotated through the two cue onset conditions and two cue types. At study, the exemplars were presented in a different pseudo-random sequence for each participant. The study lists were constrained to avoid long sequences of either R or F items, because such sequences may confound the effect of the interval available for the rehearsal of R items (cf. Allen & Vokey, 1998).

The test lists were comprised of the corresponding category names for each of the experimental
conditions that appeared at study: (1) remember-immediate; (2) forget-immediate; (3) remember-delayed; and (4) forget-delayed. Eight category names appeared in the inclusion test and the other eight category names appeared in the exclusion test. Category names from the remaining eight additional category names corresponded to exemplars of non-studied items that were used as a measure of baseline performance at test.

### 7.2.2.3 Procedure

Participants were informed that they would be presented with a series of words that would be associated with two types of instruction: to-be-remembered ('RRR') or to-be-forgotten ('FFF'), and only those exemplars that were cued, ‘RRR’ would be tested on a later memory test. In the immediate cue condition, each exemplar was presented for 1 second, and the onset of the ‘RRR’ or ‘FFF’ cue immediately followed the presentation of the exemplar. The cue remained on the screen for 1 second. A postcue period of 5 seconds followed the offset of the cue. In the delayed cue condition, each exemplar was presented for 1 second and then disappeared; the cue was presented 5 seconds after the offset of the exemplar, and the cue remained on-screen for 1 second. Therefore, the SOA for study trials in the immediate and delayed cue conditions was 7 seconds. In the immediate cue condition, each participant was instructed to, 'try to use the period following the offset of a R cue to rehearse the immediately preceding word, and if necessary other preceding R cued words.' In the delayed cue condition, each participant was instructed to 'keep the word in mind' until the presentation of the cue, and only engage in subsequent rehearsal if the item was cued with ‘RRR’. In addition, participants were instructed to avoid using the 5 second 'maintenance rehearsal' period for the rehearsal of preceding R cued exemplars.

Following the study phase, the inclusion and exclusion tests were administered to each participant in accordance with the procedure in the General Methods Chapter. Participants were explicitly informed of the difference between a direct-retrieval strategy and a generate-recognise retrieval strategy, in order to encourage the use and maintenance of a direct-retrieval strategy in the inclusion and exclusion tests.

### 7.2.3 Results

The mean proportion of correctly completed exemplars for each experimental condition are shown in Table 7.1. A 2 (age: young vs old) x 2 (test instruction: inclusion vs exclusion) x 2 (cue onset: immediate vs delayed) x 2 (cue type: R vs F) mixed factors ANOVA was performed on the proportion of correctly completed exemplars in the inclusion and exclusion tests. There were
significant main effects of age, $F(1, 30) = 8.97, p < .001$, test instruction, $F(1, 30) = 115.46, p < .001$, and cue onset, $F(1, 30) = 32.33, p < .001$, whereas cue type was not significant, $F(1, 30) = 3.52, p = .07$.

Table 7.1. Mean proportion of studied category exemplars generated in response to category names in each experimental condition.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Inclusion</th>
<th></th>
<th></th>
<th>Exclusion</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cue Onset</td>
<td>Cue Onset</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Immediate</td>
<td>Delayed</td>
<td>Immediate</td>
<td>Delayed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>F</td>
<td>R</td>
<td>F</td>
<td>R</td>
<td>F</td>
<td>R</td>
</tr>
<tr>
<td>Young</td>
<td>0.44</td>
<td>0.33</td>
<td>0.29</td>
<td>0.26</td>
<td>0.08</td>
<td>0.12</td>
</tr>
<tr>
<td>Old</td>
<td>0.29</td>
<td>0.26</td>
<td>0.21</td>
<td>0.17</td>
<td>0.12</td>
<td>0.17</td>
</tr>
</tbody>
</table>

R = to-be-remembered condition, F = to-be-forgotten condition

More importantly, there was a significant interaction between age and test instruction, $F(1, 30) = 17.86, p < 0.001$, which suggests that age had a differential effect across the inclusion and exclusion tests. In addition, three-way interactions between age, test instruction, and cue onset, $F(1, 30) = 4.76, p < .05$, and between age, cue onset, and cue type, $F(1, 30) = 5.97, p < .05$, were also significant. Significant interactions were also obtained between test instruction and cue onset, $F(1, 30) = 33.55, p < .001$, and between test instruction and cue type, $F(1, 30) = 37.95, p < .001$, which both demonstrate the differential effect of the cue onset and cue type on the inclusion and exclusion tests. Finally, the interaction between test instruction, cue onset, and cue type was also significant, $F(1, 30) = 8.06, p < .01$.

For the young adults, examination of the data in the inclusion test revealed a canonical directed forgetting effect in immediate cue onset condition, $F(1, 30) = 30.942, p < .001$, whereas in the exclusion test the difference in the retrieval of the R and F cued exemplars was not significant, $F(1, 30) = 3.39, p = .08$. In the delayed cue condition, the directed forgetting effect was not significant in either the inclusion or the exclusion test, $F(1, 30) = 3.66, p = .07$, $F(1, 30) = 0.83, p = .37$, respectively. For the older adults, the directed forgetting effect was not significant in the inclusion test for immediate cue condition, $F(1, 30) = 1.473, p = .23$, although a significant reversed directed forgetting was obtained in the exclusion test, $F(1, 30) = 6.51, p < .05$. In the delayed cue condition,
the directed forgetting effect reached significance in the inclusion test, $F(1, 30) = 9.04, p < .001$, whereas the R-F difference was not significant in the exclusion test, $F(1, 30) = .495, p = .49$. There was as an age-related difference in the inclusion test for the R items in the immediate cue condition, $F(1, 30) = 22.09, p < .001$, but not for the F items, $F(1, 30) = 2.99, p = .09$. In the exclusion test, there was a significant age-related difference for the F items, $F(1, 30) = 4.54, p < .05$, but not for the R items, $F(1, 30) = 3.81, p = .06$. In the delayed cue condition, there was a significant age-related difference in the inclusion test for the R and F items, $F(1, 30) = 17.15, p < .01, F(1, 30) = 17.85, p < .001$, respectively. In the exclusion test, the difference in the retrieval of the R and F items as a function of age did not reach significance, $F < 1$.

The conscious and unconscious parameters estimates were calculated in accordance with the computational expressions for the process dissociation procedure outlined in Chapter 2, and are presented in Table 7.2. A 2 (age: young vs old) x 2 (memory parameter: conscious vs unconscious) x 2 (cue onset: immediate vs delayed) x 2 (cue type: R vs F) mixed factors ANOVA was performed on the parameter estimates. There were significant main effects of age, $F(1, 30) = 17.35, p < .001$, cue onset, $F(1, 30) = 42.48, p < .001$, and cue type, $F(1, 30) = 22.71, p < .001$. There was a significant interaction between memory parameter and onset, $F(1, 30) = 16.87, p < .01$, and between memory parameter and cue type, $F(1, 30) = 28.49, p < .001$, indicating a differential effect of cue onset and cue type on the memory parameters. The modulating effect of cue onset and cue type on the memory parameters was also found to be significant in a three-way interaction among memory parameter, cue onset, and cue type, $F(1, 30) = 5.59, p < .05$. In relation to the age effects, the interactions between age and parameter, $F(1, 30) = 11.81, p < .001$, age, parameter, and cue onset, $F(1, 30) = 6.53, p < .01$, and age, cue onset, and cue type, $F(1, 30) = 8.78, p < .001$, were all significant.
Table 7.2. Parameter estimates of conscious and unconscious processes for each experimental condition.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Conscious Immediate</th>
<th>Conscious Delayed</th>
<th>Unconscious Immediate</th>
<th>Unconscious Delayed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>F</td>
<td>R</td>
<td>F</td>
</tr>
<tr>
<td>Young</td>
<td>0.36</td>
<td>0.22</td>
<td>0.15</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>0.12</td>
<td>0.15</td>
<td>0.17</td>
<td>0.16</td>
</tr>
<tr>
<td>Old</td>
<td>0.16</td>
<td>0.09</td>
<td>0.08</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>0.14</td>
<td>0.18</td>
<td>0.13</td>
<td>0.14</td>
</tr>
</tbody>
</table>

R = to-be-remembered condition, F = to-be-forgotten condition

For the young adults, a canonical directed forgetting effect was obtained in the immediate cue condition for the conscious parameter estimates, $F(1, 30) = 27.79, p < .001$, whereas in the unconscious parameter estimates the difference in the retrieval of the R and F cued exemplars was not significant, $F(1, 30) = 1.09, p = .30$. In the delayed cue condition, the directed forgetting effect was also significant in the conscious parameter estimates, $F(1, 30) = 4.55, p < .05$, but not in the unconscious parameter estimates, $F(1, 30) = 0.18, p = .67$. There was a facilitatory effect of the immediate cue over delayed cue onset for R and F cued exemplars in the conscious parameter estimates, $F(1, 30) = 49.14, p < .001$ and $F(1, 30) = 9.84, p < .01$, respectively, but the unconscious parameter estimates for R and F items did not differ between the immediate and delayed cue onset conditions, $Fs < 1$.

For the older adults, there was a significant directed forgetting effect in the conscious parameter estimates in the immediate cue condition, $F(1, 30) = 6.91, p < .05$, but the effect did not reach significance in the unconscious parameter, $F(1, 30) = 3.88, p = .06$. The findings in the delayed cue condition paralleled those in the immediate cue condition, since a directed forgetting effect was obtained in the conscious parameter estimates, $F(1, 30) = 7.75, p < .01$, but not in the unconscious parameter estimates, $F(1, 30) = .12, p = .73$. In contrast to the young adults, a facilitatory effect of the immediate cue over the delayed cue onset in the conscious parameter estimates was obtained for the R cued exemplars, $F(1, 30) = 7.38, p < .01$, but not for the F cued exemplars, $F(1, 30) = 3.33, p = .08$; whereas for the unconscious parameter estimates, the reverse was true, since there was a facilitatory effect was observed for the F cued exemplars, $F(1, 30) = 6.06, p < .05$, but not the R cued exemplars, $F(1, 30) = 0.15, p = .70$. 
Only the directed forgetting effect obtained in the conscious parameter estimates for the immediate cue condition varied as a function of age, $F(1, 30) = 3.89, p < .05$, and this difference was mediated by lower conscious parameter estimates for R and F items, $F(1, 30) = 19.23, p < .001$ and $F(1, 30) = 6.24, p < .05$, respectively. In contrast, unconscious parameter estimates for R and F items in the immediate cue condition did not vary as function of age, $F(1, 30) = 0.57, p = .47$ and $F(1, 30) = 2.05, p = .16$, respectively. Similarly, there was a significant age-related difference in conscious parameter estimates in the delayed cue condition for R and F items, $F(1, 30) = 10.47, p < .01$ and $F(1, 30) = 9.38, p < .01$, respectively. In contrast, the unconscious parameter estimates were equivalent as a function of age for R and F items, $F(1, 30) = 1.31, p = .26$ and $F(1, 30) = 2.17, p = .15$, respectively.

### 7.2.4 Discussion

For R and F cued category exemplars in the delayed and immediate cue conditions, the estimates of conscious processes were impaired in the older adults relative to the young adults, whereas the estimates of unconscious processes were invariant as a function of age. In the young and older adults, there was a significant directed forgetting effect in the conscious parameter estimates for both the immediate and delayed cue conditions, whereas the unconscious parameter estimates were invariant as a function directed forgetting status in the two cue conditions. The magnitude of the item directed forgetting effect obtained in the conscious parameter estimates differed as a function of age in the immediate cue condition. Overall, the directed forgetting effect in the conscious parameter estimates is consistent with a differential rehearsal account, because only R items would be expected to benefit from the processing engaged following to the presentation of the cue, because the F cue inhibits any further processing of F cued exemplars.

In the young adults, the conscious parameter estimates for the R and F cued exemplars increased as a function of the opportunity for elaborative rehearsal relative to maintenance rehearsal. In contrast, in the older adults, although the elaborative rehearsal conferred on R cued items was less effective than that found in young adults, as suggested by the lower conscious parameter estimates for R items, a facilitatory effect of elaborative rehearsal relative to maintenance rehearsal was obtained for the R items. Further, in the older adults there was a facilitatory effect of the opportunity for maintenance rehearsal relative to elaborative rehearsal for the unconscious parameter estimates of F cued exemplars. The effects of cue onset on the conscious and unconscious parameter estimates can be contrasted with evidence that has demonstrated recall is facilitated by a short cue onset, whereas recognition has been shown to be enhanced by a longer cue onset (Wetzel, 1975; Wetzel & Hunt,
1977). It is conceivable that conceptual unconscious processes are supported by maintenance rehearsal, and this can be contrasted with the null effect of maintenance rehearsal on perceptual priming (Phaf & Wolters, 1993), whereas conceptual conscious processes are facilitated by elaborative rehearsal.

However, the presence of a canonical directed forgetting effect for both age groups in the conscious parameter for the delayed cue condition suggests that the onset manipulation was not sufficient to constrain the differential rehearsal of R and F cued exemplars; consequently, this limits the implications of the facilitatory effect of maintenance rehearsal on the unconscious parameter estimates. These findings also negate the ability of the cue onset contrast to disentangle the locus of the underlying age-related deficits in item method directed forgetting with respect to the attentional inhibition and elaborative rehearsal accounts. A similar failure to inhibit a differential rehearsal strategy on R and F cued items was demonstrated by Hauselt (1998, Experiment 2, Experiment 3 and Chapter 1). In Experiment 3, Hauselt (1998) employed three methods of rehearsal that have conceptual parallels with the current work; namely: (1) each word was repeated out aloud three times, designed to invoke a maintenance rehearsal strategy (conceptually equivalent to the delayed cue condition); (2) at least three related words were generated in response to each word, which corresponds to a constrained, elaborative rehearsal strategy; and (3) unconstrained rehearsal, whereby the rehearsal of each word was expressed out aloud (conceptually equivalent to the immediate cue condition). An item method directed forgetting effect was obtained in an indirect word stem completion, when rehearsal was unconstrained (although this effect reflected contamination by conscious retrieval, as assessed by a post-experimental questionnaire), and in the unconstrained and the maintenance rehearsal conditions in a recall test. More importantly, a follow-up experiment revealed that the maintenance rehearsal condition was not sufficient to preclude the adoption of a differential rehearsal strategy (Hauselt, 1998).

As discussed earlier, it has been argued that the item method paradigm is an analogue of the levels of processing manipulation, therefore, the evidence of a dissociation in the conscious and unconscious parameter estimates as a function of item method cueing in the delayed and immediate onset conditions warrants attention. In particular, although not significant, there was a numerical trend indicating a reversed directed forgetting effect in the unconscious parameter estimates, which may suggest that since F cued exemplars underwent less rehearsal, these items were less successfully excluded on the basis of recollection than R cued exemplars, because of the impoverished information available to base an exclusion decision. Of particular relevance in this regard is study reported by Mecklenbrauker et al. (1996) in which a levels of processing manipulation was applied to a category exemplar generation task in accordance with the process
dissociation procedure. A canonical levels of processing effect was obtained in the conscious parameter estimates, whereas a reversed levels of processing effect was obtained in the unconscious parameter estimates. Mecklenbrauker et al. (1996) argued that the unconscious parameter estimates were spurious, because the core assumptions were violated by the adoption of a generate-recognize retrieval strategy (see also, Richardson-Klavehn & Gardiner, 1998). Similarly, Russo et al. (1998) demonstrated a canonical levels of processing effect for conscious parameter estimates in a word fragment completion task, whereas a reversed levels of processing effect was obtained in the unconscious parameter estimates. Therefore, it appears that unconscious parameter estimates can be biased when the retrieval of an item and the awareness of prior occurrence covary following 'strong' conceptual encoding.

More generally, it is surprising that the item method directed forgetting in the current experiment did not reach significance in the unconscious parameter estimates, because conceptual priming does appear to be sensitive to the effects of differential encoding manipulations, such as levels of processing (Hamann, 1990; Monti et al., 1996; Srinivas & Roediger, 1990). Nonetheless, it has been argued that such effects reflect contamination by conscious processes (Basden & Basden, 1996; Toth et al., 1994). Further, the absence of a directed forgetting effect in the unconscious parameter estimates is consistent with the notion that item-by-item retrieval cueing is a necessary condition for the item method directed forgetting effect to be obtained in an indirect memory test (Basden & Basden, 1996).

Returning to the interpretation of the age effects that were obtained in the current experiment. It is conceivable that in addition to impeding the adoption of a differential rehearsal strategy, an age-related deficit in attentional inhibition may lead to a failure to adequately encode the directed forgetting status of the items at study. In particular, a corollary of ageing is a reduction in the efficiency with which older adults can engage, item-specific elaborative rehearsal, which appears to be reflected in the lower level of conscious retrieval of R and F cued exemplars in comparison with the young adults. Moreover, the impairment may be particularly acute under conditions in which an experimentally-determined SOA is used and when it is necessary to devote attentional resources to task switching, such as that associated with item method cueing. More generally, the exclusion methodology is well represented in research that has examined the inhibition of information that is designated as no longer relevant, since the rate of intrusion of items in retrieval tasks is used as a metric of unconscious inhibition (Hamm & Hasher, 1992; Hartman & Hasher, 1991).

Additional information related to the operation of the differential rehearsal mechanism that supports item method directed forgetting was obtained in a series of studies reported by Allen and Vokey
Allen and Vokey (1998) reported that varying the time for rehearsal, as a parametric manipulation of the number of F trials interposed between the R trials, did not have an effect on the magnitude of an item method directed forgetting effect in recognition and indirect word fragment completion. Allen and Vokey (1998) concluded that, 'the mechanism responsible for the [item method] directed forgetting effect was acting at the time of the first instruction to remember or to forget the item, and that additional rehearsal opportunities played no significant role in directed forgetting' (p.191). Further, it was argued that directed forgetting is established following the single act of retrieval that occurs in response to an R cue (Jacoby, 1978), and this effect is not modulated by subsequent opportunities for rehearsal. However, this account is insufficient to explain the age-related differences obtained in the current experiment, since the cognitive demands imposed by such a mechanism is unlikely to exceed the upper limit available in older adults. Finally, despite evidence that memory for spatiotemporal contextual information is not predictive of the magnitude of the item method directed forgetting effect (Gilliland et al., 1996, cited by Basden & Basden 1998), an age-related deficit in memory for source information (Spencer & Raz, 1995) may be a potential determinant of the impairment in the item method directed forgetting effect. This notion reflects the more general position that there may be underlying strategic differences in the manner in which a memory task can be performed.
7.3 Experiment 4: Category Exemplar Generation: List Method Directed Forgetting Effect

7.3.1 Introduction

The canonical form of the list method paradigm was employed in the current experiment, with the F-R study list and the R-R study list manipulated as a between-participants variable (Bjork, 1970), rather than as a within-participants variable (e.g., Bjork & Bjork, 1996; Zacks et al., 1996). The manipulation of maintenance versus elaborative rehearsal utilised with the item method paradigm is not appropriate for use with the list method. Specifically, when the F cue is delayed in the list method paradigm, rehearsal is not suspended for the F items; therefore, the power of the F cue is negated, and the list method directed forgetting effect is attenuated (Timmins, 1974).

The list method directed forgetting effect is expressed by the impaired retrieval of items that appeared in the F study list, as compared to the retrieval of the items that appeared in the R study list (e.g., Bjork, 1970; Bjork, 1989). The recall of the second list of R items in the R-R condition is lower than that for the R items in a F-R condition. On the basis of these data it has been suggested that the R items in the F-R condition experience reduced proactive interference from the first list (Bjork & Bjork, 1996), because an inhibition process is argued to be instantiated immediately following the presentation of the instruction to forget (Geiselman et al., 1983), so these F items do not interfere to the same extent with the recollection of the R study list as that associated with the second R list in the R-R condition (Bjork et al., 1998). This basic pattern of findings has been obtained in a large number of studies (e.g., Basden et al., 1993; Bjork & Bjork, 1996; for reviews, see Bjork, 1989; Johnston, 1994). Further, despite the differences in the encoding instructions, the first list in both instructional conditions is assumed to undergo equivalent initial encoding to the second list because the F cue is not anticipated (Bjork, 1970; but see Whetstone et al., 1996).

Two formal conditions are necessary for a list method directed forgetting effect to be obtained. First, following the instruction to forget the initial list, there must be an explicit reinstatiation of the encoding processes for a second R list of items, so that the F study list can undergo inhibition (Bjork, 1989; Gelfand & Bjork, 1985). Specifically, the second list of words must be encoded as a R list, since cognitive operations that do not involve an intentional mnemonic strategy, such as a rating task, are not sufficient for inhibition to occur (Gelfand & Bjork, 1985). Second, the output order of responses should be subject to conscious, attentional control (Basden & Basden, 1998). Both of these conditions were met in the current experiment.
7. Category Exemplar Generation: Item and List Cuing

As discussed in Chapter 1, Basden and Basden and others have argued that the list method paradigm results in the segregation of the two study lists into two retrieval units, largely as a consequence of the separate, relational processing among the items within a list (Basden & Basden, 1998). Therefore, the encoding operations that facilitate relational processing should increase the magnitude of the list method directed forgetting effect. One method for encouraging relational processing is the presentation of items that are semantically related, such as those that occur within a semantic category (Basden & Basden, 1998; Hunt & McDaniel, 1993). Consequently, the intrinsic properties of the critical items in a category exemplar generation memory task are likely to support relational processing among the items within each of the study lists. In contrast, if the list instructions were presented across semantic categories, the magnitude of the list method directed forgetting effect would be attenuated (Horton & Petruck, 1980).

When the mid-list directed forgetting instruction is provided to participants, the retrieval of R items is favoured over that for the F items by a consciously controlled, active inhibition mechanism that inhibits the retrieval of F items by impairing access to the episode in which F items were encoded (Anderson & Bjork, 1994; Basden et al., 1993; Bjork & Bjork, 1996; Bjork, 1989; Geiselman et al., 1983; Goemert & Larson, 1994; Whetstone et al., 1996). The identification of the list method directed forgetting effect with an inhibition based mechanism is supported by three sources of evidence: (1) memory for F items is unimpaired in recognition (Elmes, Adams, & Roediger, 1970; MacLeod, 1975), but impaired in recall, which suggests that the conscious inspection of R and F items in recognition eliminates the effect, because there is a release from inhibition (e.g., Basden et al., 1993); (2) the proactive interference associated with the presentation of the first list can be reinstated in the F-R study list condition, if the F items are re-presented in such a manner that accesses the initial encoding episode (Bjork & Bjork, 1996); and (3) the relearning of F items is comparable to that for R items (Reed, 1970). Further, since the magnitude of the directed forgetting effect in recall is smaller in the list method, it has been argued that F items undergo more encoding in the list method paradigm as compared to the item method (Basden & Basden, 1996).

The notion that the retrieval inhibition mechanism is limited to the conscious domain is based, in part, on the failure to obtained a list method directed forgetting effect in indirect memory tests (Basden & Basden, 1996; Basden et al., 1993; Bjork & Bjork, 1996; MacLeod, 1989a). For example, Basden et al. (1993) obtained an equivalent level of priming for R and F cued items in an indirect word fragment completion task, whereas in the direct word fragment completion task, the retrieval of R and F study list items led to a canonical list method directed forgetting effect. This pattern of findings is also intuitively obvious, since in the absence of an intentional orientation to
retrieve studied items, retrieval inhibition would not be expected to influence indirect memory tests. More specifically, the absence of a list method directed forgetting effect in indirect memory tests suggests that either inhibition does not extend to the unconscious inhibition of F items, or the original inhibition of F items is released by the re-presentation of the critical items as a partial cues at test; in the same way that the re-presentation of F study list items operates in a recognition memory test (Wright, Burke, & Basden, 1997, cited in Basden & Basden, 1998, for additional discussion of this interpretation see, Experiment 6). The implications of this latter interpretation are that the re-exposure of F items at test is a necessary and sufficient condition for the release from inhibition of F items, and the release from inhibition does not require direct access to the initial encoding episode. Accordingly, since perceptual indirect memory tests are primarily mediated by data-driven retrieval processes and typically involve the re-presentation of studied items, is not perhaps not unsurprising that perceptual indirect tests lead to a release from inhibition.

Nonetheless, in order to fully evaluate the logic underlying the specification of the boundary conditions for a release from inhibition, the list method paradigm needs to be applied to a test of conceptual priming that does not involve the re-presentation of the studied items. In this regard, Basden and Basden (1996, Experiment 2) obtained a list method directed forgetting effect in a direct general knowledge task, but not for an indirect general knowledge task. However, the indirect general knowledge memory task does not represent a full test of the boundary conditions for a release from inhibition, because despite the fact that the critical items are not re-represented, the retrieval cues in this task involve a complex semantic cue that may involve contact with the encoding event; that is, it has been argued that this task is compromised by conscious retrieval (e.g., Fleischman & Gabrieli, 1998). In contrast, conceptual priming, in the category exemplar generation memory task, does not involve direct access to the original encoding episode in the same way as the general knowledge task, and the retrieval cues do not involve the whole or partial re-presentation of F items. Therefore, this task represents a more valid investigation of the necessary and sufficient conditions for a release from inhibition.

However, if a directed forgetting effect is obtained in the estimates of conceptual unconscious processes, the interpretation is complicated by the lack of sufficient theoretical specification of the hypothesised inhibition mechanism that supports the list method directed forgetting effect. In particular, the lack of evidence for a list method directed forgetting effect in an indirect memory test has led to the assumption that the inhibition mechanism does not attenuate the activation of F items, and thus F items have an equivalent unconscious influence as R items on indirect memory measures (Bjork & Bjork, 1996; Bjork et al., 1998). One difficulty with this position is that it reflects the failure to explicitly distinguish between the operation of the inhibition mechanism in the between-
and within-group implementations of the list method paradigm. Nonetheless, despite the fact that Whetstone et al. (1996) did not directly address this distinction in the analysis of their findings, they did argue that on the basis of the longer latencies in recognition memory for F study list items, inhibition also operates to limit access to the F study list by decreasing the activation of items in the F study list relative to the R study list (Whetstone et al., 1996). This is likely to represent at least one other locus of the list method directed forgetting effect that is worthwhile investigating, when the paradigm is implemented in a between-groups design.

Accordingly, evidence of a list method directed forgetting effect in the estimates of conceptual unconscious processes would suggest that in addition to inhibiting access to the retrieval pathways associated with the F study list items, the F cue may also inhibit the item-specific activations of F study list items in the unconscious store relative to those for R items (cf. Bjork & Bjork, 1996; Bjork et al., 1998). More generally, the explication of the inhibition mechanism becomes more complicated when extending it to the domain of unconscious processes, because it becomes necessary to posit conscious control over an unconscious processes that in turn controls access to consciousness (Arbuthnott, 1995; Hamisfeger, 1995). Indeed, this model violates the definition of an automatic process, as defined within the process dissociation procedure, since unconscious processes are assumed to operate outside conscious control.

In relation to ageing, the primary source of evidence for an age-deficit in the attentional inhibition mechanism has been impaired negative priming performance (Hasher et al., 1991; Kane et al., 1994; McDowd & Oseas-Kreger, 1991; Tipper, 1991). These findings have been subject to interpretation both within a general inhibition model, such as that proposed by Hasher and Zacks (1988), and one in which inhibition is not considered to be a unitary phenomenon (e.g., Kramer et al., 1994). As discussed earlier, there have only been a limited number of studies that have investigated list method directed forgetting as a function of age. In the second experiment conducted by Zacks et al. (1996), a variation of the within-group list method paradigm was employed, which involved a repeated study-test presentation. For each immediate recall test that followed each study block, participants were instructed to only recall R items, whereas for the final recall test, participants were directed to recall both R and F items. The magnitude of the list method directed forgetting effect was reduced in the older adults relative to the young adults in the immediate and final recall tests, with the effect mediated by the poorer recollection of R items.

In light of these foregoing findings, and on the basis of the attentional inhibition deficit hypothesis of ageing (Hasher & Zacks, 1988; Zacks & Hasher, 1994), the older adults in the current experiment were expected to show a reduced directed forgetting effect. In addition, as discussed
earlier, relational processing is an important mediating factor in the list method directed forgetting effect, since relational processing at encoding has been shown to mediate the necessary identification process that separates the F and R study lists into two, distinct, retrieval units by encouraging the encoding of spatiotemporal contextual information (Basden & Basden, 1996; Basden & Basden, 1998; Basden et al., 1993). Therefore, age-related deficits in the list method directed forgetting effect can also occur because the relational encoding of the two study lists is impaired, despite the provision of semantically related items in each study list. The prediction arises from the general deficit proposed to occur in semantic, elaborative or conceptual processing (for a review, see Burke & Light, 1981; see also, Craik, 1977; Craik & Byrd, 1982; Craik & Simon, 1980), and the more general age-related deficit in memory for spatiotemporal contextual information (Spencer & Raz, 1995).

7.3.2 Method

7.3.2.1 Participants

The participants were 32 young (Mean = 23.5 years of age; Range = 20 - 30 years of age; N males = 7; N females = 25) and 32 older adults (Mean = 71.4 years of age; Range = 63 - 75 years of age; N males = 12; N females = 20). Sixteen young adults and 16 older adults participated in the F-R study list condition, whereas the remaining 16 young adults and 16 older adults participated in the R-R study list condition. The young adults had a mean of 16.5 years of education, whereas the older adults had a mean of 16.2 years of education. Older adults scored a mean of 28.5 on the MMSE.

7.3.2.2 Design and Materials

The design comprised a 2 (age: young or old) x 2 (study list condition: F-R or R-R) x 2 (test instruction: inclusion and exclusion) mixed factorial design. Age and study list cue were between participants factors, whereas test instruction was a within participants factor. More specifically, the list method paradigm was implemented in a between-participants design, whereby half of the participants received the F-R study list configuration and half received the R-R study list configuration. At test, each participant received category name retrieval cues accompanied by either inclusion or exclusion test instructions in a mixed design.

The materials and basic design were the same as Experiments 1 and 3, with the exception of several procedural changes that were implemented to enable the list method paradigm to be employed. In particular, the study list was made up of two primary base study lists, each comprised of 48
exemplars, for both the F-R and R-R study conditions. At test, half of the exemplars from each study list appeared in the inclusion test and the remainder appeared in the exclusion test. The assignment of the words to the study lists was counterbalanced so that all categories and exemplars appeared in all experimental conditions. An additional 8 category names with the corresponding category exemplars were selected to represent a measure of baseline performance at test.

7.3.2.3 Procedure

Participants were informed that they would be presented with a series of words that they should try to remember for a later memory test. For both F-R and R-R study lists, the words were presented at a fixed rate of presentation: a fixation point appeared in the centre of the screen for 500ms, then a category exemplar followed immediately and was presented for 3 seconds. The next trial was indicated by the presentation of the fixation point. Therefore, the rate of presentation of the exemplars within each study list was experimentally determined. The mid-point of the study list was interrupted with instructions that directed participants to remember or forget the preceding list of words. In the F-R study list condition, participants were informed that, ‘The list that you have just studied was only for practice. You can forget it now. The list you will see next is the one that you should remember, so forget the practice list and concentrate on trying to learn this new list for a later memory test, since the memory test will be based only on these to-be-remembered words.’ Participants in the R-R study list condition were informed that they should remember the words that had just been presented, and also concentrate on remembering the new list of words for a subsequent memory test. The time to read the mid-list instruction was fixed at 60 seconds, which was found to be sufficient for young and older adults following pilot testing of the design. A fixed interval to read the mid-list instructions was used to ensure that any rehearsal that may have occurred during this interval was controlled.

In the inclusion test, participants were instructed to complete each category name with up to eight exemplars from the words that were studied earlier, independently of whether the studied words were in the first or second study list. In the exclusion test, the retrieval instructions directed the participants to complete each category name with the first eight exemplars that were not presented in the first or second list. As discussed earlier, the additional instructions relating to the retrieval strategy that should be employed were provided to participants in the same manner as in Experiment 3.

7.3.3 Results
The mean proportion of correctly completed exemplars in each of the experimental conditions are shown in Table 7.3. A 2 (age: young vs old) x 2 (directed forgetting condition: F-R vs R-R) x 2 (list: list 1 or list 2) x 2 (test instruction: inclusion vs exclusion) mixed factors ANOVA was performed on the proportion of correctly completed exemplars in the inclusion and exclusion tests. There were significant main effects of age, $F(1, 60) = 37.40, p < .001$, and test instruction, $F(1, 60) = 364.55, p < .001$, whereas directed forgetting condition and list were not significant, $F(1, 60) = 2.14, p = .15$ and $F(1, 60) = 2.10, p = .15$, respectively. More importantly, a significant interaction was obtained between directed forgetting condition and list, $F(1, 60) = 4.24, p < .05$, which demonstrates the differential effect each directed forgetting condition had on the retrieval of the first and second list. A significant interaction was obtained between age and list, $F(1, 60) = 5.00, p < .05$, and between age and test instruction, $F(1, 60) = 75.80, p < .001$, which indicates that the retrieval in each test condition and list was modulated by age.

Table 7.3. Mean proportion of studied category exemplars generated in response to category names in each experimental condition.

<table>
<thead>
<tr>
<th></th>
<th>Inclusion</th>
<th>Exclusion</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Directed Forgetting Condition</td>
<td>Directed Forgetting Condition</td>
</tr>
<tr>
<td></td>
<td>F-R</td>
<td>R-R</td>
</tr>
<tr>
<td>Age Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>0.37</td>
<td>0.44</td>
</tr>
<tr>
<td>Old</td>
<td>0.22</td>
<td>0.23</td>
</tr>
</tbody>
</table>

R = to-be-remembered condition, F = to-be-forgotten condition

In order to evaluate the basic between-participants implementation of the list method paradigm, several canonical comparisons were performed. In particular, comparisons were made between List 1 and List 2 in order to determine whether or not there was a difference in the retrieval between these two study lists in the F-R condition and in the R-R condition. In addition to these within-group list contrasts, the canonical list method directed forgetting effect is also typically assessed by comparing the performance between the F-R and R-R groups in accordance with two verification procedures: (1) the retrieval of List 1 words in the R-R condition should exceed the retrieval of List 1 words in the F-R condition; and (2) the retrieval of List 2 words in the F-R condition is expected
to exceed the retrieval of List 2 words in the R-R condition (Bjork, 1989). In the young and older adults, there was no significant difference between the F-R and R-R groups in the inclusion test when performance in List 1 was compared, F(1, 60) = 0.09, p = .76 and F(1, 60) = 2.77, p = .10, respectively. Similarly, in the young and older adults, there was no significant difference between the F-R and R-R groups in the inclusion test when performance in List 2 was compared, F(1, 60) = 1.24, p = .27 and F(1, 60) = 0.24, p = .62, respectively. The within-group analyses are presented below.

In the F-R condition, planned comparisons of the data for the young adults in the inclusion test revealed a canonical list method directed forgetting effect, F(1, 60) = 11.17, p < .001, whereas in the exclusion test the list method directed forgetting effect was not significant, F(1, 60) = 3.06, p = .085. In contrast, the difference between the retrieval of the F and R study lists in the older adults was not significant in either the inclusion or exclusion tests, F(1, 60) = .11, p = .73 and F(1, 60) = 32.17, p = .57, respectively. In the R-R condition, the inclusion and exclusion test performance in the young adults and older adults did not reveal a significant list method directed forgetting effect, F < 1.

In relation to the age effects in the F-R condition, there was a significant age-related difference in inclusion test for the retrieval of F and R items that favoured the young adults, F(1, 60) = 35.92, p < .001, F(1, 60) = 29.39, p < .001, respectively. In the exclusion test, there was a significant age-related difference that favoured the old adults for F items, F(1, 60) = 9.18, p < .01, whereas there was no age effect for the R items, F(1, 60) = 0.61, p = .44. In the R-R condition, there was a significant age-difference that favoured the young adults in the inclusion test for exemplars in the first and second study list, F(1, 60) = 18.63, p < .001 and F(1, 60) = 18.73, p < .001, respectively. In the exclusion test, the age-related difference was limited to the second list of exemplars, F(1, 60) = 9.19, p < .01, since there was no significant age-difference in the intrusions from the first study list, F(1, 60) = 3.59, p = .06.

The estimates of conscious and unconscious processes that were computed in accordance with the computational expressions of the process dissociation procedure are shown in Table 7.4. A 2 (age: young vs old) x 2 (directed forgetting condition: F-R vs R-R) x 2 (list: list 1 or list 2) x 2 (memory parameter: conscious vs unconscious) mixed factors ANOVA was performed on the parameter estimates. Main effects were significant for age, F(1, 60) = 68.98, p < .001, and memory parameter, F(1, 60) = 52.92, p < .01. More importantly, there was a significant interaction between directed forgetting condition and list, F(1, 60) = 5.30, p < .05, which demonstrates the differential effect of the directed forgetting manipulation on each study list. The interactions between age and parameter,
F(1, 60) = 60.67, p < .001, and between age and list were significant, F(1, 60) = 5.30, p < .05, which indicates the differential effect of age on the memory parameter estimates and list.

Table 7.4 Parameter estimates of conscious and unconscious processes for the category exemplar task.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Conscious</th>
<th>Unconscious</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F-R</td>
<td>R-R</td>
</tr>
<tr>
<td>Young</td>
<td>0.31</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>0.36</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Old</td>
<td>0.11</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>0.11</td>
<td>0.15</td>
</tr>
</tbody>
</table>

R = to-be-remembered condition, F = to-be-forgotten condition

In the young adults, planned comparison revealed a significant list method directed forgetting effect in F-R condition for both the conscious and unconscious parameter estimates, F(1, 60) = 4.43, p < .05, and F(1, 60) = 6.18, p < .01, respectively. In the R-R condition, the difference between the first and second list in the conscious and unconscious parameter estimates was not significant, F(1, 60) = 1.08, p = .303 and F(1, 60) = 0.86, p = .361, respectively. In the older adults, the list method directed forgetting effect did not reach significance in the conscious and unconscious parameter estimates, F < 1. Similarly, the difference between the first and second list in the R-R condition in the conscious and unconscious parameters estimates was not significant, F < 1.

In relation to the age effects, in the F-R condition there was a significant age-related difference in the conscious parameter estimates for the F and R study lists that favoured the young adults, F(1, 60) = 40.73 and p < .001, F(1, 60) = 29.89, p < .001, respectively, but not in unconscious parameter estimates for the F and R study lists, F(1, 60) = 3.94 and p = .06, F(1, 60) = 0.59, p = .44, respectively. In the R-R condition, there was a significant age-related difference in the conscious parameter estimates for the first and second study lists, F(1, 60) = 19.71, p < .001, F(1, 60) = 23.16, p < .001, respectively. In the unconscious parameter estimates, the age-related difference was not significant for either the first or second study list, F(1, 60) = 1.08, p = .30, F(1, 60) = 3.39, p = .07, respectively.
7.3.4 Discussion

The principal findings obtained in the current experiment can be summarised as follows: (1) in the young adults, a list method directed forgetting effect was obtained in the conscious and unconscious parameters estimates in the F-R condition, but not in the R-R condition; (2) in the older adults, the directed forgetting effect was absent in the conscious and unconscious parameter estimates in both the F-R and R-R conditions; and (3) the conscious and unconscious retrieval of exemplars from the first and second list was equivalent in the R-R condition in the young and older adults, which suggests that the effects of proactive interference were not significant. Consistent with the results from Experiments 3, in the F-R condition, age-related impairment was obtained in the estimates of conceptual conscious processes, whereas age-invariance was obtained in the estimates of conceptual unconscious processes. These findings replicate those reported extensively in the research that has applied the indirect category exemplar generation task to older adults (e.g., Isingrini et al., 1995; Light et al., 1999). Overall, the conscious retrieval of R cued exemplars in the F-R and R-R condition was lower in the older adults than in the young adults. The implications of these three principal findings will now be discussed with respect to the original hypotheses.

Evidence of the list method directed forgetting effect in the conscious parameters estimates supports the characterisation of the effect as operating through a conscious, inhibition mechanism. However, the evidence of a list method directed forgetting effect in the unconscious processes, represented a new finding, since in the extant research, a list method directed forgetting effect has not been obtained in an indirect word fragment completion task (Basden et al., 1993), an indirect general knowledge task (Basden & Basden, 1996), or an indirect word association task (Basden et al., 1993). Thus, the effect of inhibition reflected in the estimates of unconscious processes does appear to be sustained when retrieval cues are not perceptually related to the critical items, and the retrieval of items does not involve conscious access to the original encoding episode. Consequently, the retrieval cues and the functional demands associated with the exclusion test were apparently not sufficient to release the F cued items from inhibition. It is plausible that in addition to the retrieval pathways associated with the exemplars in the F study list being blocked following the presentation of the mid-list directed forgetting instruction (Bjork et al., 1998; Bjork, 1989), the effects of inhibition also operate to the suppress the item-specific activation associated with the F cued exemplars relative to R cued exemplars.

An additional interpretation of the directed forgetting effect in the unconscious parameter estimates that warrants consideration is that the effect reflected the differential rehearsal at encoding of the R
and F cued exemplars. However, this account is less plausible, since the numerical reversed directed forgetting effect did not reach significance in the estimates of unconscious processes in Experiment 3, which explicitly encouraged a differential rehearsal strategy. Further, the magnitude of a directed forgetting effect in the unconscious parameter estimates should have been larger than found with the item method directed forgetting effect. Specifically, this prediction is predicated on the logic underlying the notion that the blocked versus mixed list presentation of the levels of processing manipulation represents an analogue of the contrast between list versus item method directed forgetting (Basden & Basden, 1998), respectively. Therefore, differences in encoding between R and F items in the list method are not confounded with retrieval processes in the same way as that for the item method paradigm. Nonetheless, there is evidence to suggest that participants engage a differential rehearsal strategy in the list method paradigm, but this is not sufficient to support the effect, at least in the memory tasks that have been investigated thus far (Basden & Basden, 1998; Whetstone et al., 1996).

To the extent that attentional inhibition based mechanisms mediate the magnitude of the list method directed forgetting effect, the absence of an effect in the conscious and unconscious parameter estimates for the older adults is consistent with the view that older adults experience an impairment in the operation of attentional inhibition. These results extend the age-related deficit in the list method directed forgetting effect to the between-group implementation of the list method paradigm. Thus, it would appear that an age-related deficit also occurs under conditions in which the veracity of the F cue has not been reinforced by multiple intermediate memory tasks, as is the case in the within-group implementation (see, Zacks et al., 1996). The absence of the directed forgetting effect is argued to result from the perseveration of F items in the working memory of the older adults, which are likely to continue to undergo rehearsal following the mid-list instruction to forget. This interpretation is predicated on the evidence reported by Whetstone et al. (1996). Specifically, a list method directed forgetting effect was attenuated in participants who failed to inhibit the F study list, and this attenuated effect was mediated by a decrease in the recall of the R study list, and not by an increase in the recall of the F study list. It is perhaps not surprising that a directed forgetting effect was not evident in the unconscious parameter estimates obtained for older adults, because the underlying mechanism that supports the directed forgetting effect in both conscious and unconscious processes is likely to be the same.

One additional consequence of the age-related impairment in the inhibition of the rehearsal of F cued items is that there is an increase in the proactive interference acting on the second study list of R cued exemplars. However, there was no evidence of greater proactive interference in the older adults; although, the numerical trend in the older adults conscious parameters estimates, whereby
the estimates in the second study list were lower than the first study list in the R-R condition is consistent with the notion that older adults are more susceptible to proactive interference because this trend was not observed in the young adults. From the perspective of a resource account, the diminished working memory capacity for task relevant information that arises from the impaired efficiency of attentional inhibition in older adults will reduce the ability of older adults to devote resources to encode the R study list in the F-R condition, relative to the young adults. However, in the absence of a measure of working memory capacity, this hypothesis cannot be directly evaluated.

It does appear plausible to assume that several properties of the attentional inhibition mechanism may be shared across phenomena that include list method directed forgetting Bjork (1996), unlearning Wheeler (1995), and retrieval induced forgetting (e.g., Anderson, Bjork, & Bjork, 1994). In combination with the findings of age-related deficit in the item method directed forgetting effect, the results from the two experiments presented converge on the conclusion that older adults experience an impairment in the attentional inhibition mechanism that putatively supports each of these two phenomena. However, the dynamics and components of the inhibition mechanism that support these two effects are not necessarily equivalent, despite the advantage of parsimony gained in assuming a unitary inhibition mechanism (cf. Zacks et al., 1996). The attentional inhibition model is better able to explain the inhibitory dynamics involved at an item-specific level. In contrast, the operation of a global inhibition mechanism on a single retrieval unit is less well explained by the attentional inhibition model (Basden & Basden, 1998). Moreover, in light of the research demonstrating the fractionation of inhibition into a subset of discrete, potentially independent, processes (Kramer et al., 1994), it cannot be simply assumed that the deficit in the efficiency of inhibition within directed forgetting corresponds to the deficit obtained in tasks that involve attentional inhibition such as negative priming.

Several alternative explanations for the age-related deficit in the list method directed forgetting effect in the older adults also need to considered. A plausible alternative locus of the age-impairment in the list method directed forgetting effect is a deficiency in the ability to engage in relational processing, which enables the segregation of each study list into separate retrieval units (Basden & Basden, 1996; Gilliland et al., 1996, cited in Basden & Basden, 1998). However, despite the putative role for relational processing, it is not sufficient to produce a directed forgetting effect. For example, Whetstone et al. (1996) demonstrated that when participants were instructed to encode the list membership of words, a list method directed forgetting effect was not obtained in a recall test. A second mediating factor relates to the role of spatiotemporal contextual information. More specifically, Basden and Basden (1996) reported that when serial position judgements were used to measure memory for spatiotemporal contextual information related to R and F items cued using a
list method paradigm, the accuracy of identifying the serial positions of R and F items generated in recall was equivalent. These findings were obtained in groups of young adults in direct memory tests. However, it is not certain that the underlying dynamics of the list method directed forgetting effect will be the same for older adults. Consequently, the impairment that accompanies ageing in memory for spatiotemporal contextual information (Spencer & Raz, 1995) cannot be excluded as a determinant of the age-related deficit obtained.

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The current chapter presents a comparison of the effects of the item and list method directed forgetting paradigms on the perceptual-associative word stem completion task, utilised in Experiment 2. Thus far, there have been no studies that have applied these two directed forgetting paradigms to unrelated pairs of words; instead, the investigation of directed forgetting effects have involved words in isolation, paired associates, and pictorial stimuli. In relation to ageing, the two experiments examined whether or not there is an age-related reduction in the magnitude of the item and list method directed forgetting effects, when the dependent measure is memory for unrelated word pairs, in order to evaluate further the elaborative rehearsal and the attentional inhibition deficit accounts of cognitive ageing. Following the findings obtained in Experiment 2, an additional motivation for conducting these two experiments was to further investigate the degree to which perceptual-associative conscious and unconscious processes represent independent bases for responding, since an evaluation of the effects of the two basic directed forgetting paradigms on these processes would enable their functional characteristics to be further specified.

In Chapters 1 and 7, several sources of evidence were discussed that relate to conditions under which the item and list method directed forgetting effects are obtained. Briefly, in relation to priming, directed forgetting has not been obtained in perceptual indirect memory tests with the item method paradigm, or with the list method paradigm, when veridical measures of priming have been employed (Basden & Basden, 1996; Basden et al., 1993; Bjork & Bjork, 1996; MacLeod, 1989a). These findings have been interpreted as evidence that differential rehearsal does not influence perceptual indirect memory tests (e.g., Allen & Vokey, 1998; Basden & Basden, 1996). Further, despite the apparently well defined boundary conditions for the operation of the retrieval inhibition and differential rehearsal mechanisms, it has been argued that inhibition based processes contribute to the item method directed forgetting effect (Lehman, McKinley-Pace, Wilson, Slavsky, & Woodson, 1997; Zacks et al., 1996). Similarly, the differential processing of R and F cued items may also contribute to the list method directed forgetting effect, because F cued items do not undergo extended rehearsal, and so are less distinctive and potentially less accessible than R cued items (Basden & Basden, 1998). Thus, the conceptual limitations of trying to impose an unifactor mechanism on a particular method of directed forgetting cueing were investigated by extending the experimental conditions under which the two principle methods of directed forgetting cueing have been applied.
8.1 Experiment 5. Perceptual-Associative Word Stem Completion and Item Method Cueing

8.1.1 Introduction

The studies that have examined the item method directed forgetting effect using materials other than words in isolation have primarily employed paired associates. The findings reported in these studies have not differed from those obtained when the same protocols were applied to memory for item-specific information (e.g., Bjork, 1970; see Chapter 1 and, for a comprehensive archival review, see MacLeod, 1998). For example, Basden et al. (1993) reported that an item method directed forgetting effect was obtained in a direct paired-associate memory task, whereas the retrieval of R and F words was statistically equivalent in an indirect paired-associate memory task (Experiments 1 & 2). The perceptual-associative word stem completion task that was described in Experiment 2 provided the conditions necessary to investigate whether or not a dissociation would be obtained between conscious and unconscious processes as a function of the item method paradigm, because the reinstatement of the encoding episode at test (i.e., the presentation of the line drawing with the context word and original word stem in the intact condition) was found to lead to memory for new associations mediated by conscious and unconscious processes, rather than conscious processes alone.

The only investigation of the item method directed forgetting effect that has involved both semantically related and unrelated word pairs was reported by Golding et al. (1994). However, the words within each word pair were presented consecutively and cued individually; consequently, the method of critical item presentation corresponded to an associative lexical decision task, rather than an associative word stem completion task. In subsequent recall and recognition memory tests, a decline in the retrieval of the semantically related word pairs was obtained as a function of the cue designation conferred on each word within a word pair: arranged from the highest to lowest response accuracy, R-R, R-F, F-R, and F-F—R and F in each pair corresponds to the cue assigned to a word. These findings demonstrate that the effect of the F cue is reduced when associated with a R cue in a semantically related word pair. This may account for studies that have obtained a substantial directed forgetting effect using unrelated word lists, whereas those using related materials fail to show this effect, because a F cued item that is related to an earlier R item may become encoded in the same relational group as the R item, reducing the distinctiveness and power of the F cue. In contrast, the recall and recognition of the unrelated word pairs was only significantly different for the R-R cued pairs, with the overall recall performance being much lower.
than for the related word pairs. More importantly, the contrast of interest is that between the R-R and F-F unrelated word pairs, since this is conceptually similar to the single item R and F cue that was associated with each word pair in the current experiment.

As discussed in Chapters 1 and 6, task dissociations between direct and indirect conceptual-associative word stem completion have largely paralleled the findings obtained when the same variables are applied to item-specific direct and indirect memory tests (e.g., Graf & Schacter, 1985; Schacter & Graf, 1989). Thus, it is conceivable that a similar correspondence will occur between perceptual item-specific and perceptual association-specific memory tasks, across a variety of different variables. In particular, Moscovitch (1994b) argued that perceptual-associative priming is mediated by pre-semantic representations that are not influenced by conceptually driven variables such as levels of processing. However, a complication arises from the a priori assumption that perceptual unconscious processes are not facilitated by elaborative rehearsal (Toth et al., 1994). As discussed in Chapter 7 and in the earlier introductory chapters, this assumption remains the subject of debate, since canonical levels of processing effects have been reported for perceptual item-specific priming, even when contamination by intentional, conscious retrieval has been excluded (e.g., Nelson et al., 1999; Richardson-Klavehn & Gardiner, 1998). Further, evidence of a levels of processing effect in unconscious parameter estimates also coincides with experimental conditions that have led to the violation of the core assumptions of the process dissociation procedure; consequently, such instances may more directly address the boundary conditions of the process dissociation procedure.

One equivocal issue is whether or not the task employed in the current experiment represents a prototypical perceptual-associative memory task. One finding that suggests that the perceptual-associative word stem completion task is, in fact, mediated by perceptual unconscious processes, is the evidence from Experiment 2 that revealed no effect of divided attention on the unconscious parameter estimates. This finding is consistent with the absence of an effect of divided attention on perceptually-based item-specific priming that has been extensively reported elsewhere (for a review, see Chapters 1 & 6). Consequently, if it is presumed that the unitisation process that occurs at encoding is largely perceptually oriented (Reingold & Goshen-Gottstein, 1996a), the effect of elaborative rehearsal on the estimates of perceptual unconscious processes should be absent or only minimal (Jacoby et al., 1993b; Toth et al., 1994), whereas retrieval mediated by conscious processes should be facilitated by the perceptually oriented, elaborative rehearsal of R cued word pairs at encoding. Thus, on the basis of the findings from Experiment 2 and to the extent that the retrieval strategy and response criterion adopted by the participants operated in accordance with the boundary conditions of the process dissociation procedure, it was hypothesised that the unconscious
parameter estimates would not be sensitive to the differences in the amount of rehearsal conferred on the R and F cued items, whereas a canonical item method directed forgetting effect was predicted for the conscious parameter estimates.

Given that each unrelated word pair was cued with a single R or F cue, it is plausible to assume that each word pair represented the functional unit upon which item-specific processing was conferred at encoding. Consequently, it was hypothesised that an interaction between the test trial type and the item cue would be obtained. However, two potential forms of interaction could occur, where each outcome is contingent on the extent to which a differential rehearsal strategy is employed by the participants. First, the reinstatement of the associative context at retrieval may be sufficient to support association-specific memory independently of the cue designation. Alternatively, the F cue may lead to insufficient rehearsal to support association-specific memory, resulting in an association-specific memory effect only for R cued word pairs. However, the effect of the F cue is unlikely to result in an activation level for intact items that is below the level for recombined items, since it has been demonstrated that F cued items still undergo rehearsal (Experiment 3, Hauselt, 1998). Nonetheless, since the reinstatement of associative context at test leads to association-specific memory mediated by conscious and unconscious processes (Experiment 2, Reingold & Goshen-Gottstein, 1996a), the relative contribution of each of these processes, rather than the absolute level of associative memory, may vary as a function of cue status.

There are two principal factors that effect the amount of item-specific and relational processing conferred on critical items: (1) the orienting task at encoding; and (2) the nature of the critical items (Einstein & Hunt, 1980; Hunt & Einstein, 1981). In the current experiment, the directed forgetting instructions and the perceptually oriented encoding environment provided the conditions necessary for item-specific processing, which supports the item method directed forgetting effect (Basden & Basden, 1996; Basden et al., 1993). However, since item-specific processing appears to be primarily facilitated by encoding instructions, rather than the nature of the critical items (Engelkamp, Beigelmann, & McDaniel, 1998), the item-specific processing is likely to reflect the influence of the directed forgetting instructions.

In Experiment 3, the manipulation of the interval between the presentation of a critical item and item cue allowed quite precise predictions to be made, when the time available for rehearsal was conceptualised within the distinction between maintenance and elaborative rehearsal. However, several studies have failed to obtain an effect of the time available for rehearsal on the item method directed forgetting effect (e.g., Allen & Vokey, 1998; Hauselt, 1998). In particular, it appears that a constant stimulus onset asynchrony (SOA) across each level of cue onset is a necessary, but not
sufficient, condition to obtain an effect of both maintenance and elaborative rehearsal (see Experiment 3 and Wetzel & Hunt, 1977). This condition precludes the investigation of the effect of the time available for rehearsal in the current design, because pilot testing revealed that a self-paced rate of presentation of the word pairs at encoding was necessary to ensure that the associative memory effect was reliably obtained in the young and older adults. This finding is consistent with the notion that the encoding of association-specific information is not observed under constrained and relatively short latency conditions (see also, Bower, 1998; Howard et al., 1991). Further, a cue onset interval that is longer than 5 seconds would be unlikely to preclude the adoption of a differential rehearsal strategy for R and F cued items, since even with a 5 second delayed onset in Experiment 3, there was evidence of the adoption of a differential rehearsal strategy. Finally, a blocked design incorporating a constant SOA across the immediate and delayed cue conditions would introduce a degree of interpretative ambiguity to the effects obtained, because the time necessary to acquire new associations is likely to interact with the type of rehearsal fostered by each cue onset condition and with age.

As discussed in Experiment 3, the primary locus of inhibitory processing in the item method paradigm is hypothesised to be the termination of the rehearsal of items cued with a F instruction. If this mechanism is impaired in older adults, the ability to differentially rehearse R and F items at encoding would be expected to be attenuated (Zacks et al., 1996). However, since the item method directed forgetting effect is also supported by the ability to elaboratively rehearse R cued items, the locus of an age-related decline in the item method directed forgetting effect may reflect an impairment in the ability to inhibit the rehearsal of F items and/or a deficit in the (perceptual) elaborative rehearsal of R items. Unfortunately, the inability to apply the maintenance-elaborative rehearsal manipulation precluded the identification of which of these two mechanisms mediated any age-related deficits that were observed. Nonetheless, it is important to investigate whether or not the age-related deficit in the magnitude of the item method directed forgetting effect that was obtained for a conceptually-based memory task (Experiment 3) will be replicated for memory for association-specific information.

8.1.2 Method

8.1.2.1 Participants

The participants were 36 young (Mean = 25.4 years of age; Range = 19 - 30 years of age; N males = 10; N females = 26) and 36 older adults (Mean = 68.7 years of age; Range = 63 - 74 years of age; N males = 16; N females = 20). The young adults had a mean of 15.6 years of education, whereas the
8.1.2.2 Design and Materials

The experiment comprised a $2 \times 2 \times 2 \times 3$ mixed factorial design. Age (young and old) was a between participants factor, whereas test instructions (inclusion and exclusion), cue type (R and F), and test trial type (intact, recombined, and control) were within participant factors.

The critical items were the same as those that appeared in Experiment 2. Therefore, there were 144 word pairs organised into 48 triad arrays. The method of counterbalancing was the same as that detailed in the General Methods Chapter. One-half of the word pairs in the intact, recombined and control test trial types were allocated to the to-be-forgotten condition and the other half of the word pairs in these three trial types were allocated to the to-be-remembered condition. Therefore, each participant received 24 test trials in each of the test trial type x cue type x test instruction condition contrasts. Systematic item-specific effects were unlikely to operate, because each study sequence was pseudo-randomly generated for each participant, so that any particular R cued word pair was not systematically followed by a disproportionate number of F items.

8.1.2.3 Procedure

The format of the study phase was the same as that employed in Experiment 2, with the exception that each word pair was presented for 5 seconds, and then replaced with either a ‘RRR’ cue or a ‘FFF’ cue that remained on the screen for 1 second. The rate of study trial presentation was self-paced. Prior to the presentation of the study list, all of the participants were provided with a practice session of 8 trials that was comprised of both R and F cued word pairs, followed by a memory test for the R cued practice word pairs in order to reinforce the distinction between the R and F cues.

At test, word stems that corresponded to the target words in the intact, recombined, and control conditions were presented as retrieval cues, in accordance with the procedure detailed in Experiment 2. The only departure from this basic procedure was the modification of the inclusion and exclusion test instructions to reflect the directed forgetting component of the memory task. In the inclusion test, participants were instructed to complete each word stem with a five-letter word from both R and F cued target words. In the exclusion test, participants were instructed to complete each word stem with a five-letter word that was not presented in the study phase; therefore, both R and F cued target words were to be excluded as completions on the exclusion test trials.
8.1.3 Results

The mean proportions of correctly retrieved R and F target words are presented in Table 8.1 for each of the experimental conditions. A 2 (age: young vs old) x 2 (test instruction: inclusion vs exclusion) x 2 (test trial type: intact vs recombined) x 2 (cue type: R vs F) mixed factors ANOVA was performed on the proportion of correctly completed word stems in the inclusion and exclusion tests. There were significant main effects of age, $F(1, 70) = 5.29, p < .05$, test instruction, $F(1, 70) = 125.99, p < .001$, test trial type, $F(1, 70) = 235.54, p < .001$, and cue type, $F(1, 70) = 7.73, p < .01$. In addition, there was a significant interaction between age and test instruction, $F(1, 70) = 11.05, p < 0.001$, which suggests that age had a differential effect across the inclusion and exclusion tests. There was also significant interactions between test instruction and test trial type, $F(1, 70) = 39.27, p < 0.001$, and test instruction and cue type, $F(1, 70) = 42.23, p < .001$, which suggests that item method cueing and test trial type had a differential effect on the inclusion and exclusion tests. Moreover, the interaction between test trial type and cue type was significant, $F(1, 70) = 5.05, p < .05$. Three-way interactions between age, test instruction, and test trial type, $F(1, 70) = 15.46, p < .001$, and between test instruction, test trial type, and cue type, $F(1, 70) = 22.22, p < .001$, were also significant. Finally, the interaction between age, test instruction, test trial type, and cue type was significant, $F(1, 70) = 6.16, p < .05$.

Before an evaluation of the effects of directed forgetting was conducted, an analysis of association-specific memory effect was performed for both R and F cued word pairs. For the young adults, a significant association-specific memory effect was obtained in both the inclusion and exclusion tests, $F(1, 70) = 140.58, p < .001$ and $F(1, 70) = 21.04, p < .001$, respectively. Similarly, in the older adults, there was evidence of a significant association-specific memory effect in the inclusion and exclusion test, $F(1, 70) = 56.73, p < .001$ and $F(1, 70) = 62.07, p < .001$, respectively.
Table 8.1. Mean proportion of studied target words generated in response to word stems in each experimental condition.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Inclusion</th>
<th></th>
<th>Exclusion</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>F</td>
<td></td>
<td>R</td>
</tr>
<tr>
<td>Intact Condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>0.50</td>
<td>0.42</td>
<td>0.24</td>
<td>0.29</td>
</tr>
<tr>
<td>Old</td>
<td>0.40</td>
<td>0.34</td>
<td>0.28</td>
<td>0.29</td>
</tr>
<tr>
<td>Recombed Condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>0.31</td>
<td>0.31</td>
<td>0.22</td>
<td>0.23</td>
</tr>
<tr>
<td>Old</td>
<td>0.28</td>
<td>0.27</td>
<td>0.21</td>
<td>0.22</td>
</tr>
<tr>
<td>Control Condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>0.18</td>
<td></td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>Old</td>
<td>0.16</td>
<td></td>
<td>0.18</td>
<td></td>
</tr>
</tbody>
</table>

R = to-be-remembered; F = to-be-forgotten

For the young adults, there was evidence of a significant item method directed forgetting effect for intact word pairs in the inclusion and exclusion test, \( F(1, 70) = 41.07, p < .001 \), whereas in the recombined condition, there was no significant difference between R and F items in the inclusion and exclusion test, \( F_s < 1 \). For the older adults, a significant item method directed forgetting effect was obtained for intact word pairs in the inclusion test, \( F(1, 70) = 18.05, p < .001 \), but not in the exclusion test, \( F(1, 70) = .64, p = .43 \). For the older adults, a significant item method directed forgetting effect was obtained for intact word pairs in the inclusion test, \( F(1, 70) = 18.05, p < .001 \), but not in the exclusion test, \( F(1, 70) = .64, p = .43 \), whereas in the recombined condition, there was no significant difference between R and F items in the inclusion and exclusion tests, \( F(1, 70) = 1.44, p = .23 \) and \( F(1, 70) = 1.41, p = .24 \), respectively.

The conscious and unconscious parameters estimates were calculated in accordance with the computational expressions for the process dissociation procedure outlined in Chapter 2.
type, \( F(1, 70) = 24.68, p < .001 \). Significant three-way interactions was also obtained between age, memory parameter, and test trial type, \( F(1, 70) = 12.26, p < .001 \), and memory parameter, test trial type, and cue type, \( F(1, 70) = 9.30, p < .01 \). Finally, the interaction between age, memory parameter, test trial type, and cue type was significant, \( F(1, 70) = 5.38, p < .05 \).

Table 8.2 Parameter estimates of conscious and unconscious processes for each experimental condition.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Conscious</th>
<th>Unconscious</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>F</td>
</tr>
<tr>
<td>Intact Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>0.26</td>
<td>0.13</td>
</tr>
<tr>
<td>Old</td>
<td>0.12</td>
<td>0.06</td>
</tr>
<tr>
<td>Recombed Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>0.09</td>
<td>0.08</td>
</tr>
<tr>
<td>Old</td>
<td>0.08</td>
<td>0.05</td>
</tr>
</tbody>
</table>

R = to-be-remembered; F = to-be-forgotten

A significant conscious and unconscious association-specific memory effect was obtained in the young adults, \( F(1, 70) = 51.99, p < .001 \) and \( F(1, 70) = 93.30, p < .001 \), respectively, and these effects were significant for both R and F cued word pairs, \( ps < .01 \). In contrast, the conscious association-specific memory effect did not reach significance in the older adults, \( F(1, 70) = 2.73, p = .10 \), although this effect did reach significance for the R cued word pairs, \( F(1, 70) = 5.01, p < .05 \).

More importantly, a significant unconscious association-specific memory effect was obtained in the older adults, \( F(1, 70) = 95.41, p < .001 \), and this effect obtained for both R and F cued word pairs, \( F(1, 70) = 66.23, p < .001 \) and \( F(1, 70) = 42.71, p < .001 \), respectively. Further, the unconscious association-specific memory effect was invariant as a function of age, \( F < 1 \).

For the young adults, a significant effect item method directed forgetting effect was obtained in conscious association-specific memory effect, \( F(1, 70) = 25.89, p < .001 \), and this effect was mediated by the difference in the retrieval of intact word pairs, \( F(1, 70) = 51.97, p < .001 \), and not recombed word pairs, \( F < 1 \). In contrast, the item method directed forgetting did not reach significance in the unconscious association-specific memory effect, \( F(1, 70) = 0.02, p = .89 \), and this equivalence in the retrieval of R and F cued word pairs was obtained for both intact and recombed conditions, \( Fs < 1 \). For the older adults, a significant effect item method directed forgetting effect was obtained in conscious association-specific memory effect, \( F(1, 70) = 2.49, p = \)

.12, and this effect was mediated by the difference in the retrieval of intact word pairs, $F(1, 70) = 13.65, p < .01$, and not recombined word pairs, $F < 1$. However, the magnitude of the item method directed forgetting in the older adults was smaller than in the young adults, $F(1, 70) = 6.18, p < .05$, and this reflected lower relative levels of R and F item retrieval, $F(1, 70) = 20.99, p < .001$ and $F(1, 70) = 9.03, p < .01$, respectively. Consistent with the young adults, the item method directed forgetting did not reach significance in the unconscious association-specific memory effect, $F(1, 70) = 1.75, p < .01$, and this pattern was observed for intact and recombined word pairs, $Fs < 1$.

8.1.4 Discussion

A conscious and unconscious association-specific memory effect was obtained in the young adults for both R and F cued word pairs. In contrast, in the older adults, the conscious association-specific memory effect was only significant for R cued word pairs, whereas the unconscious association-specific memory effect was obtained for both R and F cued word pairs. Accordingly, these findings support the hypothesis that the word pairs represented the functional unit on which the differential rehearsal was conferred. Furthermore, the locus of the age-related deficit was limited to the conscious parameter estimates, since age-invariance was obtained in the estimates of unconscious processes. In relation to the item method directed forgetting effect obtained in the young and older adults, an effect was observed in the conscious parameter estimates, but not in the unconscious parameter estimates. In addition, the magnitude of the item method directed forgetting effect was smaller in the older adults.

The dissociation between the conscious and unconscious parameter estimates as a function of item method cueing corresponds to the dissociations that have been reported for perceptual direct and indirect memory tests, when contamination by conscious retrieval in perceptual priming has been excluded (e.g., Allen & Vokey, 1998; Hauselt, 1998). In addition, these results provide support for the proposition that the item method directed forgetting effect is supported by differential rehearsal at encoding, because perceptual indirect memory tests are typically not influenced by elaborative encoding (as characterised by the opportunity to elaboratively rehearse R cued items), whereas perceptual direct memory tests are facilitated by elaborative encoding (Moscovitch, 1994b; Roediger et al., 1992; but see, Thapar & Greene, 1994).

The absence of a directed forgetting effect in the estimates of perceptual-associative unconscious processes extends the boundary conditions of the logic underlying the transfer appropriate processing framework (see also, Moscovitch, 1994b). In particular, this finding suggests that perceptual-associative unconscious processes in the association word stem completion task are

primarily data-driven. Further, this conceptualisation of perceptual-associative unconscious processes is consistent with the findings reported in Experiment 2, whereby the unconscious parameter estimates were not influenced by the varying attentional load at encoding. However, the absence of an item method directed forgetting effect in the estimates of conceptual unconscious processes in Experiment 3 cannot be reconciled with the notion that conceptually-based processes are sensitive to the effects of differential rehearsal (see also, Basden & Basden, 1996). Nonetheless, Schacter and Graf (1986a) reported invariance in a conceptual-associative indirect memory test when the encoding of critical items involved sentence generation or reading a sentence. Thus, it is an oversimplification to assume that the effects obtained in perceptual and conceptual association-specific memory tasks will consistently represent an analogue of the findings obtained in conceptual and perceptual item-specific memory tasks.

The role of item-specific, distinctive processing in mediating the item method directed forgetting effect also warrants additional consideration (Basden et al., 1993; Johnston, 1994). Item-specific processing is facilitated by procedures that focus attention on individual items such as forming an image to the referent of a word (Hunt & Marschark, 1989), studying pictures that correspond to a target item (Hunt & McDaniel, 1993), or using a pleasantness rating task (Einstein & Hunt, 1980). Accordingly, the inclusion of a line drawing at encoding that related directly to the context word would be expected to provide an encoding context that facilitates the item-specific, distinctive processing of the critical items, which, in turn, supports the item method directed forgetting effect (Basden & Basden, 1996; Basden & Basden, 1998; Johnston, 1994). For example, Basden and Basden (1996) reported that the magnitude of an item method directed forgetting effect in a recall test was facilitated by encoding either pictures or imaging the referent of each word, in comparison with simply reading each word. However, Bugelski (1970) reported that an instruction to generate an image of the referent of R and F cued words at encoding eliminated the directed forgetting effect in a recall task. It is surprising that the item method directed forgetting effect was absent in this study, particularly because imaging the referent of a word has been characterised as a conceptual variable (McCauley et al., 1996). More generally, it would be interesting to compare the effects of varying the amount of perceptual and conceptual item-specific processing on the magnitude of association-specific memory effect and item method directed forgetting effect.

As discussed in the introduction, in the item method paradigm, because R cued items are processed more extensively than F cued items (Basden et al., 1993), the R items will have undergone more effective storage and subsequent retrieval relative to the F cued items, independently of the type of elaborative rehearsal that was performed. Consequently, it is conceivable that the item method directed forgetting effect is primarily influenced by differential rehearsal, rather than the particular
type of elaborative rehearsal. It is also important to note that although item-specific processing was encouraged by the perceptual encoding task and item method cueing instructions, the relation between item-specific and relational processing operates according to a simple trade-off relational model, whereby an increase in the contribution of one form of processing results in a decrease in the contribution of the other form of processing (Engelkamp et al., 1998; cf. Jones, 1987). However, since relational processing can occur spontaneously, and in the absence of an intrinsic organisational component afforded by the critical items (Einstein & Hunt, 1980), the role of relational processing in supporting the item method directed forgetting effect cannot be excluded in this experiment. Therefore, the attenuated item method directed forgetting that was observed in the older adults may also represent an age-difference in the ability to engage in relational processing.

An aspect of the design of the perceptual-associative word stem completion task that warrants discussion is the limit on the number of possible solutions. In comparison with a completion task in which each word stem can be completed with multiple solutions, as opposed to two or three, the current task encouraged an extended search strategy that may involve mechanisms similar to those that mediate explicit memory search. For example, Basden et al. (1993) demonstrated that the item-method directed forgetting effect associated with an indirect word fragment completion task that was reported by MacLeod (1989a) could only be replicated when each fragment only had one possible solution. The inference made on the basis of this finding was that this effect reflected contamination by conscious retrieval. The findings from the current experiment are consistent with these data, because the item method directed forgetting effect was limited to the conscious parameter estimates. An additional implication of restricting the number of possible solutions is that involuntary conscious memory may be fostered by this procedure (e.g., Kinoshita, 1998). However, neither of the two verification procedures that were suggested by Jacoby (1998) indicate that a generate-recognise retrieval strategy was employed (for further discussion of this issue, see Chapter 9).

A comparison of the directed forgetting effect in the estimates of perceptual-associative conscious memory revealed evidence of age-related impairment, since the difference in the conscious retrieval of R and F cued word pairs was lower in the older adults relative to the young adults, and this difference reflected the lower retrieval of R and F cued word pairs. This developmental difference is inconsistent with the argument that older adults experience a deficit in the attentional inhibition mechanism that supports differential rehearsal at encoding (for a discussion of the underlying rationale, see Experiment 4). Specifically, the smaller difference in the conscious parameter estimates for R and F cued word pairs suggests that the older adults were less able than young adults to adopt an efficient differential rehearsal strategy. However, as discussed in the introduction,
in the absence of comparison of the effects of the immediate and delayed cue onset, the age-related deficits in the magnitude of the item method directed forgetting effect can be attributed to attentional inhibition or elaborative rehearsal, or a combination of both of these factors (cf. Zacks & Hasher, 1994; Zacks et al., 1996).

There are also at least two ancillary factors that could have contributed to the age-related difference in the item method directed forgetting effect. One factor relates to the encoding strategy adopted by the participants. Specifically, in addition to engaging in the elaborative rehearsal of the word pair immediately preceding each R cue, a simple strategic approach to facilitate the retrieval of R cued items would be to regard each trial associated with a F cue as an opportunity to retrieve and rehearse prior R cued word pairs (Bjork, 1972). This strategy may be particularly effective for the most recently presented R items that precede the onset of a F cue (cf. Allen & Vokey, 1998). However, as discussed in Chapter 3, older adults may not be equally capable as young adults of performing a particular strategy that has a direct effect on task performance (Light, 1991; Salthouse, 1991). To the extent that this retrospective differential rehearsal strategy facilitates the directed forgetting effect, the putative age-deficit in working memory capacity for task relevant information and an impaired ability to engage conscious, strategic processes (Hay & Jacoby, 1996; Jennings & Jacoby, 1997; Zacks & Hasher, 1994) may have diminished the ability of the older adults to invoke the operations that support this strategy.

A second factor that has been less extensively discussed in relation to the item method directed forgetting effect is the role of spatiotemporal contextual information for the cue associated with each word pair. This factor is potentially relevant to the interpretation of the age-related effects, because older adults appear to be impaired in tasks that involve memory for spatiotemporal contextual information (Spencer & Raz, 1995). As discussed in Chapter 7, it has been argued that the directed forgetting effect reflects the loss of contextual information associated with F cued items (Geiselman et al., 1983). Both Basden and Basden (1996) and Tzeng et al. (1979) reported evidence that serial position judgements were more accurate for R items than for F items following item method cueing. However, rather than suggest that this reflected the loss of source information that is associated with directed forgetting instructions, Basden and Basden (1996) argued that this effect was a consequence of the less extensive rehearsal conferred on F items. Further, since the serial position judgements of F cued items was equivalent between the control and experimental conditions, directed forgetting does not appear to be directly mediated by the loss of spatiotemporal contextual information (Basden & Basden, 1996). Similarly, Zacks et al. (1996) argued that the impaired inhibitory processing and source monitoring accounts are not necessarily incompatible, because the failure to inhibit the rehearsal of F cued word pairs would be expected to diminish the

distinctiveness between R and F cued word pairs, so that source confusion is increased. Future research will need to directly examine the role of source memory within directed forgetting tasks in young and older adults by requiring serial position judgements of the R and F cued items that are retrieved.
8.2 Experiment 6. Perceptual-Associative Word Stem Completion and List Method Cueing

8.2.1 Introduction

The current experiment was conducted in order to further investigate the boundary conditions of the list method directed forgetting effect. Only one study has applied the list method paradigm to materials that did not involve single words in isolation, and even this study involved semantically related word pairs. As discussed in the introduction to Experiment 5, Basden et al. (1993) examined the effect of the list method paradigm on memory for semantically related word pairs as a function of the association strength between the pairs. Independently of the association strength between the pairs, the list method directed forgetting effect was limited to the direct paired-associates memory task.

The inhibition mechanism proposed to account for the list method directed forgetting effect is hypothesised to suppress the retrieval pathways associated with the F cued items; therefore, one implication is that the re-presentation of F cued items at test will lead to a release from inhibition (Bjork, 1989). However, Bjork and Bjork (1996) argued that the re-exposure of F items is not sufficient to lead to a release from inhibition. This argument was based on a comparison between the effects on a final recall test of the re-exposure of F items in a recognition task and an indirect word fragment completion task. Retrieval inhibition was only released when the re-exposure occurred within the context of the recognition memory task. In contrast, Basden and Basden (1996) reported that the presentation of a study list of single words in accordance with the list method paradigm failed to produce a directed forgetting effect in a recall test, when the period between the study lists and a final recall test was interposed by an indirect general knowledge task. Thus, a cursory examination of the findings reported by Basden and Basden (1996) and Bjork and Bjork (1996) appears to suggest these data are mutually contradictory with respect to the conditions that are necessary and sufficient to lead to a release from inhibition.

Bjork and Bjork (1996) interpreted their findings as evidence that direct contact with the original encoding event was necessary for the inhibition to be released. By extension, since indirect memory tests are mediated, in part, by unconscious, automatic processes, they will not lead to a release from inhibition.

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5 Basden and Basden (1998) argued that the term 'release from inhibition' is a misnomer, because the influence of a retrieval-based mechanism is minimal in recognition tests.
inhibition. However, the indirect word fragment completion task in their experiment did not represent a sufficient test of this hypothesis, because a smaller number of critical items were presented and retrieved in the indirect word fragment completion test than in the recognition test. Therefore, the two intervening tests were not equated in terms of number of items that could lead to a release from inhibition. Instead, Basden and Basden (1998) argued that the number of retrieval cues, rather than the type of retrieval access, determines whether or not a release from inhibition occurs. This interpretation was supported by an experiment in which the number of intervening F cued items that were re-exposed (rather than the type of task in which they occurred) was shown to be the primary determinant of whether or not a release from inhibition is obtained (Wright et al., 1997, cited in, Basden & Basden, 1998). Further, the release from inhibition did not operate as a graded function; rather, the effect was all-or-nothing. Thus, re-exposure to partial retrieval cues will release the inhibition produced by the list method, if a sufficient number of cues are presented in the context of a conceptual or perceptual indirect memory test (Basden & Basden, 1996; Bjork & Bjork, 1996; cf. Bjork, 1989).

The relevance of these findings for the current experiment relates to whether or not the perceptual-associative word stem completion task will lead to a release of the inhibition conferred on the F cued word pairs. The reinstatement of the associative context in the intact condition, which leads to retrieval mediated by conscious and unconscious processes (Experiments 2 & 5), is conceptually similar to a direct and indirect word stem completion task. Accordingly, it was hypothesised that a release from inhibition would occur as a consequence of the presentation of a partial cue (a word stem) in an associative context when items were unconsciously retrieved (cf. Bjork & Bjork, 1996). There is an additional reason to believe that a list method directed forgetting effect will not be obtained in the estimates of unconscious processes. Specifically, only one of the two formal conditions, identified in Chapter 7, necessary for a list method directed forgetting effect was met in the current experiment: the reinstatement of encoding for a second R list (Basden & Basden, 1998; Gelfand & Bjork, 1985, as cited in, Bjork, 1989). The second condition, the attentional control of the output order of responses, was not available because the order of responses was constrained by the item-by-item cueing. Nonetheless, conscious inhibition was assumed to operate at the time of the instruction to forget the first study list of word pairs.

More generally, it was demonstrated in Experiments 2 and 5 that the reinstatement of the perceptual-associative context led to age-invariant estimates of unconscious processes. When the reinstatement of context is interpreted within the environmental support hypothesis, unconscious processes, rather than conscious processes, are expected to be age-invariant (Jacoby & Hay, 1998). However, this account fails to acknowledge the contribution that the content associated with the
memory processes has on the effect of environmental support. In particular, since the perceptual encoding task appears to support unitisation by perceptually-oriented encoding processes, the effect of the reinstatement of the encoding context is likely to reflect the operation of perceptual unconscious processes. These processes are likely to be less sensitive to the effects of ageing than the unconscious influences of environmental support that are mediated by conceptual processes. Therefore, an additional motivation for conducting this experiment was to examine whether or not the age-related invariance obtained in the estimates of perceptual-associative word stem completion could be replicated a third time under conditions that do not expressly direct participants to engage in item-specific processing; rather, relational processing is encouraged by the list-wise presentation of directed forgetting instructions.

As discussed in Experiment 4, a factor that is relevant to the interpretation of the effects of ageing on the magnitude of the list method directed forgetting effect is the role of attentional inhibition, which operates to change the focus of attention in accordance with directed forgetting instructions (Zacks & Hasher, 1994). In particular, the maintenance of the activation towards the F study list is discontinued by an inhibition based mechanism that is instantiated in response to the directed forgetting cue. Moreover, the locus of the impairment in attentional inhibition has been demonstrated to be particularly acute for the identity of distractors (Zacks & Hasher, 1994), which in the list method paradigm corresponds to the F study list in the F-R study list condition. In accordance with this hypothesis, Zacks et al. (1994) reported that the list method directed forgetting effect was impaired in older adults relative to young adults, and this was mediated by a reduction in the recall of R items, since the recall of F items was equivalent to that obtained in young adults. In contrast, in Experiment 4, the conscious retrieval of R and F exemplars was lower in the older adults, and the relative level of intrusion of F cued items was higher in the older adults in the estimates of conscious processes.

8.2.2 Method

8.2.2.1 Participants

The participants were 32 young (Mean = 25.3 years of age; Range = 19 – 28 years of age; N males = 10; N females = 22) and 32 older adults (Mean = 72.2 years of age; Range = 61 – 74 years of age; N males = 12; N females = 20). The young adults had a mean of 17.4 years of education, whereas the older adults had a mean of 15.2 years of education. Older adults scored a mean of 28.9 correct responses on the MMSE.
8.2.2.2 Design and Materials

The experiment comprised a 2 x 2 x 2 x 2 mixed factorial design. Age (young and old) and directed forgetting instructions (F-R and R-R study list configurations) were between participants factors, whereas test instruction (inclusion and exclusion) and test trial type (intact, recombined, and control) were within participants factors.

Stimulus word pairs were from the same corpus as those used in Experiments 2 and 5. Therefore, the study list consisted of 144 word pairs, which were randomly divided into two equal subsets to provide 72 word pairs for each of the two study lists. The method of counterbalancing was the same as that outlined in the General Methods Chapter. One-half of the word pairs in the intact, recombined and control test trial types were designated to the to-be-forgotten condition and the other half of the word pairs were designated to the to-be-remembered condition. Therefore, each participant received 24 test trials in each of the test trial by instruction condition contrasts.

8.2.2.3 Procedure

The experimental protocols employed for the study phase were the same as those utilised in Experiments 5, with the exception that the directed forgetting instruction was presented midway through the study list. The two types of directed forgetting instruction (F-R and R-R) were the same as those detailed in Experiment 4, with the exception that they were modified to refer to the materials presented as part of the associative word stem completion task. All of the participants were provided with 6 practice pairs of words in order to ensure that they understood the nature of the encoding task. The test phase immediately followed the study phase. The format of presentation of the phase was the same as that for Experiments 2 and 5. The participants completed both inclusion and exclusion tests in accordance with the retrieval instructions described in Experiment 4, with the exception that the instructions were modified to reflect the nature of the critical items.

8.2.3 Results

Table 8.3 presents the mean proportions of correct word stem completions in each experimental condition. A 2 (age: young vs old) x 2 (directed forgetting condition: F-R and R-R) x 2 (study list: list 1 and list 2) x 2 (test instruction: inclusion and exclusion) x 2 (test trial type: intact and recombined) mixed factorial ANOVA was performed on the proportions of correct word stem completions in the inclusion and exclusion tests. Significant main effects were obtained for age, $F(1,60) = 7.95, p < .01$, test instruction, $F(1,60) = 113.02, p < .001$, and trial type, $F(1,60) = 201.62$, 217
More importantly, significant interactions were obtained between age and test instruction, $F(1,60) = 7.07, p < .01$, age and test trial type, $F(1,60) = 9.58, p < .01$, study list and test instruction, $F(1,60) = 4.80, p < .05$, and test instruction and test trial type, $F(1,60) = 49.54, p < .001$. Three-way interactions were obtained between directed forgetting condition, study list, and test trial type, $F(1,60) = 6.58, p < .01$, and between age, list, and test trial type, $F(1,60) = 7.26, p < .01$.

Table 8.3. Mean proportion of studied target words generated in response to word stems in each experimental condition.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Study List</th>
<th>Exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inclusion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F-R</td>
<td>R-R</td>
</tr>
<tr>
<td>Intact Condition</td>
<td>F</td>
<td>R</td>
</tr>
<tr>
<td>Young</td>
<td>0.44</td>
<td>0.50</td>
</tr>
<tr>
<td>Old</td>
<td>0.39</td>
<td>0.42</td>
</tr>
<tr>
<td>Recombined Condition</td>
<td>F</td>
<td>R</td>
</tr>
<tr>
<td>Young</td>
<td>0.36</td>
<td>0.33</td>
</tr>
<tr>
<td>Old</td>
<td>0.35</td>
<td>0.33</td>
</tr>
<tr>
<td>Control Condition</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>0.19</td>
<td></td>
</tr>
</tbody>
</table>

For the young adults in the F-R and R-R groups, there was evidence of a significant association-specific memory effect in the inclusion test, $F(1,60) = 71.37, p < .001$ and $F(1,60) = 154.36, p < .001$, respectively. Similarly, for the F-R and R-R groups there was evidence of a significant association-specific memory effect in the exclusion test, $F(1,60) = 4.86$ and $p < .05$, $F(1,60) = 4.85$, $p < .05$, respectively. For the older adults in the F-R group, the association-specific memory effect did not reach significance in either the inclusion or exclusion tests, $F(1,60) = 1.05, p = .31$ and $F(1,60) = 3.57, p = .6$, respectively. Nonetheless, an association-specific memory effect was obtained in the inclusion test for the F study list items, $F(1,60) = 12.47, p < .001$. For the older adults in the R-R group, there was a significant association-specific memory effect in the inclusion and exclusion tests, $F(1,60) = 43.51, p < .001$ and $F(1,60) = 4.93, p < .05$. 

R = to-be-remembered; F = to-be-forgotten
In relation to the list method directed forgetting effect, in the young adults there was evidence of a significant list method directed forgetting effect for intact word pairs in the inclusion test, $F(1,60) = 7.34, p < .01$, but not in the exclusion test, $F(1,60) = 1.08, p = .30$; whereas, a list method directed forgetting effect was not obtained for recombined word pairs in either the inclusion or exclusion tests, $Fs < 1$. In contrast, in the R-R group, there was no significant difference in retrieval between the two study lists for either intact or recombined word pairs in the inclusion and exclusion tests, $ps > .05$. In the older adults, there was no evidence of a significant directed forgetting effect for intact word pairs in either the inclusion or exclusion test, $F(1,60) = 2.20, p = .14$ and $F(1,60) = 1.05, p = .31$, respectively. Similarly, a list method directed forgetting effect was not obtained for recombined word pairs in either the inclusion or exclusion test, $Fs < 1$. For the older adults in the R-R group, there was no significant difference in retrieval between the two study lists for either intact and recombined word pairs in the inclusion and exclusion tests $ps > .05$.

The conscious and unconscious parameters estimates were calculated in accordance with the computational expressions for the process dissociation procedure outlined in Chapter 2. The parameter estimates of conscious and unconscious processes for each experimental condition are shown in Table 8.4. A 2 (age: young vs old) x 2 (directed forgetting condition: F-R and R-R) x 2 (memory parameter: conscious and unconscious) x 2 (study list: list 1 and list 2) x 2 (test trial type: intact and recombined) mixed factors ANOVA was performed on the conscious and unconscious parameter estimates. Significant main effects were obtained for age, $F(1,60) = 10.82, p < .01$, memory parameter, $F(1,60) = 537.59, p < .001$, and test trial type, $F(1,60) = 214.87, p < .001$. In addition, significant interactions were obtained between memory parameter and study list, $F(1,60) = 5.33, p < .05$, directed forgetting condition and test trial type, $F(1,60) = 6.19, p < .05$, and age and test trial type, $F(1,60) = 20.00, p < .001$. Finally, a significant three-way interaction was obtained between directed forgetting condition, study list, and test trial type, $F(1,60) = 7.79, p < .01$. 

Table 8.4. Conscious and unconscious parameter estimates for each experimental condition.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Intact Condition</th>
<th>Recombined Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F-R R-R F-R R-R</td>
<td>F-R R-R F-R R-R</td>
</tr>
<tr>
<td>Young</td>
<td>0.12 0.20 0.19 0.18</td>
<td>0.9 0.08 0.06 0.04</td>
</tr>
<tr>
<td>Old</td>
<td>0.07 0.12 0.09 0.07</td>
<td>0.03 0.08 0.02 0.06</td>
</tr>
</tbody>
</table>

R = to-be-remembered; F = to-be-forgotten

For the young adults in the F-R condition, there was a significant conscious and unconscious association-specific memory effect, $F(1,60) = 13.25, p < .001$ and $F(1,60) = 26.46, p < .001$, respectively. However, the conscious associative memory effect appears to have been mediated by the R study list, $F(1,60) = 15.16, p < .001$, rather than the F cued list, $F(1,60) = 1.68, p = .19$. Similarly, a significant conscious and unconscious association-specific memory effect was obtained in the R-R condition, $F(1,60) = 37.30, p < .001$ and $F(1,60) = 40.87, p < .001$, respectively, for both the first and second study lists, $p < .01$. For the older adults in the F-R condition, there was evidence of a significant unconscious association-specific memory effect, $F(1,60) = 10.53, p < .01$, whereas the conscious association-specific memory effect failed to reach significance, $F(1,60) = 3.54, p = .06$. The absence of a conscious association-specific memory effect was observed for both the F and R study lists, $p > .05$, whereas the unconscious association-specific memory effect was observed for both the F and R study lists, $p < .05$. For the older adults in the R-R condition, there was a significant conscious and unconscious association-specific memory effect, $F(1,60) = 6.05, p < .05$ and $F(1,60) = 17.55, p < .001$, respectively. However, the conscious association-specific memory effect was mediated by the first study list, $F(1,60) = 5.91, p < .05$, and not the second study list, $F(1,60) = 1.66, p = .20$. In contrast, the unconscious association-specific memory effect was observed in both the first and second study lists, $F(1,60) = 16.87, p < .001$ and $F(1,60) = 5.45, p < .05$, respectively.

For the young and older adults in the F-R condition, there was no significant difference between young and older adults in the unconscious association-specific memory effect, $F(1,60) = 1.80, p = .18$, for both the F and R study list, $p > .05$. Similarly, for the young and older adults in the R-R
condition, there was no significant difference between young and older adults in the unconscious association-specific memory effect, $F(1,60) = 2.42, p = .12$, for both the first and second study lists, $ps > .05$.

In relation to the list method directed forgetting effect in the young adults, a significant effect was obtained in the conscious association-specific memory effect, $F(1,60) = 4.80, p < .05$, and this effect was observed in the intact condition, $F(1,60) = 6.60, p < .01$, but not in the recombined condition, $F < 1$. In contrast, there was no evidence of a list method directed forgetting in the unconscious association-specific memory effect, $F(1,60) = 0.09, p = .77$, and this was observed in the both intact and recombined conditions, $F < 1$. For the young adults in the R-R condition, there was no significant difference between the two study lists for either the conscious or unconscious association-specific memory effect, and in the conscious and unconscious parameter estimates for either intact or recombined word pairs. For the older adults in the F-R condition, the list method directed forgetting effect did not reach significance in either the conscious or unconscious association-specific memory effect, $Fs < 1$, and in the conscious and unconscious parameter estimates for the intact and recombined conditions, $ps > .05$. Similarly, in the R-R condition, the difference between first and second lists in the conscious and unconscious association-specific memory effect was not significant, $ps > .05$, and in the conscious and unconscious parameter estimates for the intact and recombined conditions.

### 8.2.4 Discussion

The findings obtained in Experiments 2 and 5 were replicated to the extent that for the young adults in the F-R and R-R groups, significant memory for new associations was obtained in the estimates of conscious and unconscious processes, although in the directed forgetting condition this was mediated by the R study list. In the older adults, a significant conscious and unconscious association-specific memory effect was obtained in the R-R group, whereas in the F-R group, the association-specific memory effect was limited to the unconscious parameter estimates. Nonetheless, the age-related invariance in the estimates of perceptual-associative unconscious processes for both F-R and R-R groups also replicated the findings obtained in Experiments 2 and 5.

Taken together, the evidence of age-invariant unconscious associative-specific memory is inconsistent with the proposition that older adults are less able to generate contextually distinct encodings to support association-specific memory (Craik & Simon, 1980; Micco & Masson, 1991; Perlmutter, 1979; Rabinowitz et al., 1982). As discussed in the introduction, the source of
variability in the data are likely to reflect differences in the focus on conceptual and perceptual encoding operations. In the current experiment, the orientation towards perceptual encoding operations appears to be sufficient to support an age-invariant association-specific memory effect, even when there was an instruction to forget. However, since the nature of this processing cannot be determined directly, it is plausible that both perceptually and conceptually-based elaborative processing were insufficient in the older adults to support age-invariant conscious association-specific memory.

In relation to the list method directed forgetting effect, an effect was obtained in the conscious, but not the unconscious, parameter estimates for intact word pairs in the young adults. In contrast, the list method directed forgetting did not reach significance in the older adults for either the conscious and unconscious parameter estimates. Further, there was no evidence of increased proactive interference of the R items in the R-R relative to the F-R study list configuration (Bjork, 1989), as might be expected for the older adults. More generally, the pattern of the directed forgetting effect is an analogue of the findings obtained using memory tasks that involve item-by-item retrieval cueing such as the word fragment completion task (Basden et al., 1993; Bjork & Bjork, 1996), word association task (Basden et al., 1993), and word stem completion task (Allen & Vokey, 1998), since equivalent priming of R and F items has been reported. In contrast, a list method directed forgetting effect was observed in the estimates of conceptual conscious and unconscious processes that mediated the category exemplar generation task in Experiment 4.

Thus, the boundary conditions for the list method directed forgetting effect did not extend to the unconscious parameter estimates in the perceptual-associative word stem completion task. Accordingly, it is plausible to assume that the item-by-item retrieval cueing of the R and F cued items in an intact associative context appears to release the F cued items from inhibition (see also, Wright et al., 1997, cited in, Basden and Basden, 1998), when the dependent measure is unconscious parameter estimates. In order to evaluate the logic underlying this proposition, the amount of environmental support that is available at retrieval could be parametrically manipulated by providing word stem cues with one to four letters, thereby allowing the evaluation of the effect that a change in the amount of information (at an item-specific level) modulates the release from inhibition.

An additional factor that may have mitigated the different outcomes between the current experiment and Experiment 4 is that output interference was controlled by the item-by-item cueing of the retrieval cues. As discussed earlier, both the absence of output interference and the re-exposure to the R and F cued items have been shown to eliminate the list method directed forgetting effect.
The failure to obtain a list method directed forgetting effect in the older adults may have reflected insufficient relational processing of the items within a study list to facilitate the identification of each retrieval unit for suppression by conscious inhibition. Relational processing appears to be a necessary, but not sufficient, component of the list method directed forgetting effect (Basden et al., 1993). Engelkamp et al. (1998) demonstrated that relational processing is facilitated by intrinsic relations that exist among the critical items and by encoding tasks that focus on list structure; and these two factors operate in an additive, rather than redundant (Einstein & Hunt, 1980), manner. Only the encoding task met the criteria for relational processing. However, the role of relational processing is complicated by evidence that the magnitude of the list method directed forgetting effect, at least in a free recall task, is also facilitated by encoding tasks that encourage item-specific processing (Basden & Basden, 1996).

The absence of a list method directed forgetting effect in the older adults may also represent evidence for the notion that there is an age-related difference in the use of attentional inhibition in the list method paradigm, and by extension, the existence of a deficit in inhibitory processing in older adults (Dempster, 1992; Zacks et al., 1996). As discussed in the introduction, the only other study that investigated inhibitory processing in older adults, as operationalised in list method paradigm, reported a decline in the list method directed forgetting effect in recall and recognition (Zacks et al., 1996). Further, the results obtained in the current experiment are consistent with the age-related impairment in attentional inhibition, when inhibitory processing has been operationalised within paradigms such as the stopping paradigm (Kramer et al., 1994) and negative priming paradigm (Hasher et al., 1991). However, as discussed in Chapter 3, it is an oversimplification to characterise the operation of inhibitory mechanisms within a unitary construct, since there are several sources of evidence to suggest multiple inhibitory mechanisms that are differentially sensitive to the effects of ageing (e.g., Dempster, 1992; Kramer et al., 1994). Within the context of the list method paradigm, the inhibitory mechanism is argued to inhibit attention to activated information (Zacks et al., 1996), and this mechanism is both mediated by and dependent upon the integrity of the frontal lobes. Therefore, it ought to be sensitive to age-related deficits in the frontal lobes (West, 1996). By extension, it is plausible to assume that the inclusion of additional dependent measures of different forms of inhibitory processes will permit the evaluation of the effect that a change in the strength and type of the inhibition has on the list method directed forgetting effect.

Although impaired inhibitory processing is the dominant interpretation of the list method directed forgetting effect, an important alternative, or additional, mediating factor is spatiotemporal information (see Experiment 4). Given that relational processing between the word pairs within a
study list was likely to be negligible compared to that in the category exemplar generation task (because the critical items did not encourage the identification of relations), the contribution of spatiotemporal contextual information may have had a more significant role than would be expected under conditions that permit a greater degree of relational processing. In particular, the ability to distinguish between the R and F cued items on the basis of spatiotemporal contextual information enables retrieval inhibition to selectively act on the items that occurred in the F study list. However, as discussed earlier, memory for spatiotemporal contextual information does not appear to be the primary determinant of the list method directed forgetting effect (Basden & Basden, 1996; Gilliland et al., 1996). Nonetheless, since these findings were obtained in young adults, the underlying encoding operations and retrieval dynamics that support the list method directed forgetting effect may be different for older adults under some experimental conditions, since strategic differences in task performance between the two age groups cannot be excluded. Further, an impairment in the ability to distinguish between R and F cued items that undergo equivalent initial encoding has been demonstrated to prevent the retrieval inhibition of the F study list (Whetstone et al., 1996). Since memory for the spatiotemporal context in which the items occurred may represent a determinant of the list method directed forgetting effect in the older adults, it clearly warrants further attention. In the current experiment, the encoding operations conferred on each study list following the mid-study list cue would be diagnostic of the R or F status of a particular word pair, whereas the availability of the general experimental context is required to avoid the intrusion of critical items in the exclusion test.
9. General Discussion

9.1 Introduction

The focal interest of this thesis was the investigation of the effects of ageing on conscious and unconscious processes. Some of the principle methodological and theoretical limitations of foregoing research in this area were identified in the introductory review chapters, and this led to the application of the process dissociation procedure to two cells of a four cell process-matrix, which orthogonally crossed the distinction between item- and association-specific memory with the distinction between perceptual and conceptual processing. In relation to ageing, it was argued that memory tasks that are primarily mediated by conceptually-based processing and involve the formation of new associations would be vulnerable to the largest age-related effects, whereas memory tasks that are primarily mediated by perceptually-based processing and involve the reactivation of existing item-specific representations would be the least susceptible to age-related impairment. This four cell process-matrix has not been previously applied to guide experimental work that has investigated age-related differences in conscious and unconscious processes.

Two basic memory paradigms were selected for the experimental work, category exemplar generation and perceptual-associative word stem completion, because these paradigms conferred the ability to evaluate the assumptions made for the process-matrix by examining two cells, namely: conceptual, item-specific memory and perceptual, association-specific memory, respectively. These cells have only received minimal research attention in comparison with perceptual, item-specific memory and conceptual, association-specific memory. In terms of the functional demands associated with the memory task(s) selected to represent the prototype for each cell, it was initially hypothesised that the estimates of conceptually-based conscious and unconscious processes would be subject to an age-related deficit, whereas only the estimates of perceptually-based conscious-associative processes were hypothesised to be subject to an age-related deficit. These basic claims will be revisited in the current chapter in light of the experimental findings that were obtained.

In addition, it was demonstrated that the application of the process-matrix to the process dissociation procedure has important implications for the boundary conditions and the specification of the theoretical parameters within the process dissociation model. In particular, the two memory paradigms selected were shown to be susceptible to being compromised by conscious retrieval (see Chapter 1); and in the case of the category exemplar generation task, the retrieval strategy that was
employed by participants had direct consequences for the validity of the parameter estimates derived from the process dissociation procedure. An additional dichotomy that has been recently specified, which has heuristic value in relation to the interpretation of the age effects on direct and indirect memory tests, is that between identification and production processes (Fleischman & Gabrieli, 1998; Gabrieli et al., 1999b). Thus, this distinction will be incorporated into the discussion of the findings in the following sections. Consequently, the intention of the current chapter is to discuss the outcome of the application of the process-matrix to the process dissociation procedure, and relate these findings to the interpretation of cognitive ageing.

9.2 Category Exemplar Generation and Perceptual-Associative Word Stem Completion: Structural and Functional Properties

The structural and functional properties that define the category exemplar generation task and perceptual-associative word stem completion task are discussed. In addition to the differences in the contribution of conceptual and perceptual association- and item-specific information, the tasks also differed in terms of the processes that were engaged to retrieve an item or verify the attributes of the retrieval candidates. As a brief overview, the results reported in this thesis concur with the foregoing research that has reported a pattern of age-invariance in unconscious parameter estimates (Hay & Jacoby, 1996; Jacoby, 1991; Jacoby et al., 1989; Jennings & Jacoby, 1993; Rybash et al., 1998; Titov & Knight, 1997), but this has been extended to the category exemplar generation task and perceptual associative word stem completion task.

9.2.1 Category Exemplar Generation Task

The category exemplar generation task represents a canonical conceptual memory task, since the relation between the critical items at encoding and the retrieval cues should ensure that there is a significant role for top-down, conceptual processes. In addition, the task has been shown to be facilitated by conceptual encoding operations (for a review, see Roediger & McDermott, 1993). However, as discussed in Chapters 3 and 5, Vaidya et al. (1997) introduced a distinction between competitive and non-competitive retrieval access to account for a variety of functional dissociations between conceptual memory tasks. For example, functional dissociations have been obtained using variables such as levels of processing, exact and conceptual repetition, and divided attention (Cabeza, 1994; Light et al., 1999; McDermott & Roediger, 1996; Vaidya et al., 1997; Vriezen et al., 1995). By extension, there is no reason to simply assume that the effect of the attentional load manipulation (Experiment 1), the effect of the item method directed forgetting paradigm
(Experiment 4), and the effect of list method directed forgetting paradigm (Experiment 5) reported in this thesis on the category exemplar generation task will be replicated for different conceptual memory tasks.

For example, the category exemplar verification task does not involve competitive retrieval access or response production. Priming in category verification appears to be immune to the effects of divided attention at encoding (Gabrieli et al., 1999b; Light et al., 1999), which is one source of evidence that suggests category verification is dissociable from other conceptual memory tasks. One critical determinant of the effect of divided attention on conceptual priming may be the degree to which the task involves the re-presentation of the critical item at test, since an impoverished representation encoded under divided attention conditions may be reinstated by the re-presentation of the critical item at test, so that the effect of divided attention is attenuated or absent. This interpretation is embodied within the distinction between identification and production forms of repetition priming, which was originally formulated to account for a decline in word stem completion priming and invariance in perceptual identification priming, as a function of divided attention at encoding and Alzheimer's Disease (Gabrieli et al., 1994; Gabrieli et al., 1999a). More specifically, identification and production based memory paradigms are assumed to differ in terms of their demands on attentional resources (Gabrieli et al., 1997b).

However, although the identification-production distinction can accommodate the extant data that has examined the effects of divided attention on priming, the distinction is largely descriptive, because the components of encoding that are necessary to support the retrieval of items in tasks that involve either production or identification based processes have not been identified. In relation to conceptual direct and indirect memory tasks, these components include organisation, strategic identification, and verification processes that support the retrieval of response candidates. In the context of perceptual priming, these factors have been incorporated into the notion of response competition among similar retrieval candidates, when there is only one solution for each retrieval cue. Indeed, Ratcliff and her colleagues have argued that this is a critical component of the priming effects obtained in tasks such as perceptual identification and word fragment completion (e.g., Ratcliff & McKoon, 1996; Ratcliff & McKoon, 1997; Ratcliff et al., 1989).

At a more procedural level of interpretation, the demands associated with the category exemplar generation task can be modulated by the number of exemplars required in response to each category name, the number of retrieval candidates that are available in a semantic category (exhaustive versus non-exhaustive categories), and the dominance of the exemplars. All of these factors have
been varied across studies (e.g., Gabrieli et al., 1999b; Grober et al., 1992a; Light et al., 1999; Schmitter-Edgecombe, 1999, see Chapter 1). Clearly, the effect of a variable on category exemplar generation performance is likely to interact with these factors. In addition, the competitive retrieval access that underlies the category exemplar generation task may be influenced by these factors in terms of the intra-category associations that exist between response candidates. For example, if it is presumed that the category exemplar generation task involves the reactivation and strengthening of pre-existing, Type-1 associations (Bower, 1998), then the extent to which the retrieval of an exemplar leads to the retrieval of related exemplars will be determined by the dominance of the exemplar, with all other factors being equal, since the baseline activation for the target exemplar is determined by the dominance of the exemplars within a category (Bower, 1998). Further, the access to the exemplars may, under certain conditions, violate the independence assumption of the process dissociation procedure, such as when intra-category associations are "high", because the stochastic independence between items will be violated (see, Curran & Hintzman, 1997; cf. Jacoby & Shrout, 1997; Nelson et al., 1999).

Thus, it would appear that the specification of the overlap between the operations at encoding and retrieval is not sufficient to describe the functional demands associated with the category exemplar generation task, since it is the interaction between these operations and the structural properties of the task that will provide a more accurate account of the retrieval dynamics that access conceptual item-specific representations. The implications of these issues for the process dissociation procedure will be discussed in a later section.

9.2.1.1 Age-Effects in Conceptual Unconscious Processes: Conceptual Automaticity Revisited

In relation to ageing, direct and indirect tasks that involve strategic, frontal components of processing at retrieval, as conceptualised in the working-with-memory model, are assumed to be particularly susceptible to the effects of ageing (e.g., Femades & Moscovitch, 2000; Moscovitch, 1994a). There are several sources of evidence that are consistent with this position. For example, older adults experience deficits in tasks such as the verbal fluency task (e.g., Light, 1990) and the Wisconsin Card Sorting task (Leach, Warner, Hotz-Sud, Kaplan, & Freedman, 1991). The logic underlying the working-with-memory model can be extended to predict the effect of age on category exemplar generation priming. More specifically, the priming in this task would be expected to be more prone to the effects of age than priming tasks that involve item identification because of the additional demands on search and retrieval strategies when multiple completions...
need to be generated in response to a category name (Fleischman & Gabrieli, 1998; Jelicic, 1996; Rosen & Engle, 1997; Rybash, 1996). In addition, since the content of memory processes is also believed to be a determinant of the effect of age on memory (Craik, 1986), the conceptual processes associated with category exemplar generation priming should be a sensitive measure for age effects that may exist within item-specific unconscious processes.

More generally, the notion that the category exemplar generation task will be sensitive to the effects of ageing represents a formalisation of the tenets that underlie the environmental support hypothesis (Craik, 1983; Craik, 1986, Chapter 3), since the basic assumption is that age deficits are particularly acute when a memory task involves self-initiated operations. A conceptual analogue of this argument can be found in the interpretation proposed by Gabrieli et al. (1994) to account for preserved item-based priming (perceptual identification) and impaired production-based priming (word stem completion) in patients with Alzheimer’s Disease (AD). In particular, Gabrieli et al. (1994) argued that the impaired word stem completion priming did not reflect contamination by conscious processes or conceptual unconscious processes; rather, the impairment reflected a deficit in the processes that are involved in the production of responses (Fleischman & Gabrieli, 1998; Gabrieli et al., 1999b).

However, the experimental findings in the three experiments that employed the category exemplar generation task did not support this general position, because age-related deficits were only obtained in the estimates of conceptual conscious processes (Experiments 3 & 4). This is consistent with the evidence of age-invariance in conceptual priming in the indirect general knowledge task (Rastle & Burke, 1996; Small et al., 1995), the indirect word association task (McEnvoy et al., 1995), and the indirect category exemplar generation task (Isingrini et al., 1995; Light & Albertson, 1989; Light et al., 1999; Maki & Knopman, 1996; Monti et al., 1996). However, all of the studies that have investigated conceptual priming in older adults have failed to include an independent measure of conscious and unconscious processes (for additional discussion of this issue, see Chapters 1 and 5). A convergent source of evidence that suggests age-invariance in measures that involve conceptual unconscious processes comes from studies that have demonstrated age-invariance in cross-form priming (e.g., Gibson et al., 1993; Light et al., 1992; Wiggs & Martin, 1994), which is widely regarded to reflect the operation of conceptual processing because it is not dependent on the perceptual overlap between the materials at study and at test (but see, Kirsner, Dunn, & Standen, 1989; e.g., Woltz, 1996).

Several potential explanations can be proposed to account for the absence of an age-related
impairment in the estimates of conceptual unconscious processes reported in this thesis and elsewhere. One explanation can be developed from the data reported in a recent study conducted by Rosen and Engle (1997), which examined whether or not individual differences in working memory capacity and divided attention at retrieval modulated the ability to perform a category verbal fluency task. The task required the generation of category exemplars in response to a category name. Participants with 'high-span' working memory capacity had higher levels of verbal fluency than participants with 'low-span' working memory capacity; in addition, the divided attention task only impaired the verbal fluency of the high-span participants. Rosen and Engle (1997) argued that their findings suggested that retrieval processes can be mediated either by a controlled search strategy or an automatic process. In particular, retrieval processes are mediated automatically when attentional resources are impaired, whereas retrieval processes are mediated by a controlled strategy when attentional resources are available to control the sampling of retrieval candidates. If it is assumed that the older adults had less attentional resources available than the young adults for task relevant information, the greater dependence of the older adults on unconscious processes in the category exemplar generation task adults (in Experiments 3 & 4) is consistent with the notion that retrieval is mediated by unconscious processes when attentional resources are diminished.

Moreover, Rosen and Engle (1997) identified four retrieval components in the category verbal fluency task, '(a) activation automatically spreading from the cue, (b) self-monitoring of output to prevent repetition and error, (c) suppression of previously retrieved responses, and (d) generation of cues to access new names.'(p.214). In relation to ageing, the latter three components identified by Rosen and Engle (1997) are attention demanding and are therefore likely to be susceptible to an age-related reduction in attentional resources. Nonetheless, the category exemplar generation task does not appear to invoke these three components (that mediate response selection and verification) to a sufficient extent for age-related deficits to be expressed in the unconscious parameter estimates. Alternatively, these three components may operate relatively fluently within the context of the category exemplar generation. This proposition could be evaluated more directly by examining the effect of divided attention at retrieval on the category exemplar generation task.

Another potential explanation for the failure to obtain an effect of age in the unconscious parameter estimates is that the estimates of U obtained in the experiments (potentially as a consequence of the adoption of a generate-recognise retrieval strategy) may not have provided a sufficiently sensitive measure of small, but reliable, age effects in these processes. Although, there is an inherent circularity in this interpretation, the proposition that age-related deficits are present in conceptual unconscious processes can only be properly evaluated by increasing the contribution of unconscious
processes and by obtaining estimates of conceptual unconscious processes in a variety of memory
tasks. The former approach can be achieved either by changing structural aspects of the category
exemplar generation task, or by using an alternative conceptual memory task.

9.2.2 Perceptual-Associative Word Stem Completion Task

The distinction between two forms of associative word stem completion priming guided the
experimental work; namely that between conceptually-based and perceptually-based memory for
unrelated word pairs. The experimental work employed the basic paradigm developed by Reingold
and Goshen-Gottstein (1996a) in which the encoding task emphasised perceptual encoding
operations, and this led to association-specific memory that was mediated by conscious and
unconscious processes, rather than conscious processes alone, as has been reported in other studies
that have examined conceptual-associative word stem completion in older adults (e.g., Rybash et
al., 1998). It is argued that the perceptual encoding operations are likely to reflect the formation of
perceptually-oriented links that access a single unitised representation of both pair members (for a
debate of the role of unitised representations in priming, see McKoon & Ratcliff, 1992; McNamara,
1992; Schacter, 1985a), because the variables that have been demonstrated to have an effect on
conceptual-associative priming (divided attention and levels of processing) did not have an effect
on the estimates of perceptual-associative unconscious processes, as reported in Experiments 2 and
5 (if it is assumed that item method directed forgetting is a conceptual analogue of the levels of
processing manipulation). Consequently, Experiments 2 and 5 provide the first evidence to suggest
that perceptual-associative word stem completion is supported by different components of
processing to those involved in conceptual-associative word stem completion. Nonetheless, as
discussed in the Chapter 6, the operation of the mechanisms that support these two forms of
association-specific priming are not necessarily orthogonal (Schacter, 1994a).

The nature of the processes that support the formation of new associations could also be inferred
from the application of a cross-form manipulation between study and test. As discussed in Chapter
6, conceptual-associative word stem completion priming has been shown to be impaired when the
perceptual elements are changed between study and test (Schacter & Graf, 1989). This suggests
either that conceptual-associative priming is mediated by novel, highly specific information, or that
the retrieval processes that support associative priming are perceptually-based and the encoding of a
word pair is conceptually-based (Schacter & Graf, 1989; Schacter & McGlynn, 1989). By
extension, it would be interesting to apply a cross-form manipulation to the perceptual-associative
word stem completion task utilised in the experimental work presented here in order to further
identify the nature of the processes that support perceptual-associative priming, since the absence of an effect of divided attention at encoding or an effect of differential rehearsal on the unconscious parameter estimates are both consistent with the notion that these processes are mediated by perceptual processing. Further, the decline in performance when the line drawing was not represented at test, reported by Reingold and Goshen-Gottstein (1996a), also suggests that perceptual-associative word stem completion priming is mediated by hyperspecific information. In a related manner, a theoretically informative exercise would be to examine the effect of the number of individual study trial presentations on the perceptual-associative memory effect, since no effect of this variable has been obtained for serial pattern learning (Howard & Howard, 1989); and this is argued to be due to the fact that this form of priming is based on perceptual processing.

There are also at least two lexical factors that have implications for the effect of variables on the associative word stem completion task: the response dominance and the frequency of the critical words. Although there is no direct empirical evidence that has addressed the role of lexical factors in associative word stem completion, a recent study that examined the effect of word frequency and response dominance on item-specific word stem completion is instructive in this regard. In a comparison of direct and indirect word stem completion, Gabrieli et al. (1999b) compared words that were the most dominant completion with words that were either high frequency or low frequency less dominant completions, under semantic and shallow encoding conditions. In the direct memory test, a levels of processing effect was only obtained for the dominant, low frequency completions. In the indirect memory test, there was no effect of the levels of processing manipulation, but the dominance of the completions determined the magnitude of the priming obtained, with priming for the high frequency words exceeding the low frequency words. An additional lexical factor was identified in a study conducted by Weldon and Colston (1995) that measured target output position, total output in response to a word stem, and the proportion of target words produced in response to a word stem. For the present purposes, the critical finding was that output position for target completions was found to be earlier than completions based on unstudied words. This finding provides at least indirect evidence suggesting that instructing the participants in the perceptual-associative word stem completion task to provide only one completion (as adopted in the experimental work) does invoke the retrieval of target items, and is based on mnemonic processes; although this protocol has been shown to increase the role of conscious retrieval in an indirect memory test (Squire et al., 1987). Clearly, there is a significant role for lexical factors in the associative word stem completion task performance that warrants additional attention.

Finally, an issue that has been identified in a number of different theoretical perspectives: the
contribution of conscious retrieval to associative priming. As discussed in Chapter 1, task contamination in associative word stem completion has been evaluated using post-test questionnaires (Bowers & Schacter, 1990; McKone & Slee, 1997), the process dissociation procedure (Reingold & Goshen-Gottstein, 1996a; Reingold & Goshen-Gottstein, 1996b), and with patient populations that have an impaired ability to invoke conscious retrieval (Shimamura & Squire, 1989). However, it is conceivable that priming in associative word stem completion under some conditions actually reflects involuntary conscious memory, rather than voluntary conscious retrieval. Target stems that are retrieved using an involuntary retrieval strategy, and then undergo explicit recognition, would be characterised as test aware in a post-experimental questionnaire. This would also account for the apparent incompatibility between the evidence of functional dissociations between direct and indirect associative word stem completion and evidence of task contamination in indirect memory tests (Gooding et al., 1999; Kinoshita, 1998). Clearly, the role of involuntary conscious memory cannot be directly addressed using the process dissociation procedure, but as discussed in Chapter 2, alternative methods have been developed to isolate the contribution of involuntary conscious memory to memory task performance, if it does transpire that this is a veridical phenomenological state.

9.2.2.1 Perceptual-Associative Memory: Effects of Ageing

As discussed in Chapter 1, the contribution of unconscious processes to conceptual-associative word stem completion is minimal (Reingold & Goshen-Gottstein, 1996b), consequently it would appear that perceptual encoding operations need to be emphasised to provide a sufficient basis on which to evaluate age effects on unconscious associative processes (cf. Rybash et al., 1998). Experiments 2, 5, and 6 revealed a reliable interaction between age and the parameter estimates, since an age-related deficit was obtained in the estimates of perceptual conscious processes, whereas age-invariant perceptual unconscious parameter estimates were obtained. The latter findings are at variance with the classification—by researchers such as Rybash (1996; Rybash et al., 1998)—of the associative word stem completion task as a conceptual association-specific memory task, which is susceptible to age-related deficits. A qualitative distinction needs to be made between perceptual and conceptual associative word stem completion. This has important implications for the interpretation of the extant research, since the inability to obtain single-trial age-invariant associative word stem completion priming may reflect the fact that conceptual operations were emphasised at encoding. There appears to be a dearth of research available regarding the effects of ageing on perceptual-associative word stem completion; consequently, more general claims that older adults are impaired in their ability to form new associations cannot be properly validated, or at

As discussed in Chapter 1, there is evidence of age-invariance in associative lexical-decision and associative word-pair reading tasks (e.g., Howard et al., 1986; Light et al., 1992), which also both involve perceptual encoding and retrieval operations. More generally, although associative priming within latency-based paradigms is widely regarded as less prone to contamination by conscious recollection than completion-based paradigms (e.g., Goshen-Gottstein & Moscovitch, 1995a), this proposition has not been directly evaluated by the systematic application of process dissociation based approaches. An additional difficulty associated with using these latency-based tasks in an age-related study is that since association-specific memory becomes available more slowly than item-specific memory (Bowers & Schacter, 1993; Lewandowsky, Kirsner, & Bainbridge, 1989; McKone & Slee, 1997), age-related effects may be confounded by differences in baseline performance that arise from age-deficits in the speed of cognitive processing (Salthouse, 1985). Nonetheless, the self-paced encoding and retrieval protocol utilised with the perceptual-associative word stem completion task also involves interpretative difficulties, since a systematic age confound is introduced by this protocol, again due to the general slowing known to accompany ageing.

More generally, the baseline measure in the associative word stem completion task is more demanding than the baseline in the associative lexical decision task, because it is based on the distinction between intact and recombined elements, rather than the contrast between an intact condition and a control condition. Therefore, it may not be an appropriate dependent measure under all circumstances. Nonetheless, the impairment in the estimates of perceptual-associative conscious processes is unlikely to reflect the inability of the older adults to identify the status of the contextual cue with respect to the target word stem, since the method of counterbalancing of materials was designed to ensure that participants did not develop a strategy for completion based on the status of the context word (Reingold & Goshen-Gottstein, 1996b).

It would be an oversimplification to interpret the basic pattern of data presented in Experiments 2, 5, and 6 as evidence that the locus of age-deficits in association-specific memory for unrelated words is the retrieval, rather than the formation of new associations (cf. Light, 1991). Further, these findings are a problem for the activation models in which conceptual, elaborative processing is necessary to establish the new connections indexed by associative priming tests (Graf & Schacter, 1989). These findings also conflict with the position adopted by Squire (1992b, p.214) who argued, “nondeclarative (implicit) learning is specialised for incremental, cumulative change and new associations can be acquired implicitly but only after many repetitions.”
9. General Discussion

One explanation for the age-invariance in the estimates of perceptual-associative unconscious processes (Experiments 2, 5 & 6) is that the provision of a line drawing at study and test reduced the amount of self-initiated processing, because there is increased environmental support provided by the overlap between the retrieval cues and items at encoding. Further, the re-presentation of the line drawing is also potentially an important mediating factor, because older adults appear to have an impaired ability to access and activate stored visual memories (Dror & Kosslyn, 1994); this has been extensively demonstrated in paired-associated learning tasks (e.g., Hulicka & Grossman, 1967). The results reported here suggest that ageing does not alter the ability to benefit from the line drawing. Nevertheless, although the presence of an explicit line drawing suggests that the young and older adults used the same kind of supporting context, the representation of each stimulus can be encoded along a number of different dimensions and these may vary with age.

As discussed earlier, there was an interaction between age and the parameter estimates obtained in Experiments 2, 5, and 6. This basic finding can be interpreted within the frontal lobe hypothesis of ageing (West, 1996), which was discussed in Chapter 3. In particular, a study conducted by Winocur et al. (1996) reported that the magnitude of item-specific priming in a word stem completion task was correlated with performance on tests of frontal lobe function, whereas performance on a direct word stem completion task was correlated with measures of medial temporal lobe function. Winocur et al. (1996) argued that strategic processes were engendered by the requirement to search among multiple retrieval candidates, and these accounted for the correlation with the frontal lobe tests and impairment in the older adults. This position is essentially equivalent to the interpretation that would be conferred upon this pattern of findings within the identification-production distinction (e.g., Fleischman & Gabrieli, 1998). Further, Nyberg, Winocur, and Moscovitch (1997c) reported that the correlation between the magnitude of priming and frontal lobe tests could be modulated by varying the number of candidates, whereby the correlation was lower when there were only a few potential completions for each word stem, presumably because of the reduction in the demands on strategic processes. Similarly, evidence from a recent neuroimaging study revealed that the magnitude of left frontal lobe activation was increased when the number of possible response solutions to word stems involved multiple as opposed to a small number of response solutions (Desmond, Gabrieli, & Glover, 1998).

Although all of these findings were obtained for item-specific word stem completion, the logic underlying these studies can be extended to the perceptual-associative word stem completion task. In particular, given that two or three legitimate solutions were available for each word stem in the
tasks reported in this thesis, the role of strategic, frontal processes would be expected to be minimal. Thus, priming in older adults would not be expected to be impaired in this variant of the task, because a large demand is not imposed on the frontal lobes, which appear to be particularly prone to the age-related neurodegenerative effects (West, 1996). By extension, the age-invariance in associative lexical decision and the speeded reading of degraded words may also reflect the minimal role that strategic search and retrieval processes play in these tasks. Further, since conceptual-associative priming is mediated by a more direct contribution from strategic, lexical or semantic organisational components that are dependent on the integrity of the frontal lobes (Mayes & Gooding, 1989; Moscovitch & Winocur, 1995), the age-related deficits obtained in this task are consistent with the frontal lobe hypothesis of ageing (West, 1996). Nonetheless, it is important to note that the hippocampus and related structures have also been implicated in the storage and reactivation of new associations, which reflects the more general view that semantic memory supports associative memory (Schacter, 1994b).

9.3 The Effects of Varying Attentional Load: Evidence from Category Exemplar Generation and Perceptual-Associative Word Stem Completion

A parametric, rather than a binary, manipulation of attention was employed in the experimental work. As discussed in the foregoing chapters, the effects of divided attention on memory tasks has been interpreted both in terms of the transfer appropriate processing framework and a general reactivation theory of explicit and implicit memory, referred to as the attentional view in this thesis (see also, Mulligan, 1997; Mulligan, 1998). Within the attentional view, only direct memory tests are assumed to require elaborative processing that involves the formation of context-dependent representations, which are mediated by consciously controlled processes that demand attention (e.g., Craik et al., 1996; see also, Gillund & Schiffrin, 1984; Humphreys et al., 1989; Mandler, 1980). Therefore, from the perspective of the attentional view, the effects of divided attention provides a means for evaluating the automaticity of memory processes. In contrast, the effects of divided attention at encoding in the transfer appropriate processing view are assumed to be determined by the degree to which a memory test is mediated by conceptually-based processing (e.g., Mulligan, 1998).

The effects of divided attention on the inclusion test in the category exemplar generation task (Experiment 1) and the estimates of perceptual-associative conscious processes (Experiment 2) were compatible with the numerous studies that have demonstrated impaired performance in direct memory tests following divided attention at encoding (e.g., Gabrieli et al., 1997b; Mulligan, 1998;
Mulligan & Hartman, 1996). However, the crossed interaction between the parameter estimates in Experiment 1 obscured the inferences that could be made with regard to the effect of divided attention. Nonetheless, it is conceivable that the increase in the intrusion rate in the exclusion test reflected the impoverished information available for an exclusion decision. This interpretation is consistent with the decline in conceptual conscious and unconscious processes that has been reported across several different experimental protocols (e.g., Gabrieli et al., 1999a; Gabrieli et al., 1999b; Light et al., 1999; Mulligan, 1997; Mulligan, 1998; Mulligan & Hartman, 1996; Schmitter-Edgecombe, 1999).

In Experiment 2, the unconscious parameter estimates for the perceptual-associative word stem completion task were invariant as a function of the varying attentional load. These findings are at variance with the effect of divide attention reported by Gabrieli et al. (1999b) for item-specific priming in an indirect word stem completion task. This different outcome is particularly interesting, because the divided attention manipulation applied by Gabrieli et al. (1999b) involved a six item digit-letter sequence presented in accordance with the same basic experimental protocols that were utilised in Experiments 1 and 2. One basic criticism that can be levelled at their design is that the indirect test may have been compromised by conscious retrieval, because a relatively large number of items was presented at encoding (58) and the participants were provided with a long latency at test to complete each word stem (10 seconds). In addition, the completion of each word stem in Experiment 2 did not involve response competition among more than two or three legitimate response solutions, whereas each word stem in the task implemented by Gabrieli et al. (1999b) could be completed with 10 or more legitimate response solutions. This difference may fundamentally alter the sensitivity of the task to differences in the availability of attention, or type of attention (Gabrieli et al., 1999b), at encoding because additional information may be needed to apply a decision criterion to select amongst multiple response candidates. This proposition could be directly evaluated by comparing the effects of divided attention at encoding and retrieval on the two basic variants of the associative word stem completion task.

The dissociative effect of divided attention at encoding on the unconscious parameter estimates in the category exemplar generation and perceptual-associative word stem completion tasks is consistent with the transfer appropriate processing framework, but not with the attentional view. Moreover, the extensive evidence of an effect of divided attention on conceptual unconscious processes within a category exemplar generation task has broader implications for the conceptualisation of automaticity within the process dissociation framework. Specifically, although Jacoby and his colleagues have argued that automatic, unconscious processes are context-dependent
(Jacoby et al., 1993a; see also, Neumann, 1984), the nascent findings are not readily interpretable without additional assumptions. In contrast, the differential sensitivity of perceptual-associative conscious and unconscious processes to divided attention may occur because successful unconscious retrieval depends on the generation of stimulus representations for the unrelated word pairs, whereas conscious retrieval also requires that the stimuli are encoded in memory in terms of contextual cues defined in terms of spatiotemporal properties. Consequently, the information that needs to be encoded for the effective conscious retrieval of an item may require greater attentional resources than that associated with unconscious retrieval.

As discussed in Chapter 1, one approach to understanding the operation of the effect of divided attention is the interaction between the demands of the primary and secondary task. Similarly, an additional determinant of the effect of divided attention is the nature of the secondary task. For example, Stone et al. (1998) reported that a colour-naming task impaired performance on perceptual identification priming, whereas an auditory-verbal monitoring task did not have an effect on perceptual identification priming. Further, the effect of a particular secondary task may differ according to the priming measure. For example, no effect was obtained when a colour-naming task was applied at encoding to a lexical decision task (Szymanski & MacLeod, 1996), but the same secondary task impaired performance on a perceptual identification task (Stone et al., 1998). The failure to obtain valid memory parameter estimates in Experiment 1 precludes a similar comparison with Experiment 2 of the effects of the secondary task that was employed. Nonetheless, given the extant research, a dissociation is conceivable between the unconscious parameter estimates in the category exemplar generation task and the perceptual-associative word stem completion task. Stone et al. (1998) argued that the effects of divided attention reflected the extent to which the secondary task is mediated by the operations that support a particular form of priming (for a related argument applied to direct memory tests, see Fernades & Moscovitch, 2000). This position represents an instantiation of the more general theoretical position that states that the effect of a secondary task is determined by the extent to which the same domain specific resources that support the encoding of the critical items are shared between the primary and secondary tasks (e.g., Wickens, 1984). Further, since neither perceptual or lexical access was truncated by the secondary task that was employed in Experiments 1 and 2, it is likely that the secondary task interfered with later stages of critical item encoding.

9.3.1 Implications for the Attentional Resource Account of Cognitive Ageing

Age-related deficits in attentional resources have been interpreted within a variety of accounts that,
when operationalised in terms of divided attention (for reviews, see Hartley, 1992; Salthouse, 1991), predict a decline in the ability to divided attention. From a neurological perspective, there is considerable evidence to indicate that the frontal lobes undergo neural degeneration as a function of age (for a review, see Prull, Gabrieli, & Bunge, 2000; West, 1996). Even if neither the primary nor the secondary task activates the frontal lobes, the combined performance of the two tasks can still activate the frontal lobes (D'Esposito et al., 1995). However, the behavioural findings add additional layers of complexity, because the effects are modulated by several mediating factors, such as the complexity of the task and the amount of practice (e.g., McDowd & Craik, 1988; Rogers et al., 1994), which are likely to interact with age.

As discussed in Chapter 1, several studies that have applied a divided attention task to young and older adults have not found a greater age-related impairment under divided attention in direct (e.g., Baddeley et al., 1986; Nyberg, Nilsson, Olofsson, & Backman, 1997a) and indirect memory tests (e.g., Isingrini et al., 1995; Light & Prull, 1995; Light et al., 1999). The findings reported in this thesis concur with previous results and provide additional novel data, since age-invariance was obtained in the exclusion test in the category exemplar generation task as a function of increasing attentional load. However, the findings obtained in Experiment 2 are more complex, since an incremental effect of increasing attentional load was obtained in the conscious parameter estimates for the older adults, whereas in the young adults the effect of divided attention was restricted to the 5-item load. Further, although the perceptual conscious parameter estimates were impaired in older adults, the magnitude of the age effect remained equivalent under the 5-item attentional load. The divided attention task is unlikely to have imposed a large load on working memory because a passive, rote rehearsal strategy would be sufficient to maintain the digit-letter sequence (see, Parkinson, Lindholm, & Inman, 1982); therefore, it is perhaps not surprising that there was no age effect obtained with this task. Nonetheless, it may have been worthwhile to have included a greater attentional load than the five-item digit letter string in order to provide additional information to describe the relation between age and dual-task performance.

The distinction between attentional resources and attentional control, as functionally independent determinants of the effects of divided attention at encoding, is a potentially important distinction for understanding the effects of age on the ability to divide attention (Anderson et al., 1998; Craik et al., 1996). The absence of an age-related secondary task cost observed in Experiments 1 and 2 suggests that these operations consumed equivalent amounts of attentional resources in the two age groups (Anderson et al., 1998), and older adults are apparently equally able to exercise control over their encoding processes in the current task. Further, this finding is particularly interesting given the
view that locus of age-related impairment is within consciously controlled processes (Hasher & Zacks, 1979; Hay & Jacoby, 1996), since encoding is widely regarded to be under cognitive control (Craik et al., 1996). Nonetheless, this age-invariance in the secondary task costs is not unprecedented, since other studies have reported little or no age-related secondary task costs (e.g., Salthouse et al., 1984). The procedural differences between Experiments 1 and 2 and studies in which a secondary task cost has been obtained obscure simple interpretations of the different outcomes.


The item and the list method cueing paradigms were applied to the category exemplar generation task (Experiments 3 & 4) and to the perceptual-associative word stem completion task (Experiments 5 & 6). As discussed in Chapters 1, 3, 7, and 8, it has been argued that the item method directed forgetting effect is mediated by differential rehearsal at encoding, whereas the list method directed forgetting effect is attributed to the operation of intentional inhibitory processes (e.g., Basden & Basden, 1998; Bjork et al., 1998). Although the differential rehearsal and retrieval inhibition accounts have been extensively evaluated in directed forgetting research, and in this thesis, one aspect of the operations that support the directed forgetting effect that has not been articulated is the nature of the representational changes that occur in response to R and F cues. These representational changes are unlikely to be equivalent in the list and item method paradigms. One consequence of item-specific processing may be that R and F cued items are associated with a discriminatory tag (Basden & Basden, 1996; Basden & Basden, 1998; Basden et al., 1993). Moreover, since item-specific, distinctive processing is not sufficient to support directed forgetting in itself (Hauselt, 1998), the discriminatory tag may represent a necessary component for strategic retrieval, particularly when the discrimination processes becomes difficult.

In addition to age-differences in attentional inhibition and differential rehearsal, the smaller difference between R and F item retrieval observed in the older adults is likely to reflect the greater demands associated with the discrimination and verification of R and F cued items at encoding, which may involve the use of a form of discriminatory tag. One dependent measure of the discriminatory tags associated with R and F cued items is the ability to identify the spatiotemporal context in which an item occurred. As discussed in Chapter 7, the source memory for a retrieved item does not differ for R and F study list items in the list method (Geiselman et al., 1983), whereas in the item method, serial position judgements for R and F items were more accurate for R cued
words that had undergone elaborative rehearsal (Jackson & Michon, 1984). The notion of a discriminatory tag was addressed in the early work by the proponents of the selective search account of directed forgetting (Epstein, 1972; Epstein & Wilder, 1972), but additional research is clearly warranted.

In the following two subsections, it will become apparent that additional mechanisms, or increased refinement of existing mechanisms, may be required to account for the findings. In particular, the attribution of encoding and retrieval based mechanisms to the item and list method directed forgetting effect, respectively, is likely to represent an oversimplification. This issue was addressed, in part, in Chapters 7 and 8, but it will be expanded in the following subsections.

9.4.1 List Method Directed Forgetting Effect

The list method directed forgetting effect is argued to be limited to memory tasks that involve conscious, intentional retrieval (e.g., Basden et al., 1993; Bjork & Bjork, 1996). However, in Experiment 4, the application of the list-method paradigm to the category exemplar generation task led to a list method directed forgetting effect being obtained in both conscious and unconscious parameter estimates in the young adults. As discussed in Chapter 7, it is not necessary to posit a role for unconscious retrieval inhibition of the kind that occurs in the negative priming task to interpret these results (cf. Weiner & Reed, 1969); rather, a more plausible account of the results is that the F cue at encoding served to inhibit the activation associated with items in the F study list relative to items that occurred in the R study list. In the absence of a similar effect in the estimates of perceptual-associative unconscious processes (Experiment 6), it is conceivable that there is a degree of context dependence in the mechanism or effects associated with the mechanism that supports the list method directed forgetting effect. The inhibition of activation hypothesis proposed here can also account for the longer latency to respond to F study list items, as opposed to control items, which was reported by Zacks et al. (1996). Although, it is important to note that this latter finding is also consistent with the notion that increased retrieval effort and monitoring is associated with F items (Bjork, 1989), or that the intrusion of F items is greater because insufficient inhibition leads to increased output interference (Zacks et al., 1996).

One approach that could be adopted to investigate the hypothesised inhibition based mechanism that suppresses the activation of item-specific representations would be to examine the time course of such inhibitory processes, since different rates of decay have been observed for item-specific and spatiotemporal information (Riccio, Rabinowitz, & Axelrod, 1994). More generally, in order to
sustain substantive progress in understanding the operation of the inhibition mechanism, it will be necessary to apply an objective criterion to detect the presence of inhibition, such as the cue-independent impairment check (Anderson & Spellman, 1993). Further, the principle difference between list method directed forgetting studies and negative priming studies is that the distractors are not available in retrieval environment, since they are present in memory. Consequently, an ancillary factor that needs to be addressed further is the role of the distinctiveness of the representations, using, for example, a parametric manipulation of a contextual cue, such as the line drawing employed in the perceptual-associative word stem completion task.

A decline in the efficiency of an attentional inhibition based processes was hypothesised to underlie the differences in the magnitude of the list method directed forgetting effect in young and older adults. In relation to the age-related decline in the list method directed forgetting effect that was observed in Experiments 4 and 6, the increased susceptibility to task irrelevant information (at encoding) is represented by the greater intrusion of F study list items relative to R items in the older adults. It is plausible that the deficiency in inhibitory processing is also expressed in the list method paradigm as the inability to focus the inhibition exclusively on the F study list, or the perseveration of inhibition by inhibiting some of the R study list items. Further, since attentional inhibition is, by definition, resource demanding, older adults may have a smaller amount of task relevant resources available to encode the second list of R items, as expressed by the lower conscious retrieval of R items in Experiment 4 and 6. Therefore, the interpretation of the impaired list method directed forgetting effect that was observed in Experiment 6 simply in terms of an impairment in attentional inhibition does not provide sufficient information about the nature of the age deficit.

The notion of age-related deficits in inhibitory processing is a pervasive theme in theories of cognitive ageing, and age-deficits in the ability to engage inhibitory processes has been extended to tasks such as directed forgetting, negative priming, and the Stroop interference paradigm (Hasher et al., 1991; Houx, Jolles, & Vreeling, 1993; Kramer et al., 1994; May et al., 1995; Zacks et al., 1996, see also, Chapter 3). Nonetheless, as discussed in Chapter 3, the inhibition account of the age-related deficit in the list method directed forgetting effect can be reinterpreted within the distinction between consciously controlled and automatic influences of memory (Craik & Jacoby, 1996; Hay & Jacoby, 1996; Jacoby & Hay, 1998). In particular, age-related differences are expected to be greatest when memory performance is mediated by self-initiated, conscious processes, because of the greater burden on the available cognitive resources (e.g., Hay & Jacoby, 1996; Jennings & Jacoby, 1997). Moreover, this deficit in strategic, conscious control impairs the recovery of representations that are encoded within the conscious store. Accordingly, primacy is given to the
deficit in the strategic, conscious use of memory rather than attentional inhibition of items in working memory.

9.4.2 Item Method Directed Forgetting Effect

Multiple sources of evidence support the notion that the item method directed forgetting effect is mediated by differential rehearsal at encoding (Basden & Basden, 1996; Basden et al., 1993; MacLeod, 1998). Accordingly, the evidence of an item directed forgetting effect in the conscious parameter estimates for both the category exemplar generation task (Experiment 3) and the perceptual-associative word stem completion task (Experiment 5) was consistent with the position that direct memory tests are sensitive to the effects of differential rehearsal at encoding (e.g., Hamann, 1990; Monti et al., 1996; Srinivas & Roediger, 1990). However, the failure to extend the effect of differential rehearsal to the estimates of conceptual unconscious processes was somewhat surprising, because an effect of differential rehearsal has been repeatedly demonstrated for measures of conceptual priming (e.g., Hamann, 1990; Richardson-Klavehn & Gardiner, 1998; Srinivas & Roediger, 1990).

At a cursory level of interpretation, the absence of an item method directed forgetting effect in the estimates of conceptual unconscious processes is supportive of the view that a condition for the effect in indirect memory tests is the item-by-item cueing of retrieval cues (Basden & Basden, 1998). Nonetheless, this finding is at variance with the argument that there is a correspondence between the mechanisms that support the item method directed forgetting effect and levels of processing effect (Basden & Basden, 1998). In contrast, the absence of an item method directed forgetting effect in the estimates of perceptual-associative unconscious processes is entirely consistent with the argument that perceptual associative priming is insensitive to the effects of differential rehearsal (e.g., Moscovitch, 1994b). More generally, the magnitude of the item method directed forgetting effect in Experiments 3 and 5 was numerically larger than that obtained in the corresponding list method implemented in Experiments 4 and 6. Accordingly, if it presumed that evidence that the magnitude of the levels of processing effect is larger when the different encoding operations are presented in a blocked, rather than mixed, design (Challis & Brodbeck, 1992; Thapar & Greene, 1994) can be abstracted to the item and list method cueing procedure, then the item method corresponds to the mixed design, whereas the list method corresponds to the blocked design. Consequently, if differential rehearsal supported the list method directed forgetting effect, a larger directed forgetting should be obtained in experiments that implemented the list method as opposed to the item method.
An effect of differential rehearsal on the estimates of conceptual unconscious processes is also suggested by findings from a study that examined the effect of levels of processing on words that were varied along a dimension of connectivity (Nelson et al., 1999, Experiment 1). Connectivity refers to the mean number of connections among the semantic associates of a word, as defined by an association matrix among the associates. For the present purposes, the critical findings are that in a paired associate cued recall task, level of processing and word connectivity both influenced the estimates of conscious processes, whereas semantic processing only facilitated the unconscious processes when the words had a high connectivity value. Nelson et al. (1999) argued that these results may, in part, explain the presence of the levels of processing effect that is occasionally reported for perceptual indirect memory tests (e.g., Challis & Brodbeck, 1992; Thapar & Greene, 1994). If these findings are abstracted to the experimental protocols employed in Experiment 3, where the item method paradigm was applied to the category exemplar generation task, it is plausible to assume that the item method cueing should have influenced both the conscious and unconscious parameter estimates given the high connectivity of the critical items (as characterised by the exemplars within a semantic category). Thus, it is interesting that the item method directed forgetting was limited to the estimates of conceptual conscious processes. Rather than argue that the facilitation in conceptual priming that arises from conceptual encoding is a consequence of contamination by conscious influences (Jacoby et al., 1993b; Toth et al., 1994), it is possible that the invariance in the unconscious parameter estimates may have been an artefact of the measurement procedure.

In Experiment 3, rather than employ a paradigm in which rehearsal is prevented, such as the Peterson and Peterson (1959) procedure, or one in which an explicit rehearsal strategy instruction is used to equate the rehearsal conferred on R and F items (e.g., Hauselt, 1998), the type of rehearsal conferred on R and F cued exemplars was manipulated by varying the onset of the R and F cues. However, the contribution of differential rehearsal and inhibition to the item method directed forgetting effect cannot be directly evaluated, because there was an equivalent effect of directed forgetting in the immediate and delayed cue conditions. In addition, although there was evidence that the directed forgetting effect was attenuated in older adults relative to young adults in the two experiments that applied the item method paradigm, the presence of an item method directed forgetting in the immediate and delayed cue conditions in Experiment 3 precluded an analysis of the locus of the age-related deficit with respect to these two mechanisms.

Finally, the cognitive demands associated with the item and list method directed forgetting
paradigms in terms of the contribution of attentional inhibition are different, since within the list method paradigm, the retrieval of an item is likely to be followed by the retrieval of an item from the same retrieval unit (Jongeward, Woodward, & Bjork, 1975). This is more likely for items that are related, as was the case for the category exemplar generation task. Therefore, it is not obvious how a meaningful comparison can be made between the differences in the magnitude of the age-effects that were obtained across these two basic memory paradigms.

9.5 Process Dissociation Procedure: Revisited

The process dissociation procedure represents a formal, deterministic model designed to estimate the contributions of consciously controlled and automatic processes to memory tasks. As has been discussed throughout this thesis, the theoretically uninformative assumption of process purity that underlies the task dissociation logic does not allow the conscious and unconscious processes that support direct and indirect memory tests to be accurately evaluated. Moreover, even if process purity can be achieved, a model that describes the output transformations between the component processes and the dependent measures still needs to be specified (Brainerd et al., 1999). At a basal level, the process dissociation procedure is concerned with the strategic, intentional use of conscious information, and so it is more accurate to describe the procedure as one which measures the contribution of conscious and automatic uses of memory (Nelson et al., 1999), rather than conscious and unconscious processes.

The distinction between memory processes and uses of memory is an important aspect of the evaluation of the theoretical utility of the process dissociation procedure. In particular, both the experimental work presented in this thesis and other recent research demonstrating the boundary conditions of the process dissociation procedure have suggested that the theoretical quantities defined by the process dissociation model do not represent process pure measures of conscious and unconscious processes. To the extent that the process dissociation procedure was originally intended to represent a basic paradigm against which other frameworks, such as transfer appropriate processing, could be evaluated (e.g., Jacoby, 1991), it is argued that without additional modifications the current process dissociation model is insufficient.

For example, from the perspective of the task dissociation approach, an effect of a levels of processing manipulation on perceptual priming has been interpreted as evidence that conceptual processing can influence perceptual indirect memory tests (e.g., Challis & Brodbeck, 1992; Nelson et al., 1999; Thapar & Greene, 1994). However, as has been discussed in this thesis and elsewhere
(e.g., Toth et al., 1994), the effects of conceptual manipulations have also been attributed to contamination by conscious recollection in indirect memory tests, and this position is usually advocated by the proponents of the process dissociation procedure. More recent evidence has shown that the unconscious parameter estimates derived following a conceptual encoding episode are often associated with the adoption of a generate-recognise retrieval strategy. In particular, conceptual encoding has been shown to be associated with involuntary conscious memory in conceptual and perceptual indirect memory tests (e.g., Mecklenbrauker et al., 1996; Richardson-Klavehn & Gardiner, 1998; Russo et al., 1998). If this is indeed the case, then the data obtained under these conditions cannot be analysed using the original formulation of the process dissociation procedure.

Despite the obvious utility of not having to select a task that, on a priori grounds, is potentially less prone to process contamination (cf. Fleischman & Gabrieli, 1998), virtually all process dissociation studies have utilised perceptually-based memory tasks (with the exception of recognition memory). This bias may reflect an implicit acknowledgement that the procedure may not be readily applied to investigations of conceptual unconscious processes without additional modifications. The first subsection will address the boundary conditions of the process dissociation procedure in light of the results from the experimental work presented in this thesis. The modifications and specification of the boundary conditions of the process dissociation procedure that have been proposed represent the necessary evolution of the model following extensive empirical testing. The second subsection will discuss the theoretical quantities specified by the process dissociation model in terms of the distinction between conceptual and perceptual processing.

9.5.1 Core Assumptions: Boundary Conditions of the Process Dissociation Procedure

In order to derive the theoretical parameter estimates from the empirical quantities, three primary assumptions are made in the process dissociation procedure: (1) consciously controlled and automatic processes represent independent bases for responding; (2) the response criteria in the inclusion and exclusion tests are equivalent; and (3) the two theoretical quantities, conscious and unconscious processes, are equivalent across the inclusion and exclusion tests. It is important to ensure that the theoretical quantities operate in accordance with the process dissociation model to enable dissociations between the empirical quantities that are predicted and those that are not to be interpreted unequivocally. At present, it is not possible to identify which of the core assumptions is violated when the boundary conditions are not upheld. Further, the violation of the core assumptions is not always expressed as a paradoxical dissociation between the parameter estimates or by one of the diagnostic markers proposed to identify such violations (Bodner et al., 2000; cf.
A significant proportion of the criticism that has been directed at the process dissociation procedure is underscored by the debate regarding the independence relational assumption (e.g., Curran & Hintzman, 1997; Hirshman, 1998; Jacoby et al., 1997a; Joordens & Merikle, 1993; Richardson-Klavehn et al., 1996). A particularly pertinent aspect of this debate relates to the retrieval model that was articulated to support the independence assumption and equivalence of C and U, namely, the direct-retrieval strategy (e.g., Bodner et al., 2000; Jacoby, 1998; Toth et al., 1995). As discussed in Chapter 2, the adoption of a generate-recognise retrieval strategy in order to perform the inclusion and exclusion tests violates the independence assumption, because a redundancy relation holds under these conditions.

The importance of the direct-retrieval strategy for the core assumptions of the process dissociation model has led to the development of two verification procedures designed to evaluate whether or not a generate-recognise strategy has been employed (e.g., Jacoby, 1998; Toth et al., 1994): (1) the baseline rate of response in the inclusion and exclusion tests should be equivalent; (2) the estimates of unconscious processes should be above the baseline rate of responding, since under a generate-recognise retrieval strategy, items that are unconsciously retrieved are subject to an explicit recognition judgement that would increase the possibility of floor performance in the exclusion test and lead to artifically low estimates of U. This latter condition appeared to have occurred in Experiment 1, and the effect was larger in the young adults than in the older adults. Therefore, the ability to employ a particular form of retrieval is not necessarily equivalent in a between participants design, which is clearly an additional issue that warrants attention.

Jacoby (1998) evaluated the diagnostic value of these retrieval strategy verification procedures in a series of experiments based on the word stem completion paradigm, as a function of study time and divided attention. The pattern of dissociations that were obtained under test instructions that induced a generate-recognise retrieval strategy produced the anticipated 'paradoxical' findings obtained by Curran and Hintzman (1995) and observed in Experiments 1, and also produced the two diagnostic markers of a generate-recognise retrieval strategy in the data. In addition, a multinomial model constructed for the word stem completion task that employed retrieval instructions to induce a direct-retrieval strategy revealed that the direct-retrieval model provided a good fit to the data obtained, whereas a good fit to the data obtained under generate-recognise retrieval instructions was only obtained for a generate-recognise model. Jacoby (1998) argued that these goodness-of-fit tests provided evidence that it is possible to directly manipulate the retrieval strategy employed by
participants, if appropriate retrieval instructions are provided; however, an important caveat to this position is that it was only demonstrated for the word stem completion task. In addition, the manipulation of retrieval strategy may not be effective in all instances. For example, Richardson-Klavehn and Gardiner (1995) reported that a manipulation of retrieval strategy (direct-retrieval vs generate-recognise retrieval) did not have an effect on exclusion test performance (cf. Jacoby, 1998).

The verification procedures used to identify the adoption of a generate-recognise retrieval strategy have been the subject of continued evaluation, since it is not certain that the two diagnostic markers will be obtained under all conditions. For example, Bodner et al. (2000) reported that the adoption of a strict response criterion for the recognition stage of a generate-recognise retrieval strategy resulted in only a few false recognitions and largely equivalent baseline rates of completion in the inclusion and exclusion tests. Accordingly, it was argued that the two diagnostic markers are sensitive to the response criterion for excluding studied items in the exclusion test, rather than retrieval orientation, as suggested by Jacoby (1998). Consequently, if the verification procedures employed by Jacoby and colleagues are not sensitive to the retrieval dynamics of a generate-recognise retrieval strategy, the validity of the parameter estimates are undermined under conditions in which the adoption of a generate-recognise strategy is not identified. Further, if the response criterion is a primary mediating factor under some circumstances, it is plausible that age-differences in the response criterion adopted will interact with the ability to detect the adoption of a generate-recognise retrieval strategy using the verification procedures.

Jacoby (1998) argued that the incorporation of a generate-recognise model into the process dissociation procedure is no less problematic, since equivalent difficulties exist with this approach in terms of ensuring that the assumptions underlying the generate-recognise retrieval strategy are not violated (see also, Jacoby & Hay, 1998). Nonetheless, it may not be possible for participants to operate in accordance with the direct-retrieval strategy for some indirect memory tests such as word stem completion, when items have undergone conceptual encoding (e.g., Bodner et al., 2000; Curran & Hintzman, 1995; Nyberg et al., 1997b; Richardson-Klavehn & Gardiner, 1998; Russo et al., 1998). The category exemplar generation task may also be susceptible to a similar constraint on the mode of retrieval that can be employed by participants. In particular, in spite of the provision of explicit instructions to employ a direct-retrieval strategy, the participants appeared to adopt a generate-recognise strategy in the category exemplar generation task following encoding under a varying attentional load (Experiment 1). Under these conditions, conscious and unconscious processes would not have independently contributed to performance, which could explain the
crossed interaction obtained as a function of divided attention (see also, Mecklenbrauker et al., 1996; Richardson-Klavehn & Gardiner, 1998).

Therefore, there is a need to develop a process dissociation model that is designed to analyse data that has been acquired when a generate-recognise retrieval strategy has been employed by participants (cf. Jacoby, 1998), and which also includes the capability to correct the baseline rate of responding under a generate-recognise retrieval strategy. Moreover, since the process dissociation procedure has only been articulated in terms of the core assumptions that are upheld by a direct-retrieval strategy, the potential task-based restrictions identified in this thesis support the view that it is equally important to evaluate the process dissociation procedure in terms of the boundary conditions, as it is to assess the underlying structure of the model. However, a more fundamental limitation of the general logic that underlies the selection of a model of retrieval is that it is based on inductive reasoning, rather than an objective measure of the retrieval strategy employed by participants.

An additional objection to the process dissociation procedure relates to the notion that it is, in fact, necessary to select a relational model to describe the operation of the theoretical quantities (see Chapter 2 & Hirshman, 1998). The viability of the independence, redundancy, and exclusivity assumptions is undermined by the fact that they are based on prima facie notions; therefore, the demonstration of 'canonical' effects of variables such as divided attention on the parameter estimates will remain open to interpretation. For example, Cowan and Stadler (1996) demonstrated that the fixed amount of overlap specified in the exclusivity and redundancy relational models limits their ability to account for the effects of divided attention on conscious and unconscious processes with the same degree of parsimony as the independence relational model (cf. Curran & Hintzman, 1995).

Finally, instances in which there is an opposing effect across conditions such that the change in the parameter estimates is not sufficiently symmetrical can lead to an artifactual increase in the unconscious parameter estimates, whereas opposing and symmetrical effects led to little or no change in the estimate of the unconscious parameter (Hirshman, 1998). Therefore, since memory paradigms are not equivalent in terms of their susceptibility to violations of the core assumptions of the process dissociation procedure, the success of the application of the process dissociation procedure is dependent, in part, on the particular instantiation of the procedure within a memory paradigm.
9. General Discussion

9.5.1.1 The Process Dissociation Model: An Assumption of Age-Invariance

The application of the process dissociation procedure to investigate the effects of ageing was predicated on the assumption that the values of the parameters in the process dissociation model, rather than the structure of the model, are influenced by ageing. One consequence of this assumption is that the effects of ageing are presumed to operate at the level of individual processes. These age-effects are expected to be expressed in terms of differences in the ability to operate in accordance with the inclusion and exclusion test instructions (Graf & Komatsu, 1994), to operate strategically (Rybash et al., 1998), and in terms of differences in motivational level (Visser & Merikle, 1999). Fortunately, the importance of the latter factor has recently been negated, since Visser and Merikle (1999) observed an effect of motivational level on the conscious parameter estimates in a test of perception, whereas no effect of this variable was found in a memory task.

When the opposition logic is applied to young and older adults, differences in the ease with which conscious processes are employed are expected between the age groups (Jacoby & Hay, 1998), but there are also potential differences in the strategic use of conscious processes in relation to the task demands. For example, in the category exemplar generation task that was employed in the experimental work, the participants could have tried to select low-dominance category names in the exclusion test to avoid providing a previously presented item as a completion; that is, the responses could have been strategically determined, rather than reflect the products of retrieval from the unconscious memory store. Age-related differences in the availability or use of this strategy would obscure the interpretation of any age-related effects that were obtained. Specifically, a floor level of exclusion performance in some young adults, but not in older adults, could be interpreted as evidence that young adults have a greater availability of conscious controlled processes to exclude items, or it may reflect an increased tendency to capitalise on a strategic, rather than mnemonic, approach to the exclusion test. A similar opportunity to operate strategically would be less probable in the perceptual-associative word stem completion task, because the completion of the target word stems was constrained so that only five letter words constituted legitimate response solutions, which was the same as the length as the target words in the study set (cf. Rybash et al., 1998).

As discussed in Chapters 2, 5 and 7, the direct-retrieval and generate-recognise retrieval strategies have been identified as two competing models of retrieval. It is conceivable that a generate-recognise strategy would be adopted by participants when the target item is not immediately available under a direct-retrieval strategy; that is, the generate-recognise strategy may well represent the alternate, default strategy. If this is indeed the case, there may be additional variability
between participants in the criterion used to switch between the direct-retrieval and generate-recognise retrieval strategies. Further, as discussed in the preceding section, in spite of the provision of extensive training in five of the experiments presented in this thesis to ensure that both young and older adults adopted the direct-retrieval strategy in the exclusion and inclusion tests, the direct-retrieval strategy cannot always be engaged by older adults (Reder et al., 1986). Therefore, in addition to the rationale outlined in the foregoing subsection, there is a need for an independent measurement of the retrieval strategy that is employed by participants, potentially on a trial-by-trial basis, particularly when subject variables such as age are a factor in a process dissociation analysis. In addition, if a generate-recognise retrieval strategy is adopted by participants, and it is assumed that involuntary retrieval is the same for young and older adults, then an effect of ageing in the inclusion and exclusion tests is likely to occur only to the extent that older adults are less able to utilise recognition to oppose the influences of involuntary retrieval. Nonetheless, because performance close to floor in both the exclusion and inclusion tests was occasionally obtained in the young and older adults, older adults appear to able to follow the instructions at test; although overall, the incidence of performance at floor level is likely to be greater in the young adults.

**9.5.2 Specification of Theoretical Quantities**

Inclusion and exclusion tests are argued to be mediated by two independent bases for responding, one controlled and one automatic (Jacoby, 1991). As discussed in Chapter 3, the unconscious parameter conforms to some of the basic criteria that have been used to characterise an automatic process (e.g., Posner & Snyder, 1975); namely, the process does not demand significant cognitive resources and it is not subject to voluntary control. The dual process conceptualisation employed within the process dissociation procedure reflects the broader theoretical context in which a distinction is made between memory processes that support the context dependent encoding of events and those that support familiarity, activation, or perceptual fluency based mnemonic processes (e.g., Humphreys et al., 1989; Mandler, 1980). Therefore, the process dissociation procedure is subject to similar criticisms that have been levelled at dual process conceptualisations, in terms of the specification of the theoretical quantities (see Chapter 2).

One of these criticisms is that the early assumptions about the modularity of conscious and unconscious memory processes are no longer tenable, since memory processes only make sense relative to some specific feature or function of memory at some specific level of description (Toth & Hunt, 1999). In more procedural terms, the theoretical quantities have not been articulated in terms of the functional demands associated with a memory task. For example, the notion that
conscious retrieval involves a greater contribution from conceptual processing than unconscious retrieval (Craik et al., 1994; Roediger et al., 1992) cannot be easily accommodated without additional assumptions. One approach has been to argue that the formation and retrieval of contextual associations and semantically rich information leads to conscious recollection that arises from a consciousness system (termed, CAS Schacter, 1989). However, the critical element that distinguishes conscious and unconscious processes is not the availability of contextual information, since the conscious retrieval of information is not necessarily accompanied by the retrieval of contextual information (Schacter, Harbluk, & McLachlan, 1984), and contextual variables can influence unconscious retrieval (Graf, 1994; Lewandowsky et al., 1989). Instead, it is the availability of phenomenological awareness (cf. Tulving, 1985b).

The experimental work presented in this thesis also underscored the need to examine a more relativistic conceptualisation of the unconscious parameter (Jacoby et al., 1993a; see also, Neumann, 1984). Specifically, the retrieval cues and task demands associated with category exemplar generation and perceptual-associative word stem completion modulated the nature of the unconscious processes that mediated task performance, as demonstrated by the different effects of the same encoding variables across the two basic memory tasks. Thus, the appropriate unit of analysis for the theoretical quantities must include the functional demands associated with the performance of the task. More generally, even if particular components of processing that are specifiable cannot be formally modelled to account for all experimental conditions, it does not follow that the formal modelling approach should be abandoned, since the development of non-deterministic, fuzzy logic based models will provide the necessary degrees of freedom to eventually describe the retrieval dynamics and processes associated with memory tasks (e.g., Brainerd et al., 1999). In addition, the inclusion of an independent on-line measure of the phenomenological state of awareness associated with memory retrieval will avoid the concerns associated with post facto measures of awareness such as the post-experimental questionnaire. The independence remember-know procedure is instructive in this regard, since it yields conscious and unconscious parameter estimates from a single test phase instruction (Jacoby, 1998; Jacoby et al., 1997b).

As discussed in Chapter 2, Richardson-Klavehn et al. (1996) argued that the theoretical quantities specified within the process dissociation procedure conflate retrieval volition and memorial state of awareness, and in doing so, the concept of involuntary conscious memory cannot be incorporated. Reingold and Toth (1996) argued that involuntary conscious memory can be mapped onto the generation and recognise stages of a generate-recognise retrieval strategy, whereby generation corresponds to involuntary retrieval and recognition corresponds to conscious awareness. On the
basis of the experimental work that has been conducted to address this issue and the findings presented here, retrieval mediated by involuntary conscious memory is argued to be precipitated by conceptual encoding in association with perceptual and conceptual indirect memory tests (see also, Bodner et al., 2000; Mecklenbrauker et al., 1996; Nelson et al., 1999; Richardson-Klavehn & Gardiner, 1998). However, Richardson-Klavehn and Gardiner did not extend their framework to the particular model of retrieval proposed by Reingold and Toth (Richardson-Klavehn & Gardiner, 1998; Richardson-Klavehn et al., 1996). Further, the concept of involuntary conscious memory can, in fact, in some instances be interpreted within a single processes model of memory (Challis, 1999). Nonetheless, the distinction between voluntary conscious and involuntary conscious memory may still represent an important phenomenological distinction.

More generally, the distinction between perceptual and conceptual processing is limited by the lack of an objective measure of these processes. Development within the levels of processing framework has paralleled the progress in the perceptual-conceptual processing distinction, since graded functions have been described for levels of processing effects across different memory paradigms (Challis, Velichkovsky, & Craik, 1996; Velichkovsky, 1999). However, there are still several capabilities that will need to be integrated into the perceptual-conceptual processing framework. As discussed in Chapter 1, it has been suggested that increasing the number of criterial variables would, in part, resolve some of the apparent paradoxical findings; however this could itself lead to additional conflicting outcomes. The theoretical utility of such an approach is also limited, because the increased inferential power only reflects a larger set of constraints on a smaller number of memory tests, and therefore this approach would negate the value of a classification scheme.

As discussed in Chapter 1, a more productive approach would involve the identification of subclasses of processes within conceptual and perceptual memory tests (McDermott & Roediger, 1996; Weldon & Coyote, 1996). For instance, Cabeza (1994) suggested that subclasses of conceptual processes need to be identified by observing the effect of encoding manipulations to determine how the subclasses of conceptual processes map onto the various direct and indirect memory tests (see also, Vaidya et al., 1997, discussed earlier). This will involve the principled characterisation of the independent contributions of perceptual and conceptual processes within a particular memory test, in much the same way that the process dissociation procedure enables the evaluations of the contributions of conscious and unconscious processes. As a future goal, the perceptual-conceptual framework will need to specify the interaction between conceptual-perceptual processing and conscious-unconscious processes at a phenomenological and an empirical level (Moscovitch et al., 1994; Roediger & McDermott, 1993).
9.6 Conclusion

The experimental work presented in this thesis was designed to evaluate the hypothesis that age-related deficits in memory are limited to conscious processes. The approach adopted initially involved reviewing a range of disparate research domains in order to provide better theoretical integration. This review revealed the degree of specificity necessary to interpret age effects in conscious and unconscious memory processes. The four-cell process-matrix taxonomic scheme that was introduced in Chapter 1 was based on the assumption that prototypical memory tasks can be identified whose structural and functional properties represent a benchmark for comparison between each of the cells. However, it can be argued that the four-cell process matrix was relatively crude; indeed, the logic underlying the basic process dissociation and components of processing approach contrasts markedly with the notion of a particular memory task as a prototype for a taxonomic category. Nonetheless, the process-matrix provided a basis for understanding the mechanisms underlying priming and identifying the changes that these mechanisms undergo as a function of age.

An additional consideration that was identified as being necessary for the interpretation of the sources of variability in the extant research was the influence of methodological factors, in particular, task process purity. It was demonstrated that this factor is necessary, but not sufficient, to account for age-impaired priming. More generally, it is argued that the identification of the sources of variability in dependent measures of unconscious memory processes, rather than whether or not unconscious processes are impaired by age, is a more pertinent research question.

It is clear from the experimental evidence presented in this thesis that it is insufficient to describe the nature of age-differences in association- and item-specific memory simply in terms of factors such as computational complexity (Schacter, 1994a), or in terms of the contribution of self-initiated, effortful processing (Bower, 1998); rather, it is necessary to investigate age-differences in specific processes and the functional demands associated with memory tasks. For example, priming is argued to represent a change in bias towards responding with previously studied items (Light & Kennison, 1996a; but see, Light & Kennison, 1996b; e.g., McKoon & Ratcliff, 1996; Ratcliff & McKoon, 1997), which reflects the operation of facilitation and inhibition based processes in priming. However, the notion that specific, inhibitory processes or resources within a particular cognitive domain represent the basic mediating factors that account for the age-related differences that were observed in the experimental work could not be established with any certainty. This is largely due to the absence of independent measures of cognitive resource capacity and inhibitory functioning. Nonetheless, beyond the boundaries of individual studies, where these constructs have been applied, the cognitive resource and inhibition accounts of cognitive ageing are able to explain
a large corpus of data that has reported multiple, specific age-deficits in cognition. Further, both of these constructs have been identified with discrete neuronal circuits and mechanisms (e.g., Houghton & Tipper, 1996). Nevertheless, in order to provide a more complete account of ageing and cognition, the relation between specific processes or capacities will also need to be specified; for example, processing speed and working memory capacity have been shown to be related to one another (e.g., Park, Smith, Lautenschlager, & Earles, 1996).

The results obtained in the experimental work have quite broad implications for understanding age-related differences in conscious and unconscious memory processes in terms of the complex interactions among various forms of memory, the components of processing that subserve these forms of memory, and for establishing a foundation on which the practical problems of age-related memory decline can be addressed. One thing is clear though, the theoretical approaches to understanding age-related differences in explicit memory do not appear to be sufficient to account for the age effects associated with implicit memory. Moreover, the general approach that was adopted in this thesis is somewhat at variance with the notion that pervades much of cognitive ageing research, where it is assumed that there is a decline in a single mechanism or attribute of cognition that underlies all functional deficits in cognition (e.g., Salthouse, 1996). Therefore, both the appropriate unit of analysis to interpret age-related differences and the theoretical utility of these two basic approaches remains a subject for debate. The approach adopted here also has implications for the interpretation of the dependent measures used when investigating a decline in a single mechanism, since aggregate measures are likely to obscure deficits in specific components of processing.

At present, the dissociation between conscious and unconscious processes as a function of age can, at best, only be described as a partial dissociation, since there is evidence of age-related impairment in both direct and indirect memory tests, although the decline in memory task performance is larger for direct memory tests (Fleischman & Gabrieli, 1998; Prull et al., 2000; Rybash, 1996; Titov & Knight, 1997; Zacks, Hasher, & Li, 1999). In the experimental research presented in this thesis, the question of whether or not older adults are subject to an impairment in conceptual unconscious processes was only partially answered, because of the difficulties with applying the process dissociation procedure to the category exemplar generation task. The difficulties associated with drawing inferences about qualitative differences in performance based on partial dissociations have been described at length by those working with neuropsychological populations (Shimamura, 1993). The principle objection is that a partial dissociation may be quantitative, rather than qualitative, with the difference reflecting a difference on a dimension such as task difficulty. This
interpretation can be countered by using a 'weakened control group' of young adults (Shimamura, 1993), since if the indirect test is still performed differently by the older adults (e.g., Russo & Parkin, 1993) or age-differences in opposite directions are observed on the direct and indirect memory tests, the age-differences are likely to be veridical. Nonetheless, if the nascent research does reveal age-invariance in a variety of different dependent measures of unconscious memory processes, one plausible interpretation is that the early processing stages are unimpaired by ageing. Therefore, by extension age-related deficits in conscious processes should be investigated at later stages of processing. However, the opposite conclusion, small age-related deficits in early processing stages are amplified through later stages, still remains tenable given our present knowledge (Craik & Jennings, 1992).

More generally, the research examining the effect of ageing on conscious and unconscious processes is at its infancy, since most of the studies have employed cross-sectional designs that involve two, polarised age-groups, and have rarely compared several indirect memory tests in the same study (Roediger et al., 1999). By studying the subtle interaction among indirect tests and between direct and indirect tests, a clearer and more complete understanding of the way ageing effects memory will be possible. Further, it is an oversimplification to assume that the amount of priming is a direct reflection of the degree of encoding, since the relation between priming phenomena and encoding is still not well understood. Both the magnitude of priming and the degree of encoding can be influenced by many factors, and there is little evidence examining the nature of correspondence between the two processes. Nevertheless, the existence of priming does suggest that some form of stimulus activation has occurred, and the finding of qualitatively similar priming in both young and older adults implies that roughly comparable kinds of stimulus activation processes are present in both age groups. Research will need to focus on whether or not there are age-related differences in particular aspects of encoding, such as when associational or organisational processes can be invoked.

A more unified conceptualisation of the phenomena subsumed within the explicit and implicit memory framework will also be dependent upon improvements in the inferential procedures used to identify the components of processing that mediate task performance. Overall, the experiments reported here revealed the methodological and theoretical utility of the process dissociation procedure to investigate consciously controlled and automatic processes, under experimental conditions that uphold the core assumptions of the model. However, the functional dissociations that were obtained were not all of the canonical form where a single variable influences one parameter estimate but does not influence the other, as hypothesised by the proponents of the
process dissociation procedure (and the task dissociation approach). Evidently, future research will need to continue to assess the validity and reliability of the measures of conscious and unconscious memory processes.
10. References


10. References

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11. Appendix

11.1 Verbatim Instructions

The following chapter provides the verbatim instructions that were supplied to the participants in each of the six experiments. As discussed in the General Methods Chapter and in the Experimental Chapters, these verbatim instructions were supplemented with additional oral instructions to ensure that participants understood the task requirements.

11.1.1 Experiment 1: The Effect of Age and Varying Attentional Load on Category Exemplar Generation

11.1.1.1 Study Phase

Please read the instructions carefully before you begin.

You will see a series of words presented individually on the computer screen. The presentation of each word represents one trial. Each trial is composed of 5 stages:

1 'PRESS BUTTON TO CONTINUE' appears on the screen. This action begins each trial.
2 A fixation point will then appear in the form of an asterisk ' * '.
3 Following a short interval, either a series of dashes '---' or a digit-letter sequence comprised of 3 or 5 alternating digits and letters appears in place of the fixation point. You should say the word 'blank' if you see the dashes, or read the digit-letter sequence aloud. The digit-letter sequence for each trial should be retained in memory until a RECALL signal is given in stage 5.
4 Next, a word will appear. You should read this word and try to remember it for later.
5 Finally, either the word 'BLANK' appears if dashes were presented in stage 3, or the word 'RECALL' appears if a digit-letter sequence was presented in stage 3. You should read the word 'blank' aloud, or repeat back aloud the digits and letters presented in stage 3.

The trial cycle will then begin again with stage 1. The procedure is therefore self-paced. To ensure that you understand the procedure you will first be given the opportunity for practice trials.

PRESS THE CENTRE BUTTON TO CONTINUE
11.1.1.2 Test Phase

The test phase was comprised of inclusion and exclusion tests that were presented in a blocked design. As discussed in the General Methods Chapter, a mixed design was employed to present the retrieval cues in the inclusion and exclusion tests for all of the remaining experiments.

11.1.1.2.1 Inclusion Test

Please read the instructions carefully before you begin.

PROCEDURE

The procedure consists of a series of self-paced trials, each with the following sequence:

1. 'PRESS BUTTON TO CONTINUE' appears on the screen. This action begins each trial.
2. A central fixation point ' * ' will then appear. You must look at this part of the screen throughout each trial.
3. A category name will then appear in place of the fixation point. Each category name will remain on the screen.
4. Your task is to provide words belonging to each category name from the studied words in the first part of the experiment—the so-called study phase. If you cannot recall a word from the study phase of the experiment that fits the category name, then just complete the category name with the first appropriate words that come to mind. You can provide up to eight such words for each category.

Your responses to the test should be recorded on the supplied response sheet.

PRESS THE CENTRE BUTTON TO CONTINUE

11.1.1.2.1 Exclusion Test

Please read the instructions carefully before you begin.

PROCEDURE

The procedure consists of a series of self-paced trials, each with the following sequence:
11. Appendix

- 'PRESS BUTTON TO CONTINUE' appears on the screen. This action begins each trial.
- A central fixation point ' * ' will then appear. You must look at this part of the screen throughout each trial.
- A category name will then appear in place of the fixation point. Each category name will remain on the screen.
- Your task is to write down, as fast as you can, the first words that come to mind belonging to that category name. You can provide up to eight such category exemplars. If some of the category exemplars that come to mind were presented in the first part of the experiment, then DO NOT include them in your responses to that category name.

Your responses should be recorded on the supplied response sheet. Once again, ensure that you are certain that the category exemplars did not appear in the first part of the experiment.

PRESS THE CENTRE BUTTON TO CONTINUE.

11.1.2 Experiment 2: Consequences of Varying Attentional Load on Memory for New Associations: Limits on Loss?

11.1.2.1 Study Phase

Please read the instructions carefully before you begin.

You will see a series of word pairs and pictures presented on the computer screen. The presentation of each word pair and picture represents one study trial. Each trial is composed of 5 stages:

1. 'PRESS BUTTON TO CONTINUE' appears on the screen. This action begins each trial.
2. A fixation point will then appear in the form ' * '.
3. Next, either a series of dashes '---' OR digit-letter sequence of 3 OR 5 digits and letters will appear. You should say the word 'blank' if you see the dashes, or read the digits and letters aloud for that trial. The digit-letter sequence should be retained in memory until the RECALL prompt is given in stage 5.
4. Following a short interval, a pair of words (e.g., cat--shout) and a picture will appear. The word pair and picture will remain on the screen for about 5 seconds. You should read the word pair out aloud.
5. Finally, the word 'BLANK' will appear if dashes were presented in stage 3, or the prompt 'RECALL' will appear if a digit-letter sequence was presented in stage 3. You should read the word blank aloud, or repeat back aloud the digits and letters committed to memory in stage 3.

The trial cycle will then begin again with stage 1. The procedure is therefore self-paced. In order to ensure that you understand the procedure, you will be given the opportunity for practice trials.

PRESS THE SPACEBAR TO BEGIN THE PRACTICE TRIALS

11.1.2.2 Test Phase

You will see a series of items presented on the computer screen. The presentation of each set of items represents one trial. Each test trial is composed of the following stages:

- 'PRESS BUTTON TO CONTINUE' appears on the screen. This action begins each trial.
- A fixation point will then appear in the form '*'.
- Following a short interval, a word and a three letter 'word stem' (e.g., cat—sho__) with a picture (that corresponds to the word on the left) will appear in place of the fixation point. The word, three letter word stem, and picture will remain on the screen for about 10 seconds. In addition, either the word 'OLD' or the word 'NEW' will appear below the words and picture.
- If you see the word 'NEW', you should complete the word stem with a 5 LETTER word that is not from the previous list. That is, try and think of a new, unstudied word. Try and do these trials as fast as you can.
- If you see the word 'OLD', complete the stem with a 5 LETTER word, studied word from the study list you have just been presented. If you cannot think of an appropriate studied word, complete the stem with the first word that comes to mind. This is often quite effective.

The trial cycle will then begin again with stage 1. The procedure is therefore self-paced. You should avoid proper names, plurals and declensions of verbs in your responses to the word stems. If you cannot complete the stem with a suitable word then you may continue onto the next trial. However, please only use this option if you are certain that you cannot find a suitable completion.

In order to ensure that you understand the procedure, you will be given the opportunity for practice trials. Your responses should be recorded on the supplied response sheet.

PRESS THE SPACEBAR TO BEGIN THE PRACTICE TRIALS
11.1.3 Experiment 3: Category Exemplar Generation: Item Method Direct Forgetting Effect

11.1.3.1 Study Phase

11.1.3.1.1 Immediate Cue Condition

Please read the instructions carefully before you begin.

You will see a series of words presented on the computer screen. The presentation of each word and cue represents one study trial. Each study trial is comprised of 2 stages:

1. A word (e.g., cat) will appear. The word will remain on the screen for 1 second. You should read the word out aloud.
2. Then a cue to either remember - RRR - or to forget - FFF - the word for a later memory test will appear immediately. You should follow this instruction. That is, you should only be concerned with trying to remember words that are cued with the RRR cue.

The memory test will be based only on the to-be-remembered words, so there is no need to remember the to-be-forgotten words. You should try to rehearse the to-be-remembered word during the period after the RRR cue, since this will aid later recall. That is, try to use the period following the offset of a R cue to rehearse the immediately preceding word, and if necessary other preceding R cued words. The trial cycle will then begin again with stage 1. In order to ensure that you understand the procedure, you will be given the opportunity for practice trials.

PRESS THE SPACEBAR TO BEGIN THE PRACTICE TRIALS

11.1.3.1.2 Delayed Cue Condition

You will see a series of words presented in the same sequence as before. However, the interval BETWEEN each stage of a study trial has changed in this next part. To reiterate the instructions you were shown before:

1. A word (e.g., cat) will appear. The word will remain on the screen for 1 second. You should read the word out aloud.
2. Then a cue to either remember - RRR - or to forget - FFF - the word for the later test will appear after about 5 seconds. Therefore, you should keep the word in mind until the RRR or
FFF cue appears, and then only begin the process of trying to remember a word if it is cued RRR. You should not rehearse previously presented RRR cued words during the period before the presentation of the cue.

The memory test will be based only on the to-be-remembered words (RRR), so there is no need to remember the to-be-forgotten words (FFF). You should try to rehearse the to-be-remembered word during the period after the RRR cue since this will aid later recall, although the interval will be relatively short. The trial cycle will then begin again with stage 1.

You will NOT be given the opportunity to practice, since the procedure is the same as before. Only the intervals between the words and cue has changed. The actual time that the words (1 second) and cues (1 second) stay on screen has not changed.

PRESS THE SPACEBAR TO CONTINUE WITH THE NEXT PART OF THE STUDY LIST.

11.1.3.2 Test Phase

You will see a series of items presented on the computer screen. The presentation of each set of items represents one test trial. Each test trial is composed of the following 5 stages:

- 'PRESS BUTTON TO CONTINUE' appears on the screen. This action begins each trial.
- A fixation point will then appear in the form ' * '.
- Following a short interval, a category name will appear in place of the fixation point. The category name will remain on the screen for about 8 seconds. In addition, either the word 'OLD' or the word 'NEW' will appear below the category name.
- If you see the word 'NEW', you should avoid providing words belonging to the category name from the list of words that you have just seen in the study list. That is, try and think of 8 new, unseen words, avoiding both 'RRR' and 'FFF' cued words. Try and do these trials as fast as you can.
- If you see the word 'OLD', you should try and provide 8 words belonging to the category from the study list you have just seen. You should use both words that were cued 'RRR' and those words cued 'FFF'. If you cannot think of appropriate words, provide words that belong to the category name based on the first words that come to mind. This is often quite effective.

The trial cycle will then begin again with stage 1. The procedure is therefore self-paced. Your responses should be recorded on the supplied response sheet.
If you cannot provide 8 appropriate words for each category name (exemplars) then you may continue onto the next trial. However, please only use this option if you are certain that you cannot think of 8 exemplars for each category name in accordance with the instructions for that test trial.

PRESS THE SPACEBAR TO BEGIN THE TEST TRIALS

11.1.4 Experiment 4: Category Exemplar Generation: List Method Direct Forgetting Effect

11.1.4.1 Study Phase: List 1 Instructions for R-R and F-R Conditions

Please read the instructions carefully before you begin.

You will see a series of words presented on the computer screen for a later memory test. The presentation of each word represents one study trial. Each trial is composed of 2 stages:

1. A fixation point will appear in the form ‘*’.
2. A word will then appear. The word will remain on the screen for 3 seconds. You should read the word out aloud.

The rate of presentation of the trials is controlled by the computer, so your role is simply to attend to the words that will be presented, and try and remember them for a later memory test. The trial cycle will automatically begin again with stage 1 and continue until the entire series of words has been shown.

PRESS THE SPACEBAR TO BEGIN.

11.1.4.1.1 Mid-List Instructions for F-R Condition: List 2 Instructions

The list of words that you have just seen was for practice. You can forget it now. The list you will see next is the one that you should put effort into remembering, so forget the practice list you have just seen and concentrate on trying to learn this new list for a later memory test, since the memory test will be based only on these on these to-be-remembered words. The study format will be as in the practice list before. To reiterate the instructions you were shown before:
You will see a series of words presented on the computer screen. The presentation of each word represents one trial. Each study trial is composed of 2 stages:

1. A fixation point will appear in the form ' * '.
2. A word will then appear. The word will remain on the screen for 3 seconds. You should read the word out aloud.

Your ability to remember these words is going to be tested, so maximise your effort for learning the words in the following list. The trial cycle will then begin again with stage 1.

PRESS THE SPACEBAR TO CONTINUE WITH THE ACTUAL STUDY LIST.

11.1.4.1.2 Mid-List Instructions for R-R Condition: List 2 Instructions

You will now be given a short break before continuing with the list of words that you need to remember for the later memory test. The study format will be the same as the list presented before. To reiterate the instructions you were shown before:

You will see a series of words presented on the computer screen. The presentation of each word represents one study trial. Each trial is composed of 2 stages:

- A fixation point will appear in the form ' * '.
- A word will then appear. The word will remain on the screen for 3 seconds. You should read the word out aloud.

The trial cycle will then begin again with stage 1. Your ability to remember these words is going to be tested, so ensure that you continue to attend to these words in order to learn the words in the following list, in the same way as you did with the first part of the study list.

PRESS THE SPACEBAR TO CONTINUE WITH THE SECOND PART OF THE STUDY LIST.

11.1.4.2 Test Phase

You will see a series of items presented on the computer screen. The presentation of each set of items represents one test trial. Each test trial is composed of the following stages:
1. 'PRESS BUTTON TO CONTINUE' appears on the screen. This action begins each trial.

2. A fixation point will then appear in the form ' * '.

3. Following a short interval, a category name will appear in place of the fixation point. The category name will remain on the screen for about 8 seconds. In addition, either the word 'OLD' or the word 'NEW' will appear below the category name.

4. If you see the word 'NEW', you should avoid providing words belonging to the category name that were in the two lists of words that you have just seen. That is, try and think of 8 new, unseen words, avoiding the words from both lists shown at study. Try and do these trials as fast as you can.

5. If you see the word 'OLD', you should try and provide 8 words belonging to the category name from the two lists you have just seen. You should use words from both lists shown at study. If you cannot think of compatible words, provide words belonging to the category based on the first words that come to mind. This is often quite effective.

The trial cycle will then begin again with stage 1. If you cannot provide 8 category exemplars for each category name then you may continue onto the next trial. However, please only use this option if you are certain that you cannot think of 8 exemplars for each category name.

PRESS THE SPACEBAR TO BEGIN THE TEST TRIALS

11.1.5 Experiment 5: Perceptual-Associative Word Stem Completion and Item Method Cueing

11.1.5.1 Study Phase

Please read the instructions carefully before you begin.

You will see a series of word pairs and pictures presented on the computer screen. The presentation of each word pair and picture represents one study trial. Each study trial is composed of 4 stages:

- 'PRESS BUTTON TO CONTINUE' appears on the screen. This action begins each trial.
- A fixation point will then appear in the form ' * '.
- Next, a pair of words (e.g., cat-shout) and a picture will appear. The word pair and picture will remain on the screen. You should read the word pair out aloud.
Then a cue to either remember - RRR - or to forget - FFF - the word pair for the later test will appear. You should follow the instruction.

The memory test will be based only on the to-be-remembered word pairs (RRR), so there is no need to remember the to-be-forgotten word pairs (FFF). You should try to rehearse the to-be-remembered word during the period after the RRR cue, since this will aid later recall. That is, try to use the period following the offset of a RRR cue to rehearse the immediately preceding word, and if necessary other preceding R cued words. The trial cycle will then begin again with stage 1.

In order to ensure that you understand the procedure, you will be given the opportunity for practice trials.

PRESS THE SPACEBAR TO BEGIN THE PRACTICE TRIALS

11.1.5.2 Test Phase

You will see a series of items presented on the computer screen. The presentation of each set of items represents one test trial. Each test trial is comprised of the following stages:

1. 'PRESS BUTTON TO CONTINUE' appears on the screen. This action begins each trial.
2. A fixation point will then appear in the form '★'.
3. Following a short interval, a word and a three letter word stem (e.g., cat--sho__) with a picture will appear in place of the fixation point. The word, three letter word stem, and picture will remain on the screen for about 10 seconds. In addition, either the word 'OLD' or the word 'NEW' will appear below the words and picture.
4. If you see the word 'NEW', you should complete the word stem using a 5 LETTER word that was not in the list of words that you have just seen. That is, try and think of a new, unseen word, avoiding both 'RRR' and 'FFF' cued words. Try and do these trials as fast as you can.
5. If you see the word 'OLD', complete the word stem with a 5 LETTER word from the list you have just seen. You should use words that were cued 'RRR' and those words cued 'FFF'. If you cannot think of a compatible word, complete the stem with the first 5 LETTER word that comes to mind. This is often quite effective.

The trial cycle will then begin again with stage 1. The procedure is therefore self-paced. In order to ensure that you understand the procedure, you will be given the opportunity for practice trials. Your responses should be recorded on the supplied response sheet.
If you cannot complete the word stems with a suitable word then you may continue onto the next trial. However, please only use this option if you are certain that you cannot find a suitable completion.

PRESS THE SPACEBAR TO BEGIN THE PRACTICE TRIALS

11.1.6 Experiment 6: Perceptual-Associative Word Stem Completion and List Method

Cueing

11.1.6.1 Study Phase: List 1 Instructions for R-R and F-R Conditions

Please read the instructions carefully before you begin.

You will see a series of word pairs and pictures presented on the computer screen. The presentation of each word pair and picture represents one study trial. Each study trial is composed of 3 stages:

1. 'PRESS BUTTON TO CONTINUE' appears on the screen. This action begins each trial.
2. A fixation point will then appear in the form ' * '.
3. Next, a pair of words (e.g., cat—shout) and a picture will appear. The word pair and picture will remain on the screen for about 5 seconds. You should read the word pair out aloud.

The trial cycle will then begin again with stage 1 and continue until the entire series of words has been shown.

PRESS THE SPACEBAR TO BEGIN.

11.1.6.1.1 Mid-list Instructions for F-R Condition: List 2 Instructions

The list of word pairs and pictures that you have just seen was just for practice. You can forget them now. The list you will see next is the one that you should put effort into remembering, so forget the practice list you have just seen and concentrate on trying to learn this new list for a later memory test, since the memory test will be based only on these on these to-be-remembered words. The study format will be as in the practice list before. To reiterate the instructions you were shown before:

You will see a series of word pairs and pictures presented on the computer screen. The presentation of each word pair and picture represents one trial. Each study trial is composed of 3 stages:
1. 'PRESS BUTTON TO CONTINUE' appears on the screen. This action begins each trial.
2. A fixation point will then appear in the form ' * '.
3. Next, a pair of words (e.g., cat—shout) and a picture will appear. The word pair and picture will remain on the screen for about 5 seconds. You should read the word pair out aloud.

The trial cycle will then begin again with stage 1. Your ability to remember these words is going to be tested, so maximise your effort for learning the words in the following list.

PRESS THE SPACEBAR TO CONTINUE WITH THE ACTUAL STUDY LIST.

11.1.6.1.2 Mid-List Instructions for R-R Condition: List 2 Instructions

You will now be given a short break before continuing with the list of word pairs that you need to remember for a later memory test. The study format will be as in the list presented before. To reiterate the instructions you were shown before:

You will see a series of word pairs and pictures presented on the computer screen. The presentation of each word pair and picture represents one study trial. Each trial is composed of 3 stages:

1. 'PRESS BUTTON TO CONTINUE' appears on the screen. This action begins each trial.
2. A fixation point will then appear in the form ' * '.
3. Next, a pair of words (e.g., cat—shout) and a picture will appear. The word pair and picture will remain on the screen for about 5 seconds. You should read the word pair out aloud.

The trial cycle will then begin again with stage 1. Your ability to remember these word pairs is going to be tested, so ensure that you continue to attend to these words in order to learn the word pairs in the following list.

PRESS THE SPACEBAR TO CONTINUE WITH THE SECOND PART OF THE STUDY LIST.

11.1.6.2 Test Phase

You will see a series of items presented on the computer screen. The presentation of each set of items represents one test trial. Each test trial is composed of the following stages:

1. 'PRESS BUTTON TO CONTINUE' appears on the screen. This action begins each trial.
2. A fixation point will then appear in the form '*'.

3. Following a short interval, a word and a three letter word stem (e.g., cat--sho__) with a picture will appear in place of the fixation point. The word, three letter word stem, and picture will remain on the screen for about 10 seconds. In addition, either the word 'OLD' or the word 'NEW' will appear below the words and picture.

4. If you see the word 'NEW', you should complete the word stem using a 5 LETTER word that was not in the list of words that you have just seen. That is, try and think of new, unseen 5 LETTER words, avoiding the words from both lists shown at study. Try and do these trials as fast as you can.

5. If you see the word 'OLD', you should try and complete the word stem with a 5 LETTER word from the lists you have just seen. You should use words from both lists. If you cannot think of compatible words, provide the first compatible word that comes to mind. This is often quite effective.

The trial cycle will then begin again with stage 1. The procedure is therefore self-paced. Your responses should be recorded on the supplied response sheet. If you cannot provide a 5 letter word for a word stem then you may continue onto the next trial. However, please only use this option if you are certain that you cannot think of a word for each word stem in accordance with the instructions for that trial.

PRESS THE SPACEBAR TO BEGIN THE TEST TRIALS.