REAL-LIFE PROBLEM SOLVING AND EXECUTIVE FUNCTION IN RELATION TO THE FRONTAL LOBES

A thesis submitted for the degree of
Doctor of Philosophy
by
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On a personal level, I should like to extend special thanks to my husband, Shaun Pye, for his love, support and tolerance. In addition, I should like to thank my parents and family. Special thanks should go to my friends at the Institute of Psychiatry, particularly Tim, Nicola, Adam, Kate R and Sami, for their welcome messages of encouragement.
Clinical accounts of the behaviour of people with frontal lobe lesions suggest that they often show marked difficulties in aspects of problem-solving and decision-making in their daily lives. Despite these real-life problems, studies have shown that some of these patients perform well on laboratory tests of executive function. This has led to a drive to create laboratory measures with greater ecological validity than those commonly used in neuropsychological assessment and rehabilitation, which differ from real-life problem situations in a number of ways, including the amount of structure and feedback provided by the test. In addition, real-life problems are likely to draw more heavily than abstract executive measures on factors such as interpersonal comprehension and judgement, and previous experience.

This thesis describes a series of experimental studies designed to address these issues. The aim was to examine real-life problem-solving in participants with frontal lobe involvement, and the measures in each study were intended to have greater ecological validity than most standardised measures. The first study showed that participants with anterior lesions were impaired in a range of aspects of real-life problem-solving, and it was postulated that a range of important factors contributed to their deficits, including executive impairment, poor selection of courses of action, deficits in understanding interpersonal processes, and an inability to apply their previous experience to the task. The subsequent studies examined these factors further, both by manipulating the problem-solving measures, and by studying groups of participants with different types of frontal lobe involvement, who also differed in their life experience. Overall, it was concluded that these factors were all relevant to aspects of real-life problem-solving performance. The results are considered in the light of current models of frontal lobe functioning, and the implications of the findings are discussed.
The studies described in this thesis were designed and conducted by Sarah Crawford in collaboration with myself as supervisor. Sarah Crawford was responsible for all the recruitment, data collection and analysis presented in the thesis.


Shelley Channon
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CHAPTER 1
INTRODUCTION TO LITERATURE REVIEW

1.1 EXECUTIVE FUNCTION AND ECOLOGICAL VALIDITY

1.1.1 Ecological validity
Neuropsychological assessments may be conducted for a range of reasons, such as diagnosis and research, but also to aid in planning rehabilitation programmes and targets, and helping patients understand the implications of their injury for their future life (Lezak, 1995). The logical inference from this is that the results of the assessments must provide reliable and valid information about the implications for functioning in daily life. However, this has been questioned with regard to a range of processes. For example, it has been claimed that while standardised memory measures may show that a person has a deficit, they do not necessarily enable an accurate prediction of what types of difficulties the person will have with their everyday memory (Sunderland, Harris & Baddeley, 1983). In consequence of observations such as this, there has been a drive to create measures that have greater ‘ecological validity’, in that they have predictive power regarding what kinds of real-life tasks the person is likely to find difficult (Wilson, 1993). Such measures have been developed in fields including memory (e.g. Rivermead Behavioural Memory Test, Wilson, Cockburn and Baddeley, 1985; Autobiographical Memory Interview, Kopelman, Wilson & Baddeley, 1990) and attention (e.g. Behavioural Inattention Test, Wilson, Cockburn & Halligan, 1987; Test of Everyday Attention, Robertson, Ward, Ridgeway & Nimmo-Smith, 1994). More recently, attention has turned to the issues of developing ecologically valid measures of executive function.

1.1.2 Executive function
Although historically there have been debates about whether cognitive functioning is an all-or-none phenomenon, it is now widely accepted that different aspects of functioning must be potentially separate from each other. The strongest type of
support for this assertion is the observation of double dissociations in functioning. For example, if one patient shows intact performance in one cognitive domain but severely impaired performance in another, while a different patient shows the opposite pattern, this is presented as evidence that the two domains are likely to be functionally separate, and depend on different brain systems. However, there are many methodological issues in this field, and caution is needed when extrapolating theories of normal functioning from single case studies (see Shallice, 1988 for a discussion). There is still debate about the extent of modularity of cognitive function, and the specialisation of different brain regions. Cipolotti and Warrington (1995) argue that a thorough neuropsychological assessment attempts to determine both premorbid level of functioning and current intellectual functioning, in addition to administering specific tests of memory, language, calculation, problem solving, alertness, and visuospatial functioning. Even within these headings, there are numerous possible ways in which these functions can be split into dissociable subprocesses. For example, within memory, it is argued that aspects such as verbal versus nonverbal, recall versus recognition, and implicit versus explicit memory need to be assessed, as they can potentially be affected independently.

Current models of the modularity of brain functioning tend to recognise the executive functions as a separate system that requires specialised assessment. Executive processes are thought to underpin performance on tasks involving reasoning, problem-solving, planning and decision-making, which are crucial processes involved in daily life. Deficits in real life problem-solving performance have been associated particularly with damage to the frontal lobes of the brain. In overall terms, the executive system has been conceptualised as being particularly important when tasks involve novelty (e.g. Shallice & Burgess, 1993; Daffner, Mesulam, Scinto, Acar, Calvo, Faust et al, 2000). Fractionation of executive function is still an issue of debate, although proposed potentially separable subprocesses include the ability to sustain attention, change set, inhibit irrelevant responses and monitor responses (Crawford, 1998). Evidence for the involvement of prefrontal areas in novel but not well-learned tasks has been provided by functional imaging studies (see e.g. Passingham, 1996).
In clinical practice, there is a range of standardised measures purported to measure executive function. However, it is recognised that it is inappropriate to use only one such test and then extrapolate about the person’s real-life problem solving abilities from that data. For example, in a discussion of the essential measures that should be included in an assessment of older people’s abilities, Davies (1996) argues that three different kinds of executive tests should be included. These are a measure of verbal fluency (e.g. Benton & Hamsher, 1976; Thurstone & Thurstone, 1962), a test of set-shifting ability, such as the Trail Making Test (Reitan, 1958) or Stroop Test (Stroop, 1935), and measures of judgement and/or reasoning, for which he suggests using one or more of the Cognitive Estimates Test (Shallice & Evans, 1978), Wisconsin Card Sorting Test (Milner 1963; Nelson 1976), Tower of London Test (Shallice, 1982) or Six Elements Test (Shallice & Burgess, 1991; Wilson, Alderman, Burgess, Emslie & Evans, 1996). Thus, at a clinical level there is recognition that executive function is likely to be fractionated, and therefore different tasks may be measuring separable sub-processes.

1.1.3 Focus of literature review
The next section of this review focuses on the impact of frontal lobe lesions, and discusses fractionation of executive functions, and localisation of deficits within the frontal lobes. The review will also focus on the reasons why there has been a drive to develop more ecologically valid measures of executive function in order to discover ways of measuring real-life difficulties within a structured laboratory setting. The relationships between performance on such newer measures and existing standardised tests will also be considered. Theories of real-life problem-solving and the functions of the frontal lobes will be discussed. In addition, the effects of other types of disruption to frontal lobe functioning will be considered, as determining patterns of performance on both real-life-type tasks and standardised measures in groups other than those with acquired structural brain lesions can help to enhance our knowledge of the processes involved in real-life problem-solving and their relation to brain functioning.
CHAPTER 2
FRONTAL LOBE LESIONS

2.1 CONSEQUENCES OF FRONTAL LOBE LESIONS

Clinical descriptions of the consequences of frontal lobe damage often describe changes in personality, emotion, and social behaviour. For example, Prigatano (1991a, 1991b) described patients with lesions to the frontal lobes who showed inappropriate social behaviour such as standing too close to people, staring, and making personal comments, and being unable to recognise when other people were upset. Other case studies of patients with lesions involving the frontal cortex have described features such as tactlessness, inability to make friends, relationship difficulties, and inappropriate conversational topics with professionals e.g. focusing on sex and violence, and criminal activity (e.g. Bardenhagen, Bowden, Shields, McKay, Smith, Vogrin et al, 1999; Dimitrov, Phipps, Zahn & Grafman, 1999).

Frontal lobe lesions have also been linked with increased amounts of aggression and violent behaviour, which can contribute to family difficulties (Grafman, Schwab, Warden, Pridgen, Brown & Salazar, 1996). It has been reported that patients with frontal lobe damage are often relatively unaware of their difficulties, or have limited insight into the effects their problems have on their daily functioning (e.g. Prigatano, 1991a; Stuss, 1991a). This may occur even when the patient is aware from the reactions of others that their behaviour must be in some way unusual (Dalla Barba, Bartolomeo, Ergis, Boissé & Bachoud-Levi, 1999). Lack of awareness may contribute to socially inappropriate behaviour if patients are unable to appreciate that they have behaved in a manner that is upsetting to other people. It has been observed that the extent of the socially inappropriate behaviour shown in such patients can bear close comparison with diagnostic criteria for Antisocial Personality Disorder (Blair & Cipolotti, 2000). Alternatively, some patients with frontal lobe lesions show a different pattern of behaviour, manifesting as apathy and lack of initiation, and resulting in relative social isolation (Brazzelli, Colombo, Della Sala & Spinnler, 1994).
As described above, damage to the frontal lobes is also associated with deficits in cognitive function, particularly executive function. The concept of 'executive function' comes from Baddeley's model of working memory (e.g. Baddeley, 1986), which proposed that the 'central executive' was responsible for the attentional control of working memory. The central executive is a similar concept to the 'supervisory attentional system' model of frontal lobe function, originally described by Norman and Shallice (1986), which is proposed to be involved in the performance of any task that does not depend solely on well-learned routines. Therefore, the executive system is implicated in a wide variety of tasks involving processes such as decision making and planning.

Until recently, the class of functions now considered to be 'executive functions' were termed 'frontal lobe functions'. However, this term has lost favour due to the implicit assumption that such deficits should only be seen in people with direct frontal lobe involvement. It is known that patients with damage to areas outside the frontal lobes can also show deficits on executive measures, and that the personality changes that are thought to be typical of frontal lobe dysfunction can also be seen in conditions that are not associated with focal frontal lobe damage (Baddeley & Della Sala, 1996). The term 'dysexecutive syndrome' was therefore coined in order to describe patients with these deficits without needing to refer to the anatomical site of the brain dysfunction (e.g. Baddeley & Wilson, 1988). In spite of this, the high likelihood of such deficits following structural damage to the frontal cortex means that attempts to elucidate the exact nature and localisation of executive processes using behavioural methodology, tend to focus on the performance of patients with focal frontal lesions.

2.2 DISSOCIATIONS BETWEEN BEHAVIOUR AND PERFORMANCE ON STANDARDISED MEASURES

There is now a considerable body of work showing that some patients with known frontal lobe lesions can have difficulties in their daily lives that are typical of dysexecutive syndrome but that are not picked up by abstract standardised tasks of executive function. For example, Eslinger and Damasio (1985) reported on a single
case, referred to as EVR, who had surgery to remove a bilateral orbitofrontal meningioma. He performed normally on both the Wisconsin Card Sorting Test (WCST), and a modified cognitive estimation test. However, he had marked difficulties in his daily life, such as investing money unwisely, losing jobs, and being disorganised, all of which were not characteristic of him prior to the surgery. Similar dissociations between difficulties in real-life behaviour in the context of relatively subtle deficits or intact performance on standardised neuropsychological tests have been reported in other studies, including three single cases described by Shallice and Burgess (1991).

Most of the cases described above had lesions extending into both right and left frontal lobe regions. Therefore, the question arises of whether such dissociations are only seen following bilateral lesions. However, there are some studies of people with unilateral lesions who show a similar pattern, for example one case study described a patient with a unilateral left-sided lesion involving both orbital and dorsolateral areas, who showed inappropriate social behaviour in his daily life that was qualitatively similar to that reported in EVR, but performed normally on tests including the WCST, Cognitive Estimates, and Six Elements Test (Goldstein, Bernard, Fenwick, Burgess & McNeil, 1993). Two further cases with unilateral left-sided lesions have been described, who showed long-term difficulties in aspects of their daily lives, in the context of normal performance on standardised tests such as the WCST, Trail Making and Six Elements Test (Bardenhagen et al, 1999). Similar observations have been reported in cases with unilateral right-sided lesions (Dimitrov et al, 1999; Nies, 1999).

The dissociation between difficulties with everyday planning and decision-making in the context of intact performance on standardised laboratory tests has been termed ‘strategy application disorder’ (e.g. Goldstein, et al, 1993; Burgess, 2000a). The fact that these marked everyday deficits can easily be observed in daily life, yet cannot be detected using standard assessment tools, has led to a move to develop measures that are sensitive to these problems, yet retain the qualities of a standardised assessment. Work in this area will be reviewed below, along with a consideration of the factors involved in real-life problem-solving, and theoretical
models. Many models of real-life problem-solving deficits in patients with focal lesions relate performance to aspects of executive function, and to particular neuroanatomical lesion sites. The neuroanatomy of the frontal lobes is therefore discussed below, followed by a consideration of the executive functions.

2.3 NEUROANATOMY OF THE FRONTAL LOBES

The frontal lobes can be divided into three main areas on the basis of function, the primary motor cortex, premotor cortex, and prefrontal cortex (Kolb & Whishaw, 1990). Studies of the cognitive, behavioural and personality effects of focal lesions tend to refer to patients with damage to the prefrontal areas. The prefrontal cortex is also subdivided into different regions. Kolb and Whishaw (1990) refer to dorsolateral, inferior and medial areas as having potentially different roles in cognition. Within this definition, the inferior area includes the orbitofrontal cortex, and the medial area includes the cingulate regions. Other basic texts on frontal lobe neuroanatomy take the narrower view, and refer to the functional distinction between dorsolateral, orbitofrontal and anterior cingulate regions (e.g. Malloy, Cohen & Jenkins, 1998). The exact boundaries of these different areas are not always consistent between studies (see Elliott, Dolan & Frith, 2000 for a discussion), and it has been argued that determining clear limits for these areas within the frontal lobes is problematic (Damasio, 1991).

In broad terms, these areas are thought to have different roles in normal functioning. Thus, damage to dorsolateral prefrontal areas is associated with impairments in aspects of executive function as measured by standardised tests, orbitofrontal damage is associated with socially inappropriate behaviour, disinhibition and emotional lability, while lesions to the anterior cingulate are said to produce symptoms of apathy, difficulty initiating behaviour, and flat affect (e.g. Kolb & Whishaw, 1990; Duffy & Campbell, 1994; Lezak, 1995; Malloy et al, 1998). The term ‘ventromedial’ is used to refer to the combination of orbitofrontal and anterior cingulate areas (Daum & Mayes, 2000). The evidence regarding proposed functional distinctions between these areas is discussed below. It is argued that lateralisation of function is less pronounced in the frontal lobes
compared with other cortical areas (Kolb & Whishaw, 1990), although the evidence regarding left- versus right-sided lesions will also be discussed below where this has been addressed.

Duncan and Owen (2000) argued that exploring fractionation within frontal cortex might be limited by the large number of connections that exist both within the region, and between frontal areas and non-frontal cortical and subcortical regions. Thus, a deficit seen following a focal lesion may occur because the connections to the critical area have been damaged, rather than because that specific region of cortex subserves the behaviour in question. One method of investigating localisation that has gained popularity in recent years is functional imaging of non-brain-injured participants while they are carrying out various cognitive tasks. In their review, Duncan and Owen (2000) argued that the evidence at present indicates that lateral and anterior cingulate areas are activated in a range of different tasks, including inhibition of a prepotent response, working memory and task novelty, while the studies they reviewed had not found orbitofrontal activation during any of the measures. Evidence from lesion studies will be considered below.

2.4 STANDARDISED ASSESSMENT OF THE EXECUTIVE FUNCTIONS

The central executive or supervisory attentional system was conceived as a higher-order processing centre that acts as a control system over other cognitive processes in tasks that do not depend solely on well-learned routines (e.g. Baddeley, Della Sala, Gray, Papagno & Spinnler, 1997), although other viewpoints dispute this (e.g. Kimberg & Farah, 1993). The central executive has been described as important in tasks that involve novelty (Shallice & Burgess, 1993). However, this is clearly a very broad definition, encompassing a range of types of function. There are many tasks that are purported to measure ‘executive function’ which, on the surface, appear to share little in common in terms of task demands. It is now widely accepted that people can show deficits on some executive tests but not others, and that there are often poor correlations between many executive tests (e.g. Burgess, 1997; Rabbitt 1997). Poor correlations could be accounted for in a number of ways, such as the tests loading on the same overall ‘executive function’, but requiring
different underlying non-executive processes. Alternatively, the executive functions might be fractionated into different sub-processes, and therefore different tests may be measuring separate aspects of executive function (see e.g. Stuss, Shallice, Alexander & Picton, 1995 for a discussion). The model of executive function put forward by Norman and Shallice (1986) has been revised (e.g. Shallice & Burgess 1991, 1993, 1996) and now argues that the system is fractionated into a range of sub-processes, which are likely to have separate neural bases. Thus, selective damage is likely to affect only some of the sub-processes.

The task of categorising tasks thought to involve executive skills into those using different sub-processes is complicated by standardised measures being relatively impure. For example, it has been argued that performance on the Wisconsin Card Sorting Test, a widely used clinical measure of executive function, is dependent on a range of potentially separable sub-processes including abstraction, flexibility, attribute identification, categorisation, working memory, inhibition, selective attention, and encoding of verbal feedback (Ozonoff, Strayer, McMahon & Filloux, 1998). Moreover, executive tests rely on a range of other, non-executive processes such as visuo-spatial and language abilities, which are additional sources of possible failure. Burgess (1997) argues that impairments on standardised 'executive' tests can be seen in patients without frontal lobe damage, because they have difficulties with the non-executive task demands, in spite of intact executive abilities. Rabbitt (1997) argues that investigating the distinctions between executive and non-executive tests is also hampered by the psychometric properties of many executive tests, which, by their nature, have low test-retest reliability (due to losing novelty on repeated testing), and where the validity in terms of predicting dysexecutive behaviour, is often questionable, as shown by the distinctions between real-life behaviour and task performance described above.

These observations demonstrate that any investigation of executive processes requires a comprehensive battery of executive tests. The decision as to which tests to include is still open to question with regard to the need to assess all the potentially separable sub-processes of executive function. Distinguishing tasks on the basis of task demands is one method of deciding which ones to include,
although this has been criticised due to the lack of empirical evidence as to whether the different tasks actually have separate underlying processes (Lowe & Rabbitt, 1997). Moreover, it has been argued that even if the exact processes involved are distinct, it is nevertheless plausible that the same underlying brain structures are responsible (Rabbitt, 1997). However, it is clear that performance on a range of executive tests does not always correlate, and in the absence of definitive details about which measures to include, it is practical to base decisions on research into fractionated sub-processes. Some of these processes that have been proposed to be potentially independent from each other include inhibition, planning/intentionality, executive memory, initiation and deductive reasoning. Some empirical evidence that inhibition, intentionality and executive memory are indeed separable was provided in a factor analysis examining performance on standardised executive measures and relatives’ or carers’ reports of patients’ dysexecutive behaviours in daily life (Burgess, Alderman, Evans, Emslie & Wilson, 1998).

2.4.1 Inhibition
Clinical presentations of people with frontal lobe damage often refer to patients’ difficulties inhibiting inappropriate behaviour. Inhibitory deficits are thought to be a feature of executive processes, although the correlations between measures thought to assess it are often poor (Rabbitt, 1997). It has been argued that there may be different types of inhibition, for example the ability to rapidly shift set is thought to be potentially dissociable from the inability to inhibit a prepotent response (e.g. Miyake, Friedman, Emerson, Witzki & Howarter, 2000). Measures of inhibition of prepotent responses have also been linked with strategy generation, and therefore, these will be considered separately from measures of set-shifting.

2.4.1.1 Attention and set-shifting
Tasks such as the Trail Making test are thought to measure set shifting, and the difference in time between parts A and B has been postulated to represent executive control processes (Arbuthnott & Frank, 2000). Other studies have shown that patients with frontal lobe involvement are slower than both control participants, and those with nonfrontal lesions, on both parts of the task, and that they also make a higher number of errors (Stuss, Bisschop, Alexander, Levine,
Katz & Izukawa, 2001); this applied particularly to patients with dorsolateral lesions. The Wisconsin Card Sorting Test is another widely used measure that involves set shifting, and impairments on this task have also been shown in patients with frontal lobe involvement (e.g. Stuss, Levine, Alexander, Hong, Palumbo, Hamer, et al, 2000). However, as described above (section 2.4), this test assesses a wide range of executive and non-executive processes, and it can therefore be difficult to determine the source of failure, which has been presented as a reason against its use in routine clinical practice (Crawford, 1998). Work has also indicated that it is not sensitive enough to differentiate between patients with frontal versus non-frontal brain lesions (Anderson, Damasio, Jones & Tranel, 1991). Impairment on other measures of set shifting has also been shown in patients with focal frontal lesions, and it has been conceptualised as a deficit of attention (Owen, Roberts, Polkey, Sahakian & Robbins, 1991). The frontal lobes have also been implicated in other aspects of attention such as sustained attention (Wilkins, Shallice & McCarthy, 1987; Koski & Petrides, 2001).

2.4.1.2 Inhibition and strategy generation

Ability to inhibit a prepotent response has been assessed using measures such as the Stroop test (Stroop, 1935) and the Hayling test (Burgess & Shallice, 1996a). Studies have shown that patients with frontal lobe lesions perform more poorly than those with posterior lesions on the Stroop test (Stuss, Floden, Alexander, Levine & Katz, 2001). Latéralisation evidence is conflicting, with some studies showing greater impairment associated with left-sided lesions (e.g. Perret 1974), and others with right-sided lesions (e.g. Vendrell, Junqué, Pujol, Jurado, Molet & Grafman, 1995). The Hayling test consists of two parts. In the first part, participants are asked to provide straightforward completions to sentences, while the second part requires them to inhibit straightforward completions, and, instead, provide a word that makes no sense at all in the context of the sentence. The study found that patients with frontal lobe lesions were slower than both control participants and participants with posterior lesions at the first part of the task, which was thought to represent a deficit in initiation. The anterior group also gained higher error scores than the other groups on the second part of the task in which they had to suppress prepotent responses. Burgess and Shallice argued that
one of the factors in the anterior group's difficulties on part B was their deficits in generating and adopting strategies. Functional imaging studies have implicated areas of the left frontal lobe in both the initiation and response suppression aspects of the Hayling test (Collette, Van der Linden, Delfiore, Deguildre, Luxen & Salmon, 2001). Another study using a task based on the Hayling test found that relative to initiation, the suppression condition was associated with activation in both right and left frontal areas, in addition to some regions outside the frontal lobes (De Zubicaray, Zelaya, Andrew, Williams & Bullmore, 2000).

Verbal fluency tests are also thought to measure aspects of initiation and strategy generation. There are different types of fluency measures, all of which require participants to generate as many items (letters, categories or designs) as they can within a restricted time period. Studies have shown that patients with frontal lobes lesions are impaired relative to control participants on these tasks (e.g. Stuss, Alexander, Hamer, Palumbo, Dempster, Binns et al, 1998; Baldo, Shimamura, Delis, Karmer & Kaplan, 2001). Poor performance on verbal (letter and category) fluency tests has been associated particularly with left frontal lesions (e.g. Milner, 1964; Paulesu, Goldacre, Scifo, Cappa, Gilardi, Castiglioni et al, 1997; Tucha, Smely & Lange, 1999; Baldo et al, 2001). This has been linked particularly with left-sided lesions of the medial and dorsolateral areas (Stuss et al, 1998), although the same study reported that patients with right-sided medial frontal lesions also showed a degree of impairment on these tasks. The findings with regard to design fluency are mixed, with some studies reporting no impairment in patients with frontal lobe lesions (Tucha et al, 1999), others finding selective right-sided impairment (Ruff, Allen, Farrow, Niemann & Wylie, 1994), and others reporting that both left- and right-sided lesions are associated with impairment (Baldo et al, 2001).

2.4.2 Planning and Intentionality
The debate about the exact nature of executive processes that are involved in different tasks extends to measures of 'planning' ability. Frontal lobe dysfunction has been associated with impairment on the Tower of Hanoi (Morris, Miotto, Feigenbaum, Bullock & Polkey, 1997) and Tower of London tests (Carlin,
Bonerba, Phipps, Alexander, Shapiro & Grafman, 2000; Owen, Downes, Sahakian, Polkey & Robbins, 1990), both of which have been conceptualised as measures of planning (e.g. Shallice, 1982). However, it has been argued that the two tasks are fundamentally different, and that, rather than measuring planning, the Tower of Hanoi actually assesses working memory and the ability to inhibit a prepotent response (Goel & Grafman, 1995; Goel, Pullara & Grafman, 2001). This was based on their research showing that the deficit in patients with frontal lobe lesions was not in their use of strategies, but instead in whether or not they perform a counterintuitive move that appears to take them away from the goal, described as a goal-subgoal conflict. Another study looked at lateralisation effects on the Tower of Hanoi, and claimed that while the impairment in participants with left-sided frontal lesions was consistent with a failure to inhibit a prepotent response (goal-subgoal conflict), the deficits seen in those with right-sided lesions were attributable to a specific impairment in spatial memory ability (Morris et al, 1997).

Similarly, research into the processes involved in intact performance on the Tower of London test has concluded that the nature of the planning processes may be somewhat different from those originally conceptualised (Phillips, Wynn, McPherson & Gilhooly, 2001). A functional imaging study indicated that impaired performance in patients with frontal lobe lesions on the Tower of London may be attributable to deficits in generation or inhibition, impulsivity, or memory difficulties rather than disrupted planning ability (Rowe, Owen, Johnsrude & Passingham, 2001). One possible explanation for these findings is that planning might not be one separable sub-process of executive function, but might be better perceived as a multidimensional construct itself, with failure on planning tasks occurring for a variety of reasons.

An alternative method of assessing planning ability would be to assess 'Intentionality', which is related to planning and decision-making processes, and insight (Burgess et al, 1998). The authors put forward a theoretical basis for considering this as a dissociable executive skill, and argued that the Six Elements Test (SET) is an effective instrument for assessing it. The standardised version of the SET is part of the Behavioural Assessment of the Dysexecutive Syndrome (BADS) battery (Wilson et al, 1996). This version is a modified version of that
developed in the original study (Shallice & Burgess, 1991), but has been demonstrated to be sensitive to the impairments shown by patients with dysexecutive behaviours caused by neurological conditions (Burgess et al, 1998). The Six Elements test is one of a range of tests thought to measure ‘multitasking’ (Burgess, 2000a). The intentionality component of multitasking measures has been linked with prospective memory processes, and to medial areas of the frontal lobes, particularly area 10 (Burgess, Veitch, Costello & Shallice, 2000).

2.4.3 Executive memory

Executive processes are also implicated in other types of tasks. For example, a range of memory impairments have been described in patients with focal frontal lesions, including measures of free recall (e.g. Gershberg & Shimamura, 1995; Daum & Mayes, 2000), memory for temporal order (e.g. Kopelman, Stanhope & Kingsley, 1997; Daum & Mayes, 2000), and prospective memory (e.g. Burgess et al, 2000; Cockburn, 1995). Frontal lesions are also associated with increased amounts of confabulation and other false memories (e.g. Moscovitch & Melo, 1997; Parkin, 1997). Theories regarding the role of the frontal lobes in memory processes have tended to characterise these impairments as being attributable to executive deficits (see e.g. Mayes & Daum, 1997 for a discussion). For example, rather than reflecting a deficit in memory per se, free-recall impairments in patients with frontal lobe lesions are generally thought to be attributable to executive deficits in terms of active processes of strategic encoding and retrieval, involving inhibition of irrelevant information and monitoring of responses (Shimamura, Janowsky & Squire, 1991; Della Rochetta & Milner, 1993; Gershberg & Shimamura, 1995; Henson, Shallice & Dolan, 1999). Functional imaging studies have provided support for the role of the frontal lobes in free recall, implicating the left frontal lobe in encoding and the right frontal lobe in retrieval (Fletcher, Shallice & Dolan, 1998; Fletcher, Shallice, Frith, Frackowiak & Dolan, 1998).

2.4.4 Deductive reasoning/fluid intelligence

Deductive reasoning is another aspect of functioning that has been related to frontal lobe impairment. Intellectual ability is often stated to be relatively preserved following frontal lobe damage. However, it has been argued that that there is a
distinction between 'crystallised' and 'fluid' intelligence, in that the former is thought to be more knowledge-based than the latter (e.g. Duncan, Burgess & Emslie, 1995; Duncan, Emslie & Williams, 1996). Duncan argued that fluid intelligence measures have stronger correlations than crystallised measures with 'Spearman's g', or 'general intelligence'. He argued that patients with frontal lobe lesions perform relatively well on measures that are largely dependent on crystallised intelligence, such as verbal subtests of the Wechsler Adult Intelligence Scales (Wechsler 1981, 1997), in the context of being impaired on measures of fluid intelligence, such as the Culture Fair test (Duncan et al, 1995); this was presented as evidence that 'g' is dependent on intact frontal lobe functioning. Therefore, deductive reasoning has been conceptualised as one potentially separable aspect of executive function that can be measured using tests such as Raven's matrices (Ardila, 1999; Crinella & Yu, 2000).

2.5 SUMMARY OF CHAPTER 2
The literature reviewed above shows that it is important to develop measures of real-life problem-solving that are sensitive to the everyday deficits shown by patients with frontal lobe lesions. The available evidence on executive functions indicates that these are likely to be fractionated. There is also some evidence that fractionated functions may have different brain bases. For example, decision-making/intentionality has been linked with medial area 10, while inhibitory processes have been linked particularly with lateral areas of frontal cortex (Duncan & Owen, 2000; Stuss et al, 2001). Therefore, any study examining the relationships between executive skills and real-life problem-solving should include a comprehensive battery of tests, representing all the categories listed above. The next section discusses postulated differences between real-life problem-solving and standardised laboratory tests, and reviews the evidence to date on developing new, ecologically valid tools, for assessing patients with frontal lobe lesions.
CHAPTER 3
REAL-LIFE PROBLEM-SOLVING AND FRONTAL LOBE LESIONS

3.1 FORMAL ASSESSMENT OF REAL-LIFE PROBLEM-SOLVING

As reviewed above in section 2.1, a range of single case studies has been described, all of who showed intact performance on a range of executive measures in the context of marked difficulties in their daily lives. Since these observations have been made, there has been a drive to create measures that are sensitive to these deficits that can nevertheless be administered in a standardised fashion in a laboratory setting.

3.1.1 Differences between real-life tasks and laboratory measures

There are some crucial distinctions between standard laboratory measures and the types of difficulties patients with dysexecutive behaviours show in their daily lives. Lezak (1995) argued that the amount of structure provided within a task was a crucial aspect. She stated that one of the important sources of difficulty in patients with dysexecutive behaviours was their inability to structure tasks for themselves. However, this ability is not assessed in most standardised measures, which are highly structured by their nature.

Another method of distinguishing between different types of tasks is to split them into those involving ‘formal’ and those involving ‘informal’, or ‘everyday’ reasoning (e.g. Galotti, 1989). Formal tasks are well-defined, containing all the information needed to solve the problem, and usually have only one correct answer. Most standardised executive measures fall within this description. By contrast, everyday reasoning tasks are ill-defined, requiring the use of information beyond that provided in the immediate problem, and they often have several possible solutions. The role of experience is therefore more important in ill-defined tasks (e.g. Kahney, 1993; Evans, 1986). Other factors that might potentially be more important in everyday problem-solving situations compared with laboratory performance are social factors, emotions, and personal relevance.
D'Zurilla and Goldfried (1971) argued that there are many inter-related processes involved in everyday problem-solving. These include recognising the relevant aspects of the problem, generating a range of possible solutions, deciding which solution is the most appropriate for resolving the problem, and monitoring the effectiveness of the solution after it has been carried out.

Therefore, there is a range of possible differences between everyday and laboratory problem-solving. Attempts to assess real-life problems in the laboratory should therefore focus on addressing some of the issues outlined above.

3.1.2 Real-life-type measures and patients with frontal lobe lesions
Some attempts at designing more ecologically valid measures have focused specifically on the interpersonal deficits that are associated with frontal lobe damage. Others have looked at non-interpersonal aspects of decision-making and planning. These headings are based on the descriptions provided within these studies. However, some of the tasks share features in common, and there is likely to be overlap in the underlying processes involved in them.

3.1.2.1 Interpersonal problem-solving
Clinically, the inappropriate social behaviour often shown by people who have sustained frontal lobe damage is one of the most salient consequences, which can cause distress to their friends and relatives. Some studies have addressed the issue of whether these difficulties can be assessed using structured tasks. One study compared the performance of patients with structural lesions involving the frontal lobe, or frontal lobe dementia, with healthy control participants on their ability to rate the effectiveness of solutions to hypothetical problem situations (Dimitrov, Grafman & Hollnagel, 1996). This measure was originally developed to assess real-life problem solving in elderly people (Cornelius & Caspi, 1987). The task required participants to judge a given set of solutions, which removed the need for them to generate ideas themselves, enabling a direct comparison to be made between their performance and that of control participants; it was therefore examining only their ability to judge between competing alternatives. The results showed that the control group’s ratings corresponded well with normative data.
collated from previous studies. However, approximately half of the group with frontal lobe involvement differed substantially from the norms, indicating that they might have poor social problem-solving judgement. Poor performance was associated with lower scores than the other participants with frontal lobe involvement on standardised neuropsychological measures including the WCST and verbal subtests of the WAIS-R, and on a measure of real-life behaviour that was graded by an experimenter. The findings that the subgroup with poorer scores also had lower WAIS-R scores indicated that general intellectual level might have contributed to performance. This was supported by the observation that the patients who performed more poorly had lower educational levels. The full impact of these factors could not be investigated since the control group were not given the standardised tests. However, the results provided tentative evidence that some patients with frontal lobe lesions have an impairment in social decision-making as measured by a structured test. Age, gender, and site of lesion were not related to outcome.

3.1.2.2 Non-interpersonal decision-making and emotional processes
The difficulties observed in EVR, described by Eslinger and Damasio (1985) have also been framed in terms of decision-making. Investigations indicated that EVR had intact social knowledge (Saver & Damasio, 1991), but that he was unable to use this knowledge to select an appropriate response when faced with a range of possibilities. As he had bilateral lesions involving orbitofrontal areas, it was suggested that the orbitofrontal cortex is a critical area in everyday decision-making (Damasio, Tranel & Damasio, 1990). In order to investigate EVR’s impairments more fully, a ‘gambling’ test was devised, and the performance of EVR and other participants with ventromedial lesions (i.e. bilateral damage affecting orbitofrontal and medial, but not dorsolateral areas) was compared with that of control participants (Bechara, Damasio, Damasio & Anderson, 1994). The task involved selection of cards from four decks, with the aim of gaining a high score. Two of the decks contained higher rewards, but also higher overall levels of punishment than the other two. The optimal strategy was therefore to choose cards from the decks with lower absolute rewards. The findings showed that the patients performed more poorly than the control participants, in that they failed to switch to
the optimal decks. It was concluded that they were unable to adjust their responses based on the feedback about relative reward and punishment. Later studies (Bechara, Tranel, Damasio & Damasio, 1996) showed that, in contrast to the control group, the patient group did not show anticipatory skin conductance responses (SCRs) before making responses that were associated with higher overall amounts of punishment. Control participants show such responses before they are able to verbalise the relative risks of the decks (Bechara, Damasio, Tranel, & Damasio, 1997), and therefore, the authors proposed that the anticipatory SCRs reflected a nonconscious learning of reward and punishment that was compromised in the patient group due to ventromedial damage.

The findings reported above were interpreted in the context of a theory of ‘somatic markers’ (Bechara, Damasio & Damasio, 2000), which are proposed to play a crucial role in decision-making. These markers are said to provide cues based on previous learning of reward or punishment from prior experience, which influence performance before conscious knowledge is available to guide reasoning. They argue that this marker system is compromised in patients with lesions to bilateral orbital and lower mesial cortices. It has been proposed that the somatic markers enable decision-making to be ‘speeded up’ in healthy people (Rahman, Sahakian, Cardinal, Rogers & Robbins, 2001). A similar theory has been proposed by Rolls (e.g. Rolls, 1996; 1999; Rolls, Hornak, Wade & McGrath, 1994), also conceptualising the orbital frontal areas as involved in modulating behaviour according to previous experience of reward and punishment. For example, patients with lesions involving these areas have been shown to be impaired at both extinction and reversal of a previously rewarded response, showing a tendency to perseverate (Rolls et al, 1994). Some patients had a dissociation between thought and action, in that they knew how they were expected to respond, but did not carry this out. They also showed characteristic dysexecutive behaviours. The authors interpreted the findings as consistent with the orbitofrontal areas being important in social behaviour and emotion, in contrast to dorsolateral areas being important in planning and other executive processes.
Some support for this neuroanatomical dissociation has been provided by studies looking at a different gambling task, based on the same principles as the Damasio task (Rogers, Everitt, Baldacchino, Blackshaw, Swainson, Wynne, et al, 1999). The study showed that participants with damage to the orbitofrontal areas showed impairment on this task, while those whose lesions were confined to dorsolateral and dorsomedial areas did not. A functional imaging study also showed that areas of orbitofrontal, but not dorsolateral, cortex were associated with ‘risky’ decision-making (Rogers, Owen, Middleton, Williams, Pickard, Sahakian, et al, 1999). In addition, another study showed a double dissociation between gambling and working memory performance, in that patients with orbitofrontal lesions were impaired on the gambling, but not the working memory task, while the opposite pattern was seen in those with dorsolateral lesions (Bechara, Damasio, Tranel & Anderson, 1998).

Other work supporting this dissociation has been provided by studies examining different patient groups with postulated frontal lobe involvement. It has been shown that patients with Huntington’s disease show intact performance on a gambling task in the context of impaired performance on the Tower of London Test (Watkins, Rogers, Lawrence, Sahakian, Rosser & Robbins, 2000), while the reverse pattern is seen in patients with frontotemporal dementia (Rahman, Sahakian, Rogers, Hodges & Robbins, 1999). The authors argued that this is consistent with the brain regions described above, since dorsolateral areas are thought to be affected earlier than orbitofrontal areas by the disease process in Huntington’s disease, while the converse pattern is associated with frontotemporal dementia. Therefore, the evidence overall is consistent with the orbitofrontal regions being important in gambling-type tasks, and dorsolateral regions being involved in planning and non-social executive tasks.

3.1.2.3 Non-interpersonal planning and multitasking measures
Attempts to design real-life-type planning and multitasking measures are considered separately below. While multitasking measures are thought to include planning components, they are also thought to rely on additional processes as described below.
3.1.2.3.1 Planning

There have been some attempts to develop more ecologically valid planning measures. One of these described a financial planning task (Goel, Grafman, Tajik, Sheldon & Danto, 1997) in which the performance of ten participants with brain lesions including areas of the frontal lobe was compared with that of ten age- and education-matched healthy volunteers. Participants were asked to help a fictional couple to achieve four goals. These were all associated with their finances, but had different time-frames ranging from balancing their budget in the immediate term, to planning to have enough money to retire in 35 years. Participants were asked to plan out loud, and all their responses were recorded, and later coded, using a complex system. The authors argued that the anterior group did not have one ‘planning’ impairment, but instead showed a range of deficits including structuring the problem, allocating their time appropriately across the demands of the task, judging when they had achieved their goals, and looking beyond the immediate information of the task in order to apply their real-world experience. They conceptualised the difficulties in terms of a theory of ‘structured event complexes’ (Grafman, 1995). In essence, they argued that the further away the fruition of a plan is in time, the more difficult the planning will be for patients with frontal lobe lesions because the hypothetical future situation will come to differ more and more from their current situation, which will make it more difficult for the patient to retrieve information to the plan. This bears similarities with other theories regarding the role of the frontal lobes in novel situations (e.g. Shallice & Burgess, 1993). Goel et al argue that the conceptual difference between these theoretical viewpoints is whether memory traces are thought to be damaged (Goel et al, 1997), or the executive control processes, as proposed in the Shallice and Burgess model.

The same authors reported on a single case study, examining a patient’s planning ability in a hypothetical problem that was similar to those he would have encountered in his previous profession as an architect (Goel & Grafman, 2000). The patient showed a range of marked deficits in his planning ability. Of note is that his knowledge of the task, based on his experience, was intact, but he was unable to apply it efficiently to the task demands. Thus, like EVR, he showed a
dissociation between having knowledge and being able to apply it. His deficit was conceptualised primarily in terms of his inability to cope with the ill-structured nature of the task. This was manifested in an excessively long period of planning time before he was able to begin solving the problem, and an erratic approach to the various elements of the task, which he was then unable to develop effectively.

Another test of planning that was designed to have greater ecological validity was the 'Virtual Planning Test' (Miotto & Morris, 1998). This task was presented in the form of a board game, and required participants to choose a range of target activities from a set including distractor items. There were time constraints on most of the activities, and some necessitated other items to be carried out prior to their execution. They tested a group with mixed unilateral and bilateral lesions, and found that, relative to a healthy control group, they chose fewer of the target items, and were less efficient at selecting the tasks within the time constraints. They argued that the deficits were consistent with a model of disruption to the supervisory attentional system (Shallice & Burgess, 1993; 1996).

Another study looking at more ecologically valid types of planning, compared participants on their ability to describe plans verbally and then their ability to carry out their plans (Zalla, Plassiart, Pillon, Grafman & Sirigu, 2001). They noted that some of the behaviours shown by the participants with frontal lobe lesions during the execution of their plans, such as failing to fulfil goals, missing out important steps, could not have been picked up by the verbal generation phase, but required the participants to attempt to actually carry out the tasks. This clearly has importance for the development of ecologically valid measures.

3.1.2.3.2 Multitasking

'Multitasking' refers to situations in which a range of tasks have to be prioritised, planned and carried out within a specified period of time. Shallice and Burgess (1991) described three patients with frontal lobe lesions, who showed intact performance on most standardised measures in the context of everyday dysexecutive problems. They described two measures that were designed to be sensitive to these patients' impairments. The first of these was termed the 'Multiple
Errands' Test, which was carried out in a real-life setting, a shopping precinct, rather than in a laboratory. Participants were requested to carry out a range of real-life tasks such as buying items from shops, whilst not breaking a set of rules. The patients performed fewer tasks than the controls, and showed qualitative impairments in terms of rule breaks and inefficient performance. They also showed impairments on the second specially designed measure, the Six Elements Test (SET), which was intended to be a standardised laboratory analogue of the Multiple Errands Test. The results were interpreted within the context of the model of supervisory attentional functions in the frontal lobes (Norman & Shallice, 1986; Shallice, 1988). They argued that the results were consistent with a fractionated system, in which processes such as goal development, forming and monitoring plans, and prospective memory are separate, and they outlined how this accounted for the types of deficits shown in the patients.

Support for the sensitivity of the Multiple Errands Test was provided in a case study of a patient with a unilateral left sided lesion, who also demonstrated a range of difficulties on the test (Goldstein et al, 1993). Thus, there is some evidence that systematic, formal studies of 'real-life' behaviour can demonstrate the nature of the everyday difficulties shown by these patients. However, this test is clearly limited in terms of practical application by the length of time of administration, practical complexity and qualitative scoring system. By contrast, the Six Elements Test is a possible means of assessing these difficulties in a standardised setting, and a modified version is included in the BADS (Wilson et al, 1996).

Similar principles to the Six Elements test were employed in a later study, to look further at multitasking (Burgess et al, 2000). The task had a more complex set of rules than that governing the SET, and participants' ability to make and follow plans was incorporated into the procedure. Patients with lesions to the frontal lobe performed more poorly than control participants. However, the purpose of the study was to investigate whether lesions to particular areas to the frontal lobe were associated with particular types of deficits, thus providing evidence for a fractionated system; this was supported. It was argued that there are three factors involved in this task, retrospective memory, planning and prospective memory.
Anterior cingulate lesions were associated with impairments in retrospective memory. Planning was linked with right dorsolateral lesions, and prospective memory impairments with medial left hemisphere lesions, including area 10. The findings that deficits can occur separately in retrospective and prospective memory and planning demonstrates that real-life problem-solving should not be considered to be a unitary concept. Burgess (2000a, 2000b) argues that many of the everyday deficits seen in people with strategy application disorder are in situations where ‘multitasking’ is required. It is argued that situations involving multitasking share a range of characteristics, including having a number of discrete tasks with varying characteristics, which have to be carried out one at a time. Participants have to decide for themselves when they have achieved their goals, and they are given no immediate feedback. By contrast, many highly-structured standardised measures have one type of task, with a clear externally-provided goal, and feedback from an experimenter regarding the quality of performance. Thus, the challenge is to contribute further to the development of measures which are more open-ended and less structured than standard measures, and which contain multiple dimensions of problem-solving, in order to enhance knowledge of the types of processes which people with frontal lobe lesions find difficult.

3.1.3 Processes contributing to real-life problem-solving performance

3.1.3.1 Executive processes

It has been observed that in some cases, performance can be intact on standardised executive measures but impaired in real-life situations. However, there have been few systematic studies of the relationships between potentially fractionated subprocesses of executive function, and different dimensions of everyday problem-solving. For example, the stages of everyday problem solving proposed by D’Zurilla and Goldfried (1971) considered generation of a range of ideas and judgement of which idea is the most appropriate to be separate processes. The task demands of generating a range of ideas and verbal fluency tasks are, on the surface, similar, although verbal fluency would appear to be less closely related to judging which solution is most appropriate from a range of options. If executive abilities are relevant to the task demands, then participants without orbitofrontal damage
might show deficits on real-life decision-making tasks due to impaired executive skills.

3.1.3.2 Processes involved in selecting courses of action

As discussed in section 2.2, patients with frontal lobe lesions can show impairments in real-life decision-making in the context of intact performance on a range of standardised executive measures. It is therefore possible that specific deficits in decision-making and prioritising may contribute to real-life problem-solving performance in patients with anterior lesions.

3.1.3.3 Processes involved in judgement and comprehension of interpersonal factors

Several factors that potentially contribute specifically to interpersonal problem-solving will be discussed below. One of these has been derived from work with people with autism and other pervasive developmental disorders. It has been postulated that the key deficit in autism is an inability to appreciate other peoples’ mental states, known as ‘theory of mind’ (e.g. Baron-Cohen, Leslie and Frith, 1985), and that intact theory of mind ability may be dependent on the frontal lobes. Functional imaging studies have provided evidence to support this (e.g. Baron-Cohen, Ring, Moriarty, Schmitz, Costa & Ell, 1994; Fletcher, Happé, Frith, Baker, Dolan, Frackowiak & Frith, 1995; Goel, Grafman, Sadato & Hallett, 1995; Baron-Cohen, Ring, Wheelwright, Bullmore, Brammer, Simmons & Williams, 1999). However, there is ongoing debate about which specific areas of the frontal lobes are involved, as the findings have varied across these different studies. Most of the measures that have been used to assess theory of mind ability in autism, such as the classic first order false belief tasks (Wimmer & Perner, 1983), have been designed for use with young children. More recently, there have been moves to create tests that are appropriate for older children and adolescents with high-functioning autism or Aspergers’ Syndrome. For example, Happé (1994) developed a set of stories assessing ability to understand aspects of theory of mind such as sarcasm, pretence and humour. She found that these stories were sensitive to deficits shown by high-functioning autistic participants, who were able to pass standard first-order false-belief tasks.
Social comprehension performance of patients with acquired brain lesions has also been examined using tasks looking at aspects of pragmatic language. These have commonly found impairments in patients with right-sided lesions (e.g. Brownell, Simpson, Bihrl, Potter & Gardner, 1990; Winner, Brownell, Happé, Blum & Pincus, 1998; Happé, Brownell & Winner, 1999). However, these studies did not consider the anterior-posterior dimension, and McDonald (1993) has argued that this might distort the findings, and that what appear to be right-sided deficits may be accounted for by frontal lobe involvement. This corresponds with work by other authors, who have reported impairments on similar measures in patients with frontal lobe lesions (Stone, Baron-Cohen & Knight, 1992; Shammi & Stuss, 1999), and in patients with head injury, which is often linked with frontal lobe involvement (McDonald & Pearce, 1996; Bara, Tirassa & Zettin, 1997). Studies using focal lesion groups have found mixed findings. A recent study using inference and deception tasks found that participants with right-sided and bilateral frontal lesions showed greater impairments than those with left-sided frontal lesions, participants with non-frontal lesions and a healthy control group (Stuss, Gallup & Alexander, 2001). By contrast, Channon and Crawford (2000) developed a story comprehension measure based on the Happé stories, but designed for use with adults. They found that participants with left-sided anterior lesions were impaired on these stories relative to right-sided anterior participants, patients with posterior lesions, and a matched healthy control group. The left anterior group also showed poorer performance than the other groups on a battery of abstract standardised executive tests, and there were correlations between many of these measures and story comprehension performance. The discussion concluded that the most parsimonious explanation for the deficits seen on the theory-of-mind-type measure was that they were due to executive dysfunction rather than a specific deficit in social reasoning. This was strengthened by the observation that the greatest source of impairment for the left anterior participants was a failure to make non-literal inferences. This explanation of the impairments shown is consistent with the viewpoint that there is no fundamental difference in the processes used in interpersonal versus non-interpersonal reasoning. However, this could not be determined beyond doubt, as there was no matched non-interpersonal control for
the story comprehension measure. In addition, other work examining the relationship between theory of mind and executive function in patients with focal frontal lesions has concluded that the evidence suggests that they are independent processes (Rowe, Bullock, Polkey & Morris, 2001; Bach, Happé, Fleminger & Powell, 2000). The most likely explanation of these different findings is that difficulties on theory of mind tasks may occur for more than one reason, such that some patients perform poorly because of a selective deficit, while others have disruption to relevant executive sub-processes.

Some studies have attempted to address the question of whether theory of mind ability is independent of other, non-interpersonal processes by comparing performance with that on matched non-interpersonal control items. In her original study, Happé (1994) presented 24 ‘Strange Stories’ and 6 ‘Physical’ stories that were intended to function as controls as they did not involve inferences about mental states. However, the physical stories were easier to answer than the mental state stories, as the requisite information could be directly quoted from the text, and she concluded herself that they could not be considered to be a valid control. Later studies using the Strange Stories developed new control items. For example, Fletcher et al (1995) endeavoured to create stories that involved inferences, but not consideration of other people’s mental states. In a pilot study of 60 healthy control participants, they found that the mean scores of these two sets of stories did not differ, and thus concluded that they were matched for difficulty. The measures were tested on healthy volunteers in a functional imaging study, and it was found that the same areas were activated on each, but with additional activation of the left medial frontal gyrus and posterior cingulate cortex during the theory of mind items. This supports the hypothesis that theory of mind is a separate ability, with a specified brain region, and is consistent with the concept that there may be aspects of interpersonal problem-solving that are distinctly different from non-interpersonal problem-solving.

The frontal lobes have been implicated in deficits in empathy (e.g. Grattan, Bloomer, Archambault and Eslinger, 1994, Eslinger, 1998), and a functional imaging study has also linked empathy with areas of prefrontal cortex (Farrow,
Zheng, Wilkinson, Spence, Deakin, Tarrer et al, 2001). Performance on standardised measures of empathy has been related to performance on measures of ‘cognitive flexibility’ such as the Wisconsin Card Sorting Test (Grattan & Eslinger, 1989), and it is hypothesised that both processes involve the ability to consider alternative viewpoints. In addition, frontal lobe lesions have been linked with difficulties in interpreting nonverbal emotional cues such as face perception or voice intonation (Hornak, Rolls & Wade, 1996).

Blair and Cipolotti (2000) reported on a patient who showed ‘acquired sociopathy’, in that his behaviour was so socially inappropriate following his brain injury that he resembled patients diagnosed with Antisocial Personality Disorder. EVR, and other patients with ventrolateral damage, have also been described in this way. Unlike EVR, he did not show impairment on the gambling tasks, indicating that he had no difficulties with reward and punishment learning. However, he was impaired in his ability to recognise emotional facial expressions, and appeared to have difficulty understanding when people would be afraid, angry or embarrassed. He was also impaired in identifying social transgressions. This was in the context of intact theory of mind, and ability to make moral judgements. This indicates that different types of social cognition may be dissociable. The evidence indicated that a straightforward explanation in terms of general abstraction or inhibitory deficits did not fit with the evidence. The authors suggested that right orbitofrontal cortex is involved with understanding and interpreting other people’s anger, and that this system is disrupted in JS, although they note that he also had damage to the amygdala, which is known to be involved in processing emotions, particularly related to fear (Young, Hellawell, Van De Wal & Johnson, 1996; Adolphs, Tranel, Hamann, Young, Calder, Phelps et al, 1999).

Therefore, several potential factors that appear to be particularly relevant for interpersonal but not non-interpersonal situations are associated with frontal lobe lesions. However, it is also plausible that executive processes play an important role in interpersonal problem-solving. More work is needed to investigate the relative patterns of performance on equivalent measures involving interpersonal versus non-interpersonal problems.
3.1.3.4 Experience

As discussed above, one of the proposed differences between well- and ill-defined problem-solving is whether the task contains all the relevant information for solving it (Galotti, 1989; Kahney, 1993). In everyday problem-solving, the relative role of life experience is therefore thought to be greater than in well-defined problems, and research in cognitive psychology has shown that people can solve problems more successfully by applying knowledge they have gained from solving other problems (e.g. Kahney, 1993).

Some of the findings from the studies reviewed above have also concluded that the role of life experience may be crucial in aspects of real-life problem solving. For example, studies of EVR argued that he had intact social knowledge, but was unable to apply this knowledge in real-life problem-solving situations (Saver & Damasio, 1991). By contrast, it was argued that another case, MGS, did not have intact social knowledge (Dimitrov et al, 1999). Both cases had lesions involving orbitofrontal cortical areas, but EVR's injury occurred at age 35, while that of MGS occurred at age 20. The authors suggested that the reason that MGS had limited social knowledge was that he would not have had enough experience of appropriate social interactions and problem solving prior to his injury, in order to have built up a knowledge base. Other authors have argued that one of the crucial distinctions between standardised laboratory measures and real-life problem solving and planning is the increased role of experience in the latter (e.g. Goel et al, 2001). Thus, experience is widely thought to be critical to understanding everyday problem-solving, although it is rarely important in standardised executive measures.

The case of MGS is of interest because the implication is that differences in dysexecutive behaviours and real-life problem solving between different people with frontal lobe dysfunction may not be due to such factors as the site and size of lesion, but to the amount of real-world experience built up prior to the brain injury. This suggests that people with developmentally acquired brain dysfunction
affecting the prefrontal cortex might show a greater range of deficits than those with adult-acquired lesions.

The role of experience is also thought to be potentially important with regard to the performance of older people. As will be discussed in more detail later, in section 5.2, healthy older people show poorer performance than IQ- and education-matched younger samples on executive tests. This has been interpreted as consistent with differential effects of ageing on frontal cortical areas, and is thought to follow a similar model to that seen in adults with acquired frontal lesions. However, as discussed later in section 5.3, healthy older people do not tend to show the everyday dysexecutive behaviours associated with frontal lesions, and there is some evidence that they may have relatively preserved functioning in some aspects of everyday problem solving. The latter has been potentially attributed to the protective nature of their extensive real-world experience.

3.2 SUMMARY OF CHAPTER 3

The work reviewed above demonstrates that developing measures with greater 'ecological validity' is a potentially useful and valid means of assessing the real-life dysexecutive difficulties shown by people with acquired brain injury. However, there are many questions remaining unanswered. Firstly, most studies focus either on patients with extensive bilateral lesions, or on patients with mixed or unknown neurological damage. There is therefore a need for more studies of participants with unilateral lesions. Secondly, the number of studies and range of methodology remains small, particularly with regard to everyday interpersonal problem-solving. Thirdly, few studies have included a battery of standardised executive measures and investigated the relationships between performance on these and on the ecologically valid measures.

Given the range of potential processes involved in novel problem solving discussed in both the social psychology (D'Zurilla & Goldfried, 1971) and neuropsychological (e.g. Shallice & Burgess, 1996) literature, it is clearly important to assess multiple dimensions of everyday problem-solving in order to.
gain a greater understanding of the processes which patients with focal lesions find difficult.

In addition, the role of experience as discussed above leads to different predictions about the impact of frontal lobe dysfunction depending on the age at which it was acquired. Thus, assessing both a group of participants with developmentally acquired brain dysfunction, and healthy older people could help to elucidate the importance of experience, and enhance knowledge of real-life problem-solving and its relationship to executive function. The specific patterns that would be expected in these groups are discussed in more detail below.
CHAPTER 4
DEVELOPMENTAL FRONTAL LOBE DYSFUNCTION

4.1 DEVELOPMENTALLY ACQUIRED STRUCTURAL LESIONS

The prefrontal areas are thought to mature later in life than other cortical areas, with development continuing into and beyond adolescence (Stuss, 1992). Structural damage to frontal areas prior to adulthood has been associated with many of the behavioural and emotional features noted to occur following adult-acquired damage, such as inappropriate social behaviour (Anderson, Damasio, Tranel & Damasio, 2000), inability to learn from emotion-related experience (Price, Daffner, Stowe & Mesulam, 1990), and impairment on hypothetical social/moral dilemmas (Eslinger, Grattan, Damasio & Damasio, 1992). As with adult-acquired lesions, these are often seen in the context of impaired executive processes such as decision-making (Anderson et al, 2000) and planning (Eslinger et al, 1992), and other standardised measures of executive function (Price et al, 1990). It has been suggested that the behaviours seen are similar in nature, but quantitatively greater than those seen in people with adult-acquired lesions (Price et al, 1990). This is potentially consistent with the theory described above, which argues that early disruption may have a greater impact on real-life problem-solving due to the lack of protective experience. Thus, it would be predicted that adults with developmentally acquired structural lesions would show similar types of impairment, but to a quantitatively greater extent, to those with adult-acquired lesions on real-life-type tasks. However, all of the studies listed above are single cases, reflecting the relative rarity of such injuries in young people. The age of injury is also likely to be an important factor leading to differences in the amount and type of disruption seen. This is due to a number of factors including the relative plasticity of the brain in terms of ability to compensate for frontal injury (Kolb, Gibb & Gorny, 2000), and because executive skills are thought to emerge at different times in development, and there is likely to be considerable individual variation in this (Stuss, 1992). Thus, it would be extremely difficult to obtain a relatively homogeneous group of adults who had acquired frontal lobe injuries in
childhood/adolescence. An alternative way to address the role of developmental lesions would be to test a group with biochemical disruption to the frontal lobes.

It has been argued that studying the functions of the prefrontal cortex is made more difficult because there is no clinical condition that targets this area exclusively in the absence of damage to other areas (Stuss et al, 1995). However, there is a range of developmental disorders that are thought to involve biochemical and/or structural disruption to frontal areas, or areas with close reciprocal connections with the frontal lobes. These include Tourette’s syndrome, autism and attention-deficit hyperactivity disorder, all of which have been reported to be linked to some extent with impairment on standardised executive tests (see e.g. Pennington & Ozonoff, 1996).

Any of these groups could potentially be considered suitable for investigating the developmental consequences of frontal lobe dysfunction. However, the current studies will focus on those with Tourette’s syndrome (TS). TS is linked with disruption to the motor system, as manifested by both motor and vocal tics. These are thought to be due to dysfunction in fronto-striatal loops. Of note is that the profile of symptoms and behaviour in people with TS has been conceptualised as a disorder of inhibition, and people with TS often show social inappropriate behaviour. Thus, their real-life behaviour bears similarities with that seen in people with acquired, structural frontal lesions. These issues will be considered in further detail below.

4.2 TOURETTE’S SYNDROME

4.2.1 Brain basis of Tourette’s Syndrome

Tourette’s Syndrome (TS) is a developmental disorder that is characterised by the presence of a range of both motor and vocal tics. Estimates of prevalence vary, but a figure of approximately 5 per 10,000 has been generally accepted, with more males than females being affected (see e.g. Robertson 1994 for a discussion). However, some authors have suggested that TS is underdiagnosed, and Kadesjö
and Gillbert (2000) report that the prevalence figure is more likely to be somewhere between 0.15 and 1.1%.

The aetiology of TS remains unclear, although it is widely thought to be genetically determined, and to affect neurotransmitter action (see e.g. Leckman, Peterson, Anderson, Arsten, Pauls & Cohen, 1997; Robertson 1989; Robertson 1994 for reviews). Neurotransmitters that have been implicated in TS include dopaminergic, serotonergic and noradrenergic systems (Sheppard, Bradshaw, Purcell & Pantelis, 1999; Robertson, 2000). However, the evidence for disruption to dopaminergic systems is thought to be the strongest, and dopamine antagonists have been shown to be effective in treating the symptoms of TS (Leckman et al, 1997; Robertson, 2000).

The disruption to dopaminergic systems in TS has traditionally been linked particularly with dysfunction in the basal ganglia (e.g. Robertson 1994). Imaging studies have also indicated that there may be abnormalities of the basal ganglia in TS (e.g. Hyde, Stacey, Coppola, Handel, Rickler & Weinberger, 1995; Malison, McDougle, Vandyck, Sahill, Baldwin, Seibyl, et al, 1995; Moriarty, Vama, Stevens, Fish, Trimble & Robertson, 1997). Gedye (1991) argued that while basal ganglia dysfunction may be implicated in many people with TS, it is not common to all cases. He proposed that the available evidence from imaging, neurotransmitter, and other neurological studies, is consistent with the frontal lobes being the critical area affected in TS, and he likened tics to frontal lobe seizures. Many authors hold the view that both frontal and basal ganglia areas are important in TS, with the disruption being to fronto-subcortical circuits that involve the striatum, globus pallidus, thalamus and frontal lobes (Alexander, Crutcher & DeLong, 1990; Leckman et al, 1997).

Which exact regions of the frontal lobes are affected in TS is still a topic of debate. Robbins (2000) argued that abnormalities in dopaminergic systems are associated with deficits in tasks linked with lateral frontal areas, such as working memory and planning tasks, while abnormalities in serotonergic systems are associated with deficits in tasks linked with orbitofrontal areas, such as reward learning. Thus, if
dopaminergic systems are differentially affected in TS, participants with TS might be expected to show deficits on executive tasks linked with lateral cortical areas, but to show intact performance on tasks involving interpersonal factors.

Although a small number of studies have suggested that orbitofrontal areas are important in TS (e.g. Weeks, Turjanski & Brooks, 1996; Braun, Randolph, Stoetter, Mohr, Cox, Vladar et al, 1995), the majority of the evidence is consistent with disruption to lateral or anterior cingulate areas. Thus, some imaging studies have reported direct involvement of frontal regions including dorsolateral areas in TS (Eidelberg, Moeller, Antonini, Kazumata, Dhawan, Budman et al, 1997; Peterson, Staib, Scahill, Zhang, Anderson, Leckman et al, 2001), and others have implicated the anterior cingulate cortex (Chase, Geoffrey, Gillespie & Burrows, 1986). A study examining which areas of the brain were activated during tics, found that both dorsolateral and anterior cingulate regions were relevant, in addition to other areas such as the basal ganglia (Stern, Silbersweig, Chee, Holmes, Robertson, Trimble, et al, 2000). The anterior cingulate is thought to be involved in inhibitory processes, as shown by functional imaging of healthy participants when inhibiting a prepotent response (e.g. Carter, Braver, Barch, Botvinick, Noll & Cohen, 1998). Overall, the evidence regarding the brain basis of TS provides strong support that areas of the frontal lobe might be affected. If the hypothesis that lateral areas are differentially affected is correct, it might be expected that participants with TS would show deficits on standardised measures of executive function.

4.2.2 Comorbidity in TS

Many of the studies reviewed above either did not consider the role of possible comorbid conditions, or deliberately included participants who showed symptoms of Attention Deficit Hyperactivity Disorder (ADHD) and/or Obsessive-Compulsive Disorder (OCD). Both ADHD and OCD are commonly seen in association with TS. The issue of these comorbid conditions is important since structural imaging studies have linked pure ADHD with dorsolateral and anterior cingulate areas (e.g. Swanson, Castellanos, Murias, LaHoste & Kennedy, 1998), and pure OCD has been linked with orbitofrontal and anterior cingulate activity in functional imaging studies (e.g. Rauch, 2000; Saxena, Brody, Schwartz & Baxter, 1998).
The percentage of patients with TS who also meet criteria for ADHD is estimated at between 21-90% (Robertson 1994), and the percentage of patients with both TS and OCD is estimated at around 30-50% (Pauls, Raymond & Robertson, 1991). A proportion of patients are likely to meet diagnostic criteria for all three disorders. The exact relationships between these different disorders in terms of genetics, brain dysfunction, and symptomatology are not yet fully understood. Some authors argue that the nature of OCD and ADHD when combined with TS may be different from these disorders alone (e.g. Robertson, 2000). For example, the symptoms seen in patients with both TS and OCD have been described as qualitatively distinct in some ways from those seen in patients with OCD alone (George, Trimble, Ring, Sallee & Robertson, 1993; Petter, Richter & Sandor, 1998). This has led to speculation that the underlying brain mechanisms in OCD may differ depending on whether or not TS is also present. Studies examining the brain basis of ADHD and OCD have concluded that frontal lobe and basal ganglia areas are also affected in these conditions, and therefore, all three disorders potentially lead independently to disruption to fronto-striatal circuits, although possibly affecting different regions of the frontal lobes, as suggested above (e.g. Leckman, Knorr, Rasmussen & Cohen, 1991; Saxena et al 1998; Swanson et al 1998; Sheppard, et al, 1999).

4.2.3 Executive function in TS
Given that TS is associated with disruption to fronto-striatal loops, particularly those linked with lateral frontal cortex, it might be expected that people with TS would also show impairment on tests of executive function. As noted above, both ADHD and OCD are also linked with disruption to fronto-striatal loops. Since the executive processes are likely to be fractionated into a range of sub-processes, with potentially different underlying brain bases, it is possible that these disorders are associated with different patterns of impairment, due to the different loops being affected. It is therefore important to consider studies that have looked at the effects of comorbid conditions. However, due to the relatively small number of studies, those that have not considered these issues will be reviewed first.
4.2.3.1 Findings from mixed studies

In studies of adults with TS, Bornstein (1991) found impairment on some measures thought to require executive processes, such as verbal fluency and the Category test. Channon, Flynn and Robertson (1992) found impairments on the PASAT, the Trail Making test, and a letter cancellation task, but not on the Stroop test. Another study reported impairments in children with TS on verbal fluency, but not design fluency or the Wisconsin Card Sorting Test (WCST) (Sutherland, Kolb, Schoel, Whishaw & Davies, 1982). Baron-Cohen, Cross, Crowson and Robertson (1994) tested children on two tasks thought to involve inhibitory processes, namely the Luria hand alternation procedure, and a Yes-No game. They found impairment relative to age-matched controls in their TS participants. They argued that TS might reflect a failure in a particular subprocess of executive functions, which they termed the 'Intention Editor', which they postulate is invoked when a person has to choose between two or more competing intentions. Similarly, a study using adult participants found that they showed deficits on computerised tasks involving set-shifting (Georgiou, Bradshaw, Phillips, Bradshaw & Chui, 1995). They interpreted their findings as consistent with the TS participants failing to inhibit inappropriate responses. The evidence from these studies therefore indicates that participants with TS appear to show deficits on some tasks involving inhibitory processes. Some authors conceptualise the difficulties seen in TS as a selective disorder of inhibition (e.g. Leckman et al, 1991), and others have argued that TS, ADHD and OCD are all disorders of inhibition (Sheppard et al 1999). Few studies have examined performance on measures of planning and intentionality, deductive reasoning and executive memory.

4.2.3.2 Findings from studies that consider comorbidity issues

More recent studies have attempted not just to elucidate the executive profile of TS, but also to determine whether any impairments seen are due to comorbid conditions. One study examined memory functioning in adult participants without comorbid ADHD. They found that the TS participants were impaired on memory measures associated with frontal lobe functioning, including strategic free recall and working memory tasks, but not on measures associated with other cortical areas, such as recognition and semantic memory (Stebbins, Singh, Weiner, Wilson,
Goetz & Gabrieli, 1995). A study with children reported that pure TS was associated with deficits on letter fluency, although participants with ADHD in addition to TS showed a wider range of executive deficits, performing more poorly than those with pure TS on the Test of Variables of Attention, and Rey Copy organisation. (Schuerholtz, Baumgardner, Singer, Reiss & Denckla, 1996). A study using a computerised test of sustained attention and inhibition, the Continuous Performance Test (CPT), reported that children with pure TS had fewer deficits than groups with TS plus ADHD, or ADHD alone, although increased tic severity was associated with greater inhibitory difficulties (Sherman, Shepard, Joschko & Freeman, 1998). Another study compared adults with TS with those with pure ADHD (Silverstein, Como, Palumbo, West & Osborn, 1995), and found few between-group differences on inhibitory measures including the Trail Making and Stroop tasks. They also compared the performance of subgroups within the TS group, and found that there was a tendency for those with comorbid ADHD or OCD to perform more poorly than those with pure TS; this pattern was more marked for comorbid ADHD than OCD. They concluded that while some adults with TS have attentional impairments, this is not true for all cases, and the risk is greater for those with comorbid conditions. However, they used self-report data rather than diagnostic criteria to determine the presence of ADHD and OCD, and claimed that their results should be treated as preliminary in light of the small sample sizes.

Some studies have suggested that pure TS is not associated with executive deficits. For example, Yeates and Bornstein (1994) found that executive impairments were more marked in children with TS plus ADHD than those with pure TS, and argued that neuropsychological impairments in TS are more likely to be attributable to comorbid conditions than to TS. Ozonoff and colleagues (e.g. Pennington & Ozonoff 1996, Ozonoff 1997) have reviewed the available evidence on executive functioning in TS and reached a similar conclusion, namely that the executive impairments in TS might be attributable to comorbid conditions. Ozonoff and Jenson (1999) provided support for this view in a study that found impairment on the Stroop but not the WCST in children with ADHD, with no executive impairments found in those with pure TS. However, Pennington and Ozonoff also
noted that there are very few methodologically sound studies of pure TS at present. There are also a mixture of child and adult studies in the literature, which may confuse the picture further. For example, Kerbeshian and Burd (1992) report a much greater prevalence of TS in children and adolescents than in adults. One possible reason for this finding could be that the symptoms of TS improve with age, which could potentially also apply to cognitive deficits. Conversely, the frontal lobes are known to mature relatively late in development, meaning that one might expect executive deficits to be more marked in adults and adolescents than in children.

The evidence regarding executive function in TS demonstrates that more work is needed in order to clarify the impairments shown by those with pure TS. In particular, broader ranges of executive tests need to be administered, reflecting current knowledge on fractionated processes. While the presence of comorbid conditions is likely to be associated with a greater range of deficits, the evidence overall indicates that it is likely that some executive impairment is seen in pure TS, albeit relatively mild in comparison with that seen in patients with structural frontal lobe lesions.

4.2.4 Real-life problem-solving and TS

Very little work has been done on real-life problem-solving in TS. One study compared adults with TS with people with autism and healthy controls on two tasks thought to measure theory of mind ability (Baron-Cohen, Jolliffe, Mortimore & Robertson, 1997). In contrast to the autistic participants, the group with TS did not differ from the control group. However, theory of mind is only one aspect of interpersonal reasoning and problem-solving. Some evidence that people with TS may show difficulties in social interactions comes from work with children using self-report measures. For example, children with TS have been found to be at higher risk for having poor peer relations that a clinical control group (children with diabetes mellitus) (Bawdon, Stokes, Camfield, Camfield & Salisbury, 1998). Another study reported that children with TS and ADHD showed problems with social adaptation (Carter, O'Donnell, Schultz, Scahill, Leckman & Pauls, 2000). Kadesjö & Gillbert (2000) stated that the majority of their sample of children with
TS showed evidence of social interaction problems or empathy problems, such as having no friends, or not being able to adjust to the expectations or demands made of them by their peers. Another study (Kurlan, Daraggjati, Como, McDermott, Trinidad, Roddy, et al, 1996) reported that adults with TS report performing a range of socially inappropriate behaviours such as insulting other people as a habit, or yelling 'fire' in a public place. A single case study with TS, ADHD and OCD was reported to show socially inappropriate, impulsive and aggressive behaviours (Demirkol, Erdem, Inan, Yigit & Güney, 1999). Thus, while there is only a small number of relevant studies, there is evidence that people with TS may show difficulties in real-life social situations. These bear comparison with those shown by people with focal frontal lobe lesions, particularly in terms of difficulties with impulsive behaviour characterised by a lack of appropriate inhibition. The contribution of comorbid conditions has not been widely explored, and a study focusing solely on participants with TS alone would therefore help to clarify these issues.

4.3 SUMMARY OF CHAPTER 4
Overall, although people with TS can show marked socially inappropriate behaviours in their daily lives, there is little work investigating their interpersonal deficits in a formal setting. The findings with regard to their executive functions are also mixed, with comorbidity and limited choice of tests contributing to the confused picture. However, the evidence suggests that TS is likely to be associated with inhibitory deficits, since both their performance on standardised tests and clinical observations are consistent with this. These findings indicate that adults with pure TS might show fewer executive deficits than adults with acquired structural frontal lesions. This might be expected on the grounds that work with primates has indicated that brain dysfunction caused by biochemical disruption may have less severe effects on behaviour than a structural lesion to the same area (e.g. Robbins, 2000). However, a study using participants with pure TS and an extensive battery of potentially fractionated executive measures would be needed to clarify this.
In addition, with the exception of the finding that TS is associated with intact theory of mind, there has been little attempt to assess social cognition and real-life-type problem solving in this group. As noted above, TS participants might be expected to have less real-world knowledge than participants with adult-acquired lesions, albeit that this would be expected to be a relatively mild difference. Effects of TS on the development of knowledge might therefore lead to deficits on real-life-type measures that are beyond what would be predicted on the basis of their executive profile.

These findings demonstrate that assessing participants with TS on measures of real-life problem-solving and executive function might help to clarify the relative contributions of executive processes and experience to real-life problem-solving. The next section describes another group of participants with postulated frontal lobe dysfunction, who would be expected to demonstrate different patterns of performance to those with TS, due to different predictions about the executive skills and experience.
5.1 SOCIAL BEHAVIOUR IN HEALTHY OLDER PEOPLE

In contrast to the clinical observations of socially inappropriate behaviour in people with Tourette’s Syndrome, there are no behavioural or interpersonal disturbances generally reported to occur with normal ageing. There are more studies into real-life-type problem solving in older adults, partly because the demographics of Western societies are shifting towards a greater proportion of older people. It is therefore important to understand the nature of any impairments caused by the normal ageing process. Research into the performance of older adults on real-life-type tasks and standardised executive measures will be reviewed below. Firstly, the evidence regarding differential changes to the frontal lobes with age will be discussed.

5.2 BRAIN BASIS OF NORMAL AGEING

Studies of the changes to the brain incurred by the normal ageing process have deployed a variety of methods, including morphometric post-mortem analysis and structural and functional imaging techniques. Most studies in this area are cross-sectional rather than longitudinal. Thus, the brains of older people are compared with those of younger people, with the inference that differences between them are caused by normal ageing processes. However, this methodology introduces the possibility of cohort effects, in that any differences observed may be potentially due to other differences between the groups, rather than to the ageing process. In spite of this, the paucity of longitudinal studies, in which changes are monitored over time in the same individuals, means that the cross-sectional data provide the greatest source of information about age-related change, albeit with some caution needed in interpreting the findings.

Post-mortem studies have found that the overall volume of the brain begins to decrease after approximately age 60, although there is considerable individual
variation (Haug & Eggers, 1991). The same study found that decreases in volume are more marked in the frontal lobes compared with other cortical areas, with a 10% loss in frontal volume by age 80, compared with non-significant changes in temporal and parietal cortices. In non-cortical areas, they found significantly decreased volumes in the basal ganglia and white matter. However, other studies have reported slightly different findings, with changes reported in the temporal lobe, in addition to the frontal cortex (Terry, DeTeresa & Hansen, 1987). This study also concluded that age-related volume loss was not caused by an overall change in the number of neurons, but rather that the neurons tend to shrink with age.

The findings from post-mortem studies have been criticised due to the potential confounding contributions of premorbid illness, cause of death, and possible selection bias (e.g. Coffey, Wilkinson, Parashos, Soady, Sullivan, Patterson, et al, 1992). Structural imaging work has also found reduced overall brain volume with age. Some studies have reported generalised rather than focal reductions (e.g. Jernigan, Archibald, Berhow, Sowell, Foster & Hesselink, 1991), although the majority of structural MRI studies have reported greater age-related change in the frontal lobes than in other cortical areas, in both grey and white matter (Jernigan, Archibald, Fennema-Notestine, Gamst, Stout, Bonner et al, 2001; Raz, Gunning-Dixon, Head, Dupuis & Acker, 1998; Raz, Gunning, Head, Dupuis, McQuain, Briggs et al, 1997; Coffey et al, 1992). Reductions in grey matter volume are reported to occur earlier those in white matter volume (e.g. Bartzokis, Beckson, Lu, Nuechterlein, Edwards & Mintz, 2001; Jernigan et al, 2001), with differences in prefrontal white matter volume continuing to be noticeable between adults in their seventies, compared with those in their nineties (Salat, Kaye & Janowsky, 1999). The effects of age have been reported to be even for both sexes, and for the two cerebral hemispheres (Coffey et al, 1992).

The exact nature of age-related change is still a subject of debate. Some studies have reported that the number of synapses in frontal cortical areas decreases (e.g. Masliah, Mallory, Hansen, Deteresa, and Terry, 1993), although other studies have disputed this (Scheff, Price & Sparks, 2001). PET findings have found reductions
in the activity of dopamine systems with normal ageing (Inoue, Suhara, Sudo, Okubo, Yasuno, Kishimoto, et al., 2001; Bäckman, Ginovart, Dixon, Wahlin, Wahlin, Halldin et al., 2000; Volkow, Ruben, Want, Fowler, Moberg, Ding et al., 1998). This reduction has been correlated with performance on cognitive tasks, including tests of motor and executive function, linked with frontal lobe functioning (Volkow et al., 1998). Similarly, there is evidence that the serotonergic system may also be affected by the ageing process (e.g. Arranz, Eriksson, Mellerup, Plenge & Marcusson, 1993; Meltzer, Smith, DeKosky, Pollock, Mathis, Moore et al., 1998). Another study suggested that the important change with age is a reduction in the connections between cortical areas, which is most marked in the white matter of the frontal lobes (O'Sullivan, Jones, Summers, Morris, Williams & Markus, 2001). They suggest that this is the cause of age-related change on executive tests. Obviously, these findings are not mutually exclusive, and the ageing process may have a range of effects on brain functioning. Nevertheless, the evidence strongly indicates that these effects are marked in the frontal lobes.

5.3 EXECUTIVE FUNCTIONS AND NORMAL AGEING

The finding of differential frontal lobe involvement in the normal ageing process has led to predictions that older adults may show a pattern of performance similar to that seen in patients with focal frontal lobe lesions, with habitual actions being relatively preserved, but problem-solving in novel situations involving executive skills being affected.

In terms of intellectual functioning, scales such as the Wechsler Adult Intelligence scales are adjusted for age (Wechsler, 1981, 1997). This suggests that the average scores of older people are lower than those for younger people, which could be interpreted as evidence that there is a general decline in cognitive function with age. However, adjustments for increasing age are more marked on performance tasks, which generally have processing speed as an important component, than they are for verbal tasks such as Vocabulary and Information. Other work has shown that scores on crystallised intelligence measures remain relatively stable with age, while fluid intelligence scores decrease (Rabbitt, Donlan, Watson, McInnes & Bent,
1995); this is consistent with the frontal lobes being differentially affected by the ageing process.

Impairment on standardised measures of executive function has been reported with normal ageing in a wide range of studies. For instance, studies have shown age-related decrements on tests of set-shifting, such as the Trail Making Test (e.g. Wahlin, Bäckman, Wahlin and Winblad, 1996), Wisconsin Card Sorting Test (Axelrod & Henry, 1992; Daigneault, Braun & Whitaker, 1992) and the set-shifting subtest from the CANTAB battery (Robbins, James, Owen, Sahakian, Lawrence, McInnes et al 1998). Poorer performance relative to younger people has also been reported on tests of working memory (e.g. Wingfield, Stine, Lahar & Aberdeen, 1988), tasks involving inhibition of a prepotent responses, such as the Stroop (Daigneault et al, 1992) and Hayling tests (Andrés & Van der Linden, 2000), and tests of planning ability such as the Tower of London (Andrés & Van der Linden, 2000). Poorer performance with increasing age has also been found on tasks of initiation, such as Letter Fluency (Whelihan & Lesher, 1985), Category Fluency (Tomer & Levin, 1993) and Design Fluency (Mittenberg, Seidenberg, O'Leary & DiGiulio, 1989), although the findings with regard to fluency tests are less consistent (Bryan & Luszcz, 2000). There are few measures of 'Intentionality' in the ageing literature, although one study examined performance on a task based on the Six Elements test, which was designed to investigate participants' use of strategies (Levine, Stuss, Milberg, Alexander, Schwartz & Macdonald, 1998). They found that older adults performed less well than younger people, and that the qualitative nature of their performance was similar, albeit less marked, to that of participants with focal frontal lesions. The findings of age-related deficits on tests associated with frontal lobe functioning have been reported to be more marked than any age-related impairment on tests of other cognitive functions (e.g. Mittenberg et al, 1989). In addition, it has been proposed that normal age-related deficits on other types of tasks, such as measures of memory, may also be attributable to executive impairments (Parkin, 1997).

Some studies have questioned whether age-related impairments are consistent across all executive measures, or whether they are more marked on some tasks than
others. For example, a study looking at the relative performance of adults in their fifties, sixties and seventies found age-related decrements on some variables, such as the Stroop and number of categories completed on the WCST, but not on other measures, such as number of perseverative responses on the WCST (Boone, Miller, Lesser, Hill & E'Elia, 1990). However, other studies have found fairly consistent age-related change on executive measures compared with non-executive measures, and have concluded that there is general decline in 'frontal' abilities with ageing (Whelihan & Lesher, 1985). Factors such as educational level, intellectual level, sample size, and the cut-offs for the age-bands used may account for different findings.

Overall, the evidence indicates that older adults perform more poorly than younger adults on many standardised measures of executive function. Recent work has attempted to elucidate the skills underlying performance on executive tests, and has questioned whether impairment on such tasks necessarily indicates deficits in executive skills. As discussed previously, executive measures are not pure, and performance is dependent on a range of non-executive, as well as executive, processes. An investigation into the component processes in modified versions of the Stroop and Trail Making tests concluded that, when these are factored out of performance, there remains an age-related executive impairment on the Stroop, but not the Trail Making test (Wecker, Kramer, Wisniewski, Delis & Kaplan, 2000). As psychomotor speed was one of the component skills that they factored out, they argued that analysis of older adults' performance on executive tests should concentrate on errors rather than speed. However, this ignores any effects of a speed-accuracy trade-off, in that people may deliberately perform slowly in order to minimise their errors. Similarly, discussions on the factors involved in letter fluency tasks have concluded that age-related deficits may be due to factors such as handwriting speed rather than executive processes (Phillips, 1997, 1999). However, when the demands of the task were manipulated, Phillips (1999) found that older adults generated fewer and less broad strategies than younger people, consistent with the theory that ageing is associated with some decrements in executive processes. It has also been suggested that experience can have a protective effect on performance of letter fluency tasks. This is because greater practice with activities such as
crossword puzzles may have reduced the novelty of the task, and, following the models of frontal lobe functioning described earlier, this may make performance less dependent on executive processes (Phillips, 1997; Bryan & Luszcz, 2000).

5.4 REAL-LIFE PROBLEM-SOLVING AND NORMAL AGEING

In contrast to the findings reported above, it has been reported that, when questioned, older people believe that their abilities to solve problems improved with age (Williams, Denney and Schadler, 1983). The discrepancy between this and older adults’ poorer performance on standard lab measures is thought to be because the older people are referring to their ability to solve everyday and financial problems. In other words, older people believe that their abilities to solve real-life problems have improved with age. There are many studies examining the performance of older people on real-life-type tasks. These have generally employed different methodology to the studies reported earlier using participants with focal frontal lesions.

In view of older people’s poorer performance on tasks of executive function compared with younger people, one might argue that there should be comparable deficits in performance on real-life-type tasks reliant on executive skills, with the older people showing a pattern of performance similar to that seen in patients with focal frontal lobe lesions. This might also be predicted since patients with frontal lobe lesions can show intact performance on executive tests whilst demonstrating impairments on more ecologically valid tasks, implying that such tasks are more sensitive to the effects of frontal lobe disruption. However, as was described earlier, one of the differences between real-life and laboratory problem solving is the need to use real-world experience. As older people have greater life experience than younger people, it might be expected that this will mitigate against the effects of poorer executive abilities. However, it is possible that even though older people have more experience, the effects of neural loss may limit their ability to make adequate use of prior knowledge in order to guide problem-solving. For example, if the relevant knowledge and experience is rarely accessed and rehearsed in daily life, strategic processes may be important in searching for and accessing it, and
impairments in strategic processes are linked with frontal lobe dysfunction. Thus, while older adults would be expected to have more experience of real-life problem situations than younger adults, whether direct or vicarious, this would not necessarily lead to predictions of improved performance. The evidence on studies of interpersonal and non-interpersonal real-life-type problem-solving is discussed below.

5.4.1 Interpersonal and emotional measures
One study assessed participants' abilities to solve moral dilemmas, and to describe some moral dilemmas and relationship issues from their own personal lives (Pratt, Diessner, Hunsberger, Pancer & Savoy, 1991). They found no differences between an older and a middle-aged group on these measures, although they did report that people with higher education levels within each group tended to gain higher scores than those with less education. They repeated the measures after a four-year interval in order to address any longitudinal effects of age (Pratt, Diessner, Pratt, Hunsberger & Pancer, 1996). Within the older group, there was a decline over time in their perspective-taking scores on the moral dilemmas, and they also gained lower complexity scores for their personal dilemmas. However, these declines were also related to educational level, perceived socioeconomic support, and self-ratings of general health, in addition to age.

Some of the studies investigating real-life problem-solving in older adults have attempted to address the issue of whether the strategies people use change with age. Watson and Blanchard-Fields (1998) compared three groups of participants in different age bands. They were given four vignettes, and asked to rank order over seventy strategies for each one, by categorising them on an eleven-point scale from most to least effective. They found that while there were few overall differences between the groups, the older group tended to prefer a broader range of strategies than younger people. However, these effects were relatively subtle, and the methodology of the task, involving so many strategies and options, may have made it difficult for participants to rank order the solutions. In addition, they did not provide any objective data on the actual effectiveness of the strategies, and whether any of the groups chose ineffective solutions.
Another study investigated social problem-solving using a standardised questionnaire (Social Problem-Solving Inventory-Revised, D'Zurilla, Maydeu-Olivares & Kant, 1998). They found that middle-aged people gained higher scores related to rational problem-solving than both a younger and an older group, and interpreted these findings as consistent with theories that there is a peak in everyday problem-solving in middle age (e.g. Denney & Pearce, 1989). However, they argued that the most likely explanation for the pattern of findings is in terms of experience, in that the middle-aged group would be expected to have more overall experience than the younger group, and more day-to-day experience (i.e. current experience) than the older group. The study did not investigate any potential effects of education or general intellectual level, which are potentially important as discussed above.

One study addressed the issue of whether older and younger people differed in the relative weight they gave to interpersonal concerns (Strough, Berg & Sansone, 1996). They addressed this by asking participants to talk about a problem from their own lives, and outline what their goals had been, and concluded that the importance of interpersonal concerns remains relatively constant throughout the life span.

### 5.4.2 Non-interpersonal measures

Some measures of real-life problem-solving have assessed older people's abilities to carry out everyday tasks. One study looked at food preparation, medication intake and telephone use, and compared performance on actually carrying out the tasks with a pen-and-paper version (Diehl, Willis Schaie, 1995). The measures were designed to all have an element of inferential reasoning, and they found that increasing age was related to poorer performance. Performance was also related to fluid intelligence ability, which is perhaps not surprising given that the everyday measure was designed to assess reasoning. Indeed, performance was more strongly related to fluid intelligence ability than to age. There were good correlations between the real-life measure and the pen-and-paper measure, indicating that pen-and-paper methodology can potentially provide accurate information about real-life abilities. One issue that was not addressed was whether there were individual
differences in terms of familiarity of the tasks. For example, the food preparation tasks involved using a microwave oven and the study does not specify whether all participants were familiar with this method of cooking.

The study reported above indicates that the nature of the task may be important. This was addressed in another study that also looked at everyday domains, including medication use, financial planning, and food preparation/nutrition (Allaire and Marsiske, 1999). Within each domain there were various task demands that were designed to separately address reasoning, knowledge, working memory capacity, and declarative memory. They also included standardised measures purported to measure each of these. They found that all abilities were associated with poorer performance with increasing age, with the exception of those that were knowledge-based, which they interpreted as consistent with observations that crystallised intelligence is relatively preserved in older people. They also reported that the everyday and standardised measures in each domain were related to each other, although performance on the standardised measures also tended to relate to other domains in the real-life tasks, thus there was less specificity than they had predicted. This study highlights the fact that different results may be achieved depending on the types of measures used. Overall, they suggested that basic abilities may remain constant during adulthood, but that levels of competence beyond this, e.g. achieving optimal performance, may decline with age. They did not include a younger group for comparison across the age span.

Salthouse (1990a; 1990b) reviewed studies about age-related performance on practical everyday tasks. He argued that there is evidence that younger people perform better than older people on such tasks as remembering and dialling telephone numbers, and understanding labels on household items, and that declines in these abilities tends to be seen in the fifties and sixties. He also reported that, with regard to learning new skills, older people seem to need more practice than younger people. However, he speculated that perhaps it is the way people perform tasks that changes rather than overall competence. In support of this, he cited studies looking at activities such as bridge and chess, which show that older people retain the global abilities, in the context of poorer constituent skills. Thus,
experience may change the procedures by which older people solve everyday problems, and attempting to examine performance by breaking such tasks down into their constituent parts may be giving a biased and unduly pessimistic picture.

Other work has considered occupational skills. Denney (1989) argued that most of the evidence regarding laboratory problem solving measures indicates that performance begins to decline after early adulthood. However, the general expectation is that middle-aged to older adults will perform better at occupational tasks than younger people. For example, people expect senior positions in fields such as finance, law and surgery to be held by people in the middle-aged to older age ranges, consistent with the greater experience these people have being more important than subtle decrements on laboratory measures. Colonia-Willner (1998) examined the relative importance of experience and fluid intelligence on occupational performance in a sample of bank managers. Experience was assessed both in terms of number of years in the post, and by use of a standardised measure looking at ability to rank solutions in hypothetical management scenarios. She found that those people who were judged by the institution to have shown the best performance in their job, tended to be those with the greatest number of years of experience at the bank, although there was no difference in age between this group and the 'nonexperts'. Within the nonexperts, those who were above the median age and who had high scores on the standardised measure of managerial performance, nevertheless gained lower fluid intelligence scores. She argued that this group showed a normal age-related decrement on fluid intelligence, in the context of intact occupational problem solving ability. Overall, she claimed that practical knowledge can compensate for declines in ability with age. The main problem with making inferences about older people's real-life abilities from this study is that the age range considered is obviously limited to those below retirement age.

5.4.3 Mixed interpersonal and non-interpersonal measures
Cornelius and Caspi (1987) developed a measure examining problem-solving in six domains, including interpersonal, such as resolving conflicts with friends, and non-interpersonal, such as managing a home. The situations were intended to be familiar to young, middle-aged or older adults. They initially generated a range of
solutions, and asked a small normal sample to judge these on the basis of effectiveness. They then assessed three groups of participants, who were presented with four responses to each solution and asked to state the likelihood that they would do each one. They found that older people performed better than younger people and that neither group differed from middle-aged participants. The groups were matched for education, but the older group gained higher scores on a test of verbal meanings. The groups were also asked how frequently they encountered each type of situation, as a measure of experience. Older adults reported having less frequent experience of the situations than younger and middle-aged participants. However, this does not address the issue of whether they had more experience of such problems in the past.

Another study adapted the same measure, and looked at performance in three domains including friends, the home, and consumer issues (Blanchard-Fields, Chen & Norris, 1997). They tested a large sample, aged 15-79, split into 5 age-bands, although there were differences between the groups in terms of WAIS vocabulary scores, years of education and self-rated health. The study attempted to address whether strategy use changes with age, and therefore each problem had four strategies: problem-focused, cognitive analysis, passive-dependent, avoidant-denial. There was a general pattern for the three oldest age-bands to endorse ‘better’ solutions (problem-focused and cognitive analysis) than the other groups, although the main differences were seen in comparisons with the adolescent group. There were slightly different patterns between the various types of scenarios, particularly between interpersonal and practical problems, indicating that all groups may approach everyday problems differently depending on the type of task.

Denney and Palmer (1981) devised a measure of ‘practical’ problem-solving, which combined interpersonal and non-interpersonal problems. Participants were asked what they would do if they encountered each problem. A four point scoring system was devised that combined elements of quality and quantity of solutions produced. They found that adults in the middle age bands (40-59) gained higher scores than those aged younger and older, indicating a quadratic relationship between everyday problem solving and age. However, they also argued that the
problems might be ones that middle-aged people encountered more frequently. In order to address this, a later study used items that were designed to have greater pertinence for older people (Denney & Pearce, 1989). The basic procedure was the same as above, with responses scored on a four point scale according to how many safe and effective solutions were offered. Their findings were consistent with other studies showing maximum performance in middle-aged participants. They interpreted these findings as showing that experience was important in everyday problem solving, as middle-aged people performed better than younger people, but that experience could not completely mitigate against the effects of ageing. However, the scoring system combined elements of both generation and quality, meaning that the nature of the older people's proposed deficit is unclear.

The question of whether the type of measure is important was addressed by Marsiske and Willis (1995). They tested a group of older people (aged 68-94) on three measures, all of which are described above (Denney & Pearce, 1989; Cornelius & Caspi, 1987; Diehl et al, 1995). Factor analysis showed no common problem-solving factors between the three tasks. Structural equation modelling found that increased age was only associated with poorer performance on one of the three measures, that reported by Diehl and colleagues, although it only accounted for 17% of the variance. They argued that this measure might have higher cognitive demands than the other two measures. Overall, they illustrated the lack of relationship between the measures, showing that everyday problem-solving is likely to be multidimensional.

5.4.4 Contributions to real-life problem-solving in older people
Phillips and Della Salla (1998) proposed that healthy older adults would show intact performance on reasoning tasks that are dependent on everyday knowledge or interpersonal skills, while showing deficits on abstract executive tasks. As described above, the nature of the task is likely to affect problem-solving performance in older people. How far this is related to their poorer executive abilities is unclear, as none of the studies discussed above included a comprehensive battery of executive tests. The findings overall are mixed, although the majority do not find any gross effects of age on real-life-type performance.
Many studies account for this in terms of the mitigating effects of experience, although not all agree (e.g. Cornelius and Caspi, 1987). Unlike executive skills, disruption to semantic knowledge stores is not associated with alterations in brain function attributable to normal ageing, as demonstrated by intact performance on measures of crystallised intelligence such as vocabulary tests.

Phillips and Della Sala (1998) noted that there is agreement that the ageing process affects the frontal lobes and that the frontal lobes are associated with executive functions. However, the poor social control and decision making seen in people with frontal lobe lesions is not associated with normal ageing. Therefore, some participants with focal frontal lobe lesions can show poor everyday life ability in the context of preserved executive skills, while reverse pattern tends to be seen in ageing. They argue that the most likely explanation is that some areas of the frontal lobes are affected by the ageing process more than others. Specifically, they suggest that the dorsolateral areas are affected by ageing more than the orbitofrontal areas, and that this can account for the findings. Some evidence for this distinction was provided by functional imaging studies, showing age-related differences in dorsolateral but not ventolateral areas on working memory tasks (Rypma and D’Esposito, 2000).

5.5 SUMMARY OF CHAPTER 5
Overall, the evidence on real-life-type problem-solving in older adults is mixed, with some studies reporting poorer performance with increased age, others reporting similar or superior performance (e.g. Cornelius & Caspi, 1987), and other studies finding mixed results depending on the measure used (e.g. Pratt et al., 1996). The multidimensional nature of everyday problem solving is therefore particularly important to consider in this group, and more work needs to be done examining these different dimensions within the same study. When no age-related deficits have been found, it has been proposed that experience may be mitigating the effects of executive deficits. However, very few studies have directly compared performance on standardised executive measures and real-life measures, nor investigated the relationships between these. On balance, the evidence would suggest that decision-making processes in real-life situations may be intact in older
adults due to their increased life experience regarding similar situations. Therefore, a study examining the performance of older adults on real-life problem-solving, and a battery of executive measures, could help to clarify the relative contributions of experience and executive function to real-life problem-solving.
CHAPTER 6
AIMS OF EXPERIMENTAL STUDIES

The literature reviewed above has demonstrated that more work needs to be done on developing measures of real-life-type problem-solving in order to assess the deficits shown in patients with frontal lobe involvement. Studies have highlighted that everyday problem-solving is a multidimensional concept, and that many factors potentially contribute to performance including executive skills, prioritising and planning abilities, comprehension and judgement of interpersonal issues, and prior experience of similar problems. The current thesis attempts to address these issues in a series of related experiments using new real-life-type measures as described below.

6.1 STUDY 1: REAL-LIFE PROBLEM-SOLVING

The first study is split into two parts. The first part describes the development of a test designed to assess multiple dimensions of interpersonal problem-solving. The problems were intended to be open-ended, with no absolute right or wrong answers, and were administered with little direct cueing or feedback, in order to have greater ecological validity than most abstract standardised measures. Ecological validity was also increased by presenting half of the scenarios on videotape. A battery of standardised executive measures was included in the study. The performance of participants with anterior structural lesions, those with posterior structural lesions, and a matched healthy control group, was compared. It was anticipated that the anterior group would show impairment relative to the other groups on a range of aspects of problem-solving, and that these would relate to the factors outlined above, including executive function, ability to prioritise and make decisions, comprehension and judgement of interpersonal issues, and previous experience.

Part B of study 1 describes an adapted version of the real-life problem-solving measure. This was designed to be more sensitive to the deficits shown by patients with
anterior lesions, and to be shorter and more user-friendly than the original measure. The performance of participants with anterior lesions was compared with that of the matched healthy control group.

6.2 STUDIES 2 AND 3: CONTRIBUTION OF PRIOR KNOWLEDGE AND EXPERIENCE TO PROBLEM-SOLVING

Studies 2 and 3 primarily address the contribution of experience to real-life-type problem-solving performance, using the measure developed in part B of study 1. Assessing the amount of previous experience that people have with particular situations is complex, and there are no existing reliable methods to achieve this. Rather than attempting to measure previous experience directly, the strategy followed in the current thesis was to assess groups of participants who are likely to differ in the extent/quality of their experience.

Two studies were carried out, both involving participants with postulated frontal lobe involvement. Study 2 compared the performance of adults with Tourette’s Syndrome (TS), with that of a matched control group. As TS develops early in life, it would be predicted that these participants would have reduced or less effective knowledge stores, both due to the primary effects of fronto-striatal dysfunction, and to the secondary effects of the disorder, as discussed above in section 3. The main aim of study 2 was to determine whether participants with TS showed impairments in real-life-type problem-solving, as would be predicted if experience plays a crucial role in this.

Study 3 examined the performance of a group of healthy older people, compared with a matched group of younger adults. Although ageing is associated with differential changes in frontal cortex, it has been argued that the extensive experience and wisdom acquired by older people throughout the life span can have a protective effect in everyday problem-solving situations, as discussed above in section 4. The aim of study
3 was to examine whether the older group showed intact real-life-type problem-solving performance, as predicted on the basis of their greater experience.

Studies 2 and 3 also allowed further elucidation of the contribution of executive processes to performance, since TS is associated with a narrower range of executive deficits than that seen in people with anterior lesions, to the extent that some authors have argued that people with uncomplicated TS have no executive deficits (Yeates & Bornstein 1994; Ozonoff, 1997). By contrast, impairment relative to younger people has been reported on a range of standardised executive measures in older people, as described in section 4.2. Therefore, the battery of executive measures used in study 1 was also administered in studies 2 and 3, and the relationships between performance on these measures, and aspects of the real-life problem-solving test were examined.

6.3 STUDY 4: CONTRIBUTION OF SPECIFIC INTERPERSONAL PROCESSES TO REAL-LIFE PROBLEM-SOLVING

Previous work, as described in section 2.5.4.2 above, has indicated that the frontal lobes are implicated in functions involved in understanding and relating to other people, such as pragmatic language processing, theory of mind and empathy. Study 4 describes an adaptation of the test used in the previous studies, in order to assess the contribution of specific interpersonal difficulties to problem-solving performance. New problems were developed focussed on practical difficulties that minimised the need to comprehend or consider interpersonal issues. These were compared with a subset of the original problems in which interpersonal issues were central to the problem. This study compared the performance of participants with focal anterior lesions with a group of control participants. The aim was to discover whether those with anterior lesions continued to show deficits on the practical problems when these did not involve interpersonal issues.
6.4 STUDY 5: CONTRIBUTION OF SPECIFIC DEFICITS IN PRIORITISATION AND PLANNING TO REAL-LIFE PROBLEM-SOLVING

Study 5 describes the development of new measures designed to address the selection of courses of action in more detail. The new measures focussed on prioritisation and planning skills, and participants’ ability to evaluate consequences. Real-life materials were used, and there was little direct feedback on performance, and no absolute right or wrong answers, in order to increase the ecological validity of the tests. The performance of participants with anterior lesions was compared with that of a matched control group. In addition, a sample of adults with Tourette’s Syndrome was also compared with a matched control group. The aim of the study was to determine whether anterior lesions and Tourette’s Syndrome are associated with deficits in prioritisation and planning on a range of types of different tasks.
PART II: EXPERIMENTAL STUDIES

CHAPTER 7
REAL-LIFE-TYPE PROBLEM SOLVING AND STRUCTURAL FOCAL LESIONS

This chapter is split into two parts. In part A, the development of a new multi-dimensional measure of social problem-solving is described. The performance of participants with focal lesions involving the frontal lobes (anterior group), focal lesions involving cortical areas other than the frontal lobes (posterior group), and a matched healthy control group is discussed. Part B describes a shorter version of the test, which was designed to be more user-friendly than the original measure, and to be more sensitive to the impairments seen following frontal lobe damage. In part B, the performance of participants with anterior lesions is compared with that of the control group.

7.1 PART A

7.1.1 INTRODUCTION

Damage to the prefrontal cortex has often been associated with subsequent difficulties in social/interpersonal situations (e.g. Prigatano 1991a, 1991b; Dimitrov et al, 1999; Bardenhagen et al, 1999), and with impaired performance on standardised measures of executive function, as described above in section 2.4. The executive functions are thought to include processes such as response inhibition, strategy-generation, planning and decision-making, and monitoring of behaviour. These processes would all be expected to be important in everyday problem-solving, and standardised measures of executive function are often administered in clinical settings with the intention of making inferences about everyday life difficulties from performance on the standardised tasks. However, it has been established that patients with ‘dysexecutive’ behaviours may perform normally on
standardised measures of executive function, as described above in section 2.2 (Eslinger & Damasio, 1985; Goldstein et al, 1993).

Dissociations between performance on abstract neuropsychological tests of executive functions and in everyday problem-solving could be attributable to differences in the nature of the tasks, as discussed in section 3.3.1 above. For example, most standardised neuropsychological measures are tests of 'formal' reasoning (Galotti, 1989; Kahney, 1993), in that they are well-defined, usually have only one correct answer, and it is clear when satisfactory performance has been achieved. By contrast, most problems in everyday life are ill-defined, requiring the use of extra information such as from prior experience of similar problems. They also tend to have a range of possible solutions, and people may have to judge for themselves when a satisfactory outcome has been attained. Successful solution involves appreciation not only of the actual facts of the problem situation, but of all the pertinent issues, taking into consideration the motivations and sensibilities of the people involved, the practicalities, and the potential consequences of possible courses of action. Everyday problem-solving may therefore rely more heavily than many abstract tasks upon acquired social and practical knowledge. Established knowledge is in itself thought to be relatively unaffected by acquired brain injury, unless semantic knowledge stores are directly disrupted. However, there may be impairment in ability to make adequate use of prior knowledge in order to guide problem-solving.

In interpersonal problem solving, a range of additional factors may also be relevant to performance such as the ability to appreciate other people's mental states ('theory of mind', Baron-Cohen et al, 1985), empathy, aspects of pragmatic language, and ability to interpret nonverbal cues such as facial expressions. These abilities would not be expected to contribute to performance on standardised executive measures. Deficits in these abilities have been reported in people with focal frontal lesions, as discussed above in section 3.1.3.3 (e.g. Stuss et al, 2001; Grattan et al, 1994; Hornak et al, 1996).
Observations of dissociations between laboratory and real-life performance have led to a move to create measures that have greater ecological validity, and are sensitive to real-life difficulties, but which can nevertheless be administered in a standardised fashion. Dimitrov et al (1996) presented stories describing everyday social problems to people with heterogeneous frontal lobe lesions and healthy controls, and found impairment in the some of the frontal lobe group in selecting the best solution from a range of alternatives. Studies of patients with ventromedial lesions (e.g. Bechara et al, 1994, 1996) have shown that they are impaired relative to control participants on a computerised gambling task. It has been suggested that patients with ventromedial lesions have specific impairments in decision-making, in the context of intact knowledge (Saver & Damasio, 1991).

Few studies have attempted to address multiple dimensions of real-life social problem-solving in a structured setting. This chapter describes the development of a measure called the ‘Predicaments test’, which attempts to address some of these issues. The Predicaments test was designed to have many of the qualities of real-life problems, but to be administered in a standardised fashion. Thus, it contains interpersonal situations that are intended to be representative of the kinds of awkward situations people may encounter in daily life, none of which have one right or wrong answer. It was also planned that no feedback would be provided at any point as to the quality of participants’ responses, such that the emphasis was on their self-monitoring of their performance.

D’Zurilla and Goldfried (1971) argued that processes such as understanding the pertinent aspects of a problem, generating a range of solutions and deciding which solution is likely to be the most effective are potentially separate processes, albeit related to each other. It was intended that these factors would be examined separately in the Predicaments test. As decisions about which solutions are most appropriate in a given situation may be compromised if the range of solutions generated is poor, it was also decided to include an additional measure of judgement, in which participants would be asked to rank order a set of options provided to them.
Work has indicated that frontal lobe lesions can be accompanied by a lack of insight into any deficits shown (e.g. Stuss, 1991a; Markowitsch & Kessler, 2000). Stuss (1991b) reported on a single case whose self-assessment of her difficulties showed a striking lack of awareness, but when roles were switched in a role-playing situation, was able to give appropriate advice to the person who was pretending to have the same characteristics as her. Thus, her judgement was altered depending on the perspective from which she was considering the information. In order to address this within the Predicaments measure, it was decided to ask participants to provide responses from two perspectives, that of the main character in the situation, plus what they would do themselves if they were in the same situation. In addition, it was decided to assess their awareness of the awkwardness of the situations, and their judgement of the quality of their solutions, as further measures of awareness of any difficulties.

The Predicaments test was also designed to contain both video and story versions. The video version was included in order to increase the ecological validity of the task. Videotape allows presentation of the problems in real time, including both verbal and nonverbal information, and thus simulates real-life situations more effectively. Given the reported findings of impairment in the ability to judge nonverbal cues in people with frontal lobe lesions (Hornak et al, 1996), it was decided that video and story versions should be compared in order to see if the pattern of any deficits was different.

In addition, the study examines performance on a battery of standardised executive measures, and the relationships between these and the Predicaments measures. Recent work has argued that there are often poor correlations between performance on different measures of executive function (Burgess, 1997; Rabbitt, 1997). It is thought that the executive functions are likely to be fractionated (e.g. Shallice & Burgess, 1996), and therefore, poor correlations could be due to the various tasks being dependent on different subprocesses. Recent studies have provided evidence
for fractionation of executive function (e.g. Burgess et al, 1998), and the choices of
tests in the present study were based on such postulated subprocesses.

In order to address the relative contributions of the frontal lobes compared with
other cortical regions, two groups of participants with focal lesions were included
in the study. Following Burgess and Shallice (1996a, 1996b), people were selected
who had a unilateral lesion restricted to one or two lobes, and classified as anterior
if the lesion involved the frontal lobe, and as posterior if there was no frontal
involvement. A matched healthy control group was also included.

7.1.1.1 Hypotheses

1) It was predicted that the anterior group would show impairment in each of
the aspects of problem solving, including appreciation of the pertinent
details of the situations, generating a range of solutions, selecting the best
course of action, and judging the adequacy of solutions when these were
provided. It was also expected that they would show some signs of reduced
awareness of their difficulties.

2) It was predicted that the posterior group would show lesser impairment on
the Predicaments measures, relative to the anterior group.

3) On the executive battery, it was predicted that the anterior group would
show impairments on a range of the measures, while the posterior group
would again show lesser impairment.

4) It was predicted that there would be significant correlations between the
executive measures and the Predicaments measures.

7.1.2 METHOD

7.1.2.1 Participants
Sixteen participants (11m, 5f) with unilateral left-sided (5) or right-sided (11) lesions
involving damage to the frontal lobes (anterior group) participated in the study. Nine
participants (4m, 5f) with unilateral left-sided (3), or right-sided (6) lesions not
involving the frontal lobes (posterior group) were also included. Because of the need
for adequate language processing, there were more participants with right-sided than left-sided lesions. All participants were right-handed except two participants with left anterior lesions, one of whom was left-handed and one ambidextrous, and one participant with a right posterior lesion, who was left-handed. These participants were all believed to have normal speech dominance, since the two participants with left anterior lesions both had speech impairments at the time of injury, which had subsequently resolved, and the participant with a right posterior lesion had no speech or language problems at the time of injury. The aetiology of the lesions was varied, and included vascular damage (n=15), head injury (n=5), abscess (n=2), tumours (n=2) and sclerosis (n=1). Lesion evidence was based on clinical radiological MRI or CT reports, and frontal lobe lesions were classified as medial, lateral or orbital using the criteria described by Damasio and Damasio (1989); lesion sites are shown in Table 7.1.

To be included in the study, participants had to be between 18 and 70 years of age, fluent in English, and have a unilateral lesion confined to one or two lobes of at least three months duration. As adequate language processing was essential for the study, participants were excluded if they had expressive or receptive dysphasia. The Test for the Reception of Grammar (TROG; Bishop, 1989) was administered as a screen for this. Although this measure was designed primarily for the assessment of children’s understanding of grammatical constructs, it is also recommended for use with adults with acquired dysphasia. The manual states that errors on more than four blocks of the TROG are likely to be of clinical significance in young adults of average intelligence or greater. In the current study, participants were included who scored errors on three blocks or fewer, equivalent to adult performance at the 25th percentile or above. Exclusion criteria included other significant physical or psychiatric illness, alcohol or drug dependence, hydrocephalus and dementing conditions. Participants were also excluded if they gained a premorbid verbal IQ score below 85 on the NART-II (Nelson, 1991).
Table 7.1  Side and site of lesion for the anterior and posterior groups.

<table>
<thead>
<tr>
<th>Side of lesion</th>
<th>Site of lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anterior group</strong></td>
<td></td>
</tr>
<tr>
<td>1   R</td>
<td>Large orbital, medial &amp; lateral FL</td>
</tr>
<tr>
<td>2   R</td>
<td>Small medial FL plus moderate PL</td>
</tr>
<tr>
<td>3   R</td>
<td>Small medial &amp; large lateral FL</td>
</tr>
<tr>
<td>4   R</td>
<td>Moderate medial &amp; large lateral FL</td>
</tr>
<tr>
<td>5   R</td>
<td>Moderate medial &amp; lateral FL plus moderate TL</td>
</tr>
<tr>
<td>6   R</td>
<td>Small lateral FL</td>
</tr>
<tr>
<td>7   R</td>
<td>Small lateral FL plus moderate TL</td>
</tr>
<tr>
<td>8   R</td>
<td>Small lateral FL plus moderate TL</td>
</tr>
<tr>
<td>9   R</td>
<td>Moderate lateral FL plus small PL</td>
</tr>
<tr>
<td>10  R</td>
<td>Moderate lateral FL plus small PL</td>
</tr>
<tr>
<td>11  R</td>
<td>Large lateral FL plus large TL</td>
</tr>
<tr>
<td>12  L</td>
<td>Small orbital, medial &amp; lateral FL</td>
</tr>
<tr>
<td>13  L</td>
<td>Small orbital &amp; moderate lateral FL</td>
</tr>
<tr>
<td>14  L</td>
<td>Small lateral FL</td>
</tr>
<tr>
<td>15  L</td>
<td>Small lateral FL plus moderate TL</td>
</tr>
<tr>
<td>16  L</td>
<td>Moderate lateral FL plus moderate TL</td>
</tr>
<tr>
<td><strong>Posterior group</strong></td>
<td></td>
</tr>
<tr>
<td>1   R</td>
<td>Small TL</td>
</tr>
<tr>
<td>2   R</td>
<td>Small TL</td>
</tr>
<tr>
<td>3   R</td>
<td>Moderate TL plus moderate PL</td>
</tr>
<tr>
<td>4   R</td>
<td>Moderate PL</td>
</tr>
<tr>
<td>5   R</td>
<td>Moderate PL</td>
</tr>
<tr>
<td>6   R</td>
<td>Moderate PL</td>
</tr>
<tr>
<td>7   L</td>
<td>Moderate TL</td>
</tr>
<tr>
<td>8   L</td>
<td>Small TL plus small PL</td>
</tr>
<tr>
<td>9   L</td>
<td>Small TL plus small OL</td>
</tr>
</tbody>
</table>

Twenty-six healthy control participants (15m, 11f) also took part in the study (22 right-handed, 4 left-handed). The three groups of participants did not differ significantly in age, years of education, NART IQ scores, or TROG scores; these data are shown in Table 7.2. All participants gave written informed consent for the study, and were given breaks between tasks as necessary, to avoid fatigue.
Table 7.2: Mean scores and standard deviations for the anterior, posterior and control groups: age, education, NART-IQ and TROG

<table>
<thead>
<tr>
<th></th>
<th>Anterior</th>
<th></th>
<th>Posterior</th>
<th></th>
<th>Control</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>41.63</td>
<td>40.56</td>
<td>42.54</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sd</td>
<td>(12.65)</td>
<td>(13.77)</td>
<td>(13.96)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>13.00</td>
<td>13.00</td>
<td>14.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>108.50</td>
<td>108.44</td>
<td>110.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NART-IQ</td>
<td>78.19</td>
<td>78.44</td>
<td>78.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TROG score</td>
<td>(1.76)</td>
<td>(1.42)</td>
<td>(1.44)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.1.2.2 Predicaments Test

This test consisted of a series of brief videotapes and stories of everyday awkward situations or “predicaments”. Each was intended to assess the individual’s ability to generate possible solutions, and to select solutions that show appreciation of the pertinent aspects of the problem situations, and solve them in a socially appropriate and effective manner. The situations included a range of social relationships, such as family, work colleagues, and strangers, and the scenarios take place in homes, offices, outdoors, shops, and pubs. A large number of situations was initially generated on the basis of interviews with a range of people of varying ages, social backgrounds and ethnicity. These were developed and filmed, and corresponding story versions were written for each video. They were piloted on a range of healthy volunteers, and also on a small set of patients with focal lesions, in order to refine the measures and devise the scoring system. The final test consisted of two sets of 8 situations; one practice example was given at the beginning of each set. An example of a Predicament is given below, and story versions of the full set of sixteen scenarios and two practice items are provided in Appendix A. Within each group, counterbalancing of the two sets of situations was carried out so that half received set A as videos and set B as stories, and the other half received set A as stories, and set B as videos. Order of video and story presentations was also counterbalanced within groups.
7.1.2.2.1 An example of a Predicament ("Dogs")

"Anne is in her office when Tony comes in. She asks how he is, and he says he is alright, but tired. She agrees that he looks tired, and asks what is the matter. He has new neighbours who moved into the flat above his a couple of weeks ago. They are nice people, but they own dogs and keep them in their kitchen at night, which is directly above Tony's bedroom. All night, and every night since they moved in, the dogs jump around and bark. He finds it impossible to get to sleep. He says he has had a word with the neighbours, and although they were very reasonable, they said they had nowhere else to put the dogs as it is a block of flats."

7.1.2.2.2 Procedure

Within each set of 8, the situations were presented in a fixed order. At the beginning of the task participants were given some instructions; the video version of these is presented below:

"I am going to show you a series of short videos. Each one contains an awkward situation that everyone might encounter in daily life. After you have seen the video, I am going to ask you some questions about the situation. Here is a list of the questions I will ask you for each situation, so that you can get familiar with them. Some of the questions have a time limit, shown on your sheet. If you do not answer within the limit, I will ask you to give me an answer immediately. When I ask you to tell me what happened in the scene (experimenter points to the relevant place on the question sheet), please make your answer as complete as you can."

Appendix B shows the list of questions and time limits as they were presented to participants. All responses were recorded on a score-sheet. They were also audiotaped to enable a back-up check to be made if the information on the score-sheets was unclear.

7.1.2.2.3 Factual account of the problem situations

After each problem situation was presented, participants were given an opportunity to see/read it again if they wanted to. Participants were asked to describe what
happened in the situation, in order to assess their memory for the characters and overt actions. If they did not recall all the main facts spontaneously, they were prompted to give more information. They were then shown the video or story again if important details had not been mentioned, and prompted again. Finally, if the answer remained unsatisfactory, the experimenter gave a verbal summary of any pertinent details that the participant had not included. Thus, a maximum of 3 prompts was used to ensure that participants were aware of the factual details of the situation.

After they had demonstrated their understanding of the main details of the first scenario, they were told the following:

"I am now going to ask you some questions about how to solve the situation. Please make your answers as complete as you can. If I ask you to give me an answer immediately, it means you are out of time, and I want you to give me the first answer that comes to mind".

7.1.2.2.4 Ratings of awkwardness
For each problem situation, participants were asked to rate how awkward it was, both for the main character, and for themselves if they were in the same situation (0-100%). On the first item, the scale was explained to them, by informing them that ‘0’ would represent a situation that was not awkward at all, while ‘100’ would mean it was as awkward as a situation could possibly be.

7.1.2.2.5 Solution generation
For each situation, solution fluency was assessed by asking participants to generate as many potential solutions as possible. They were allowed a maximum of two minutes for this. Participants were not given any prompts for further information or clarification of their suggested solutions, to ensure that no cues were provided as to the adequacy of their responses. On the first item, participants were told the following:

"When I say this, it means that I want you to give me a range of ideas for what the character could do, not just ideas for what you think they should do."
7.1.2.2.6 Selection of optimal and personal solutions
After generating possible solutions, participants were asked to select the best solution from the perspective of the main character (Optimal Solution). They were then asked to state what they themselves would do if they were in that situation (Personal Solution), in order to examine to what extent they chose a different course of action from that which they considered to be optimal for the main character.

7.1.2.2.7 Satisfaction ratings
After giving their optimal and personal solutions, participants were asked to rate their degree of satisfaction with each (0-100%). Again, clarification about the scale was provided on the first item to ensure they understood. Participants were told that ‘0’ represented not being satisfied at all, while ‘100’ meant that they were as satisfied as they could possibly be.

7.1.2.2.8 Judgement of alternative solutions
After participants had completed each set of eight situations, they were assessed on their judgement of alternative solutions. For each problem situation, they were given five different suggestions for what the main character could do in the situation, and asked to rank them in order from best to worst. Each one contained a one-sentence summary of the Predicament to which it referred, but participants were also offered the chance to read or watch it again if they wished. The five alternative solutions for each situation were selected from pilot data collected at the beginning of the study.

7.1.2.2.9 Scoring system
The scoring system was developed by the present author and project supervisor. Initially, the pilot data collected during the development of the test was pooled, and answers were sorted into categories reflecting different types of solutions. These categories were then classified according to three criteria (see below) as to whether they were judged to show adequate appreciation of the problem, to be socially
appropriate, and to provide effective practical means of resolving the problem. Detailed guidelines were written which described each category, and gave sample answers for each. Five alternative solutions were also selected for each problem from the pilot data to represent a range of solutions for the Judgement of Alternatives task. Two new raters then attempted to classify each individual’s solutions using the scoring categories, and any difficulties arising were discussed in order to refine the classification system further. Two additional raters then went through the same procedure with the revised scoring system to create the final version.

This final scoring system was used to score the responses of the participants in the present study. All responses were rated by one rater who was blind as to the identity and group membership of the participants, and by a second rater who was not blind. The two raters agreed for 87% of ratings. All differences were resolved by reference to an additional blind rater.

7.1.2.2.9.1 Problem Appreciation

The Problem Appreciation measure assessed whether or not the solution demonstrated adequate recognition of the pertinent interpersonal/practical aspects of the problem situation that needed to be taken into account in order for a satisfactory outcome to be possible. In the example of the scenario described above, in which Tony is having difficulties because of his neighbours’ noisy dogs, the categories could be summarised as follows:

(a) Attempt to negotiate a solution with the neighbours
(b) Make further complaints (e.g. go to landlord/council/police)
(c) Alter your own life (e.g earplugs, move house)
(d) Extreme ideas (e.g. kill the dogs)
(e) Irrelevant or incomplete responses (e.g. people shouldn’t keep dogs in flats)

Categories a, b and c in this example were assigned a score of 1, and categories d and e were assigned a score of 0, to indicate adequate and poor appreciation of the pertinent issues (whether or not solutions were socially appropriate or effective).
7.1.2.2.9.2 Social Appropriateness

The categories were used to classify solutions according to whether or not the manner of dealing with the situation was socially appropriate (Social Appropriateness) (scored 1 or 0). In the example of the “Dogs” predicament shown above, the categories were classified as follows: Category (a) answers scored 1 point, category (c), (d) and (e) answers scored 0 points, and category (b) answers were split according to the degree of social appropriateness indicated (e.g. aggressive or threatening answers scored 0).

7.1.2.2.9.3 Effectiveness

The categories were also used to classify solutions according to whether or not the manner of dealing with the situation was likely to provide an effective practical means of resolving it (Effectiveness) (scored 1 or 0). In the example of the “Dogs” predicament shown above, the categories were classified as follows: Category (d) and (e) answers scored 0 points, and category (a), (b) and (c) answers were split into those scoring 1 or 0 according to the degree of practical effectiveness indicated.

7.1.2.2.9.4 Total Solution Quality

Total Solution Quality scores were also calculated by adding the three subscores (Problem Appreciation, Social Appropriateness and Effectiveness). For optimal and personal solutions, this gave two measures scored out of 3 for each item, Optimal Solution Quality and Personal Solution Quality. The three subscores were not necessarily independent, as failure to identify the pertinent aspects of the problem (Problem Appreciation) was automatically scored 0 for Social Appropriateness and Effectiveness, since it was associated with generation of a solution that did not recognise or address the correct problem.

7.1.2.2.9.5 Solution Generation

To assess how efficiently people generated solutions, the number of ideas generated for each problem situation was added to create a total score (Number of Solutions). Each of these ideas was scored for quality on the three subscales as described
above. The Total Solution Quality scores were added together and divided by Number of Solutions, to provide an Average Solution Quality score, i.e. adjusted for the number of solutions given.

7.1.2.2.9.6 Scoring examples

Solutions that scored the maximum 3 points for Total Solution Quality:
“Discuss it again with the neighbours and negotiate a compromise”
“Take it up with the council/landlord”

Sample solutions given by anterior participants that scored no points for Total Solution Quality:
“Poison the dogs”
“Shoot the dogs”
‘Make a loud noise to counteract their noise’
‘Threaten the neighbours with violence’
‘Bribe them’
‘Mention to the neighbours that I was looking after a couple of rottweilers for a friend’

7.1.2.2.9.7 Judgement of Alternatives

In order to create the Judgement of Alternatives task, five alternative solutions for each problem situation were selected from the pilot data to represent answers from at least three different scoring categories for each problem. Each of the five alternatives for each problem was scored 1 or 0 according to the system described above for Problem Appreciation, Social Appropriateness and Effectiveness, giving a Total Solution Quality score between 0 and 3. The scoring for these alternative solutions was checked by the additional raters, as described above. The rank ordering of the alternative solutions was determined by their Total Solution Quality scores. Where two or more alternative solutions shared the same Total Solution Quality score, these were ranked equally. Participants’ rank orderings of the 5 alternatives were then scored by comparing them with the optimal rank ordering derived from Total Solution Quality scores. For each problem situation, the rank
position of each answer scored between 0 and 4, according to its distance from the optimal rank position; this gave a maximum score of 20, where all 5 answers were in the correct position relative to the other 4. The maximum Judgement of Alternatives score was thus 320.

7.1.2.3 Executive battery
A battery of standardised tests was selected in order to assess aspects of executive function.

7.1.2.3.1 Deductive reasoning
The measure of deductive reasoning used in the current study was Raven’s Advanced Progressive Matrices, Set I (Raven, 1976). The test consisted of twelve items, which all contained an abstract pattern with a section missing, and six choices as to what the missing section could be. Participants were given a score out of twelve, which was then converted to an age-scaled score. The task involves reasoning about which option is the most appropriate from a set of alternatives. Performance might be expected to relate to similar processes in everyday problem-solving. In relation to the Predicaments task, Raven’s matrices scores might be most closely related to selection of optimal and personal solutions, and Judgement of Alternatives.

7.1.2.3.2 Attention and set-shifting
The ability to shift attention between competing sets of items is thought to reflect the ability to be flexible in behaviour (e.g. Kolb & Whishaw, 1996). In real-life problem-solving, impairments might be expected to contribute particularly to difficulties in generating a range of solutions under time pressure.

Three measures of attention and set-shifting were included, the Trail Making Test (Reitan, 1958), the Rule Shift Cards test (Wilson et al, 1996), and Cancellation tasks (Wilson et al, 1987). The Trail Making Test consists of two parts, both of which are timed. In part A, participants are asked to draw a line to join dots numbered 1-25 in numerical order. In part B, they have to alternate between
numbers and letters, starting at 1, and finishing at 13. The Rule Shift Cards test is a subtest of the BADS battery, and consists of two parts, both of which involve presenting the participant with a booklet depicting red and black playing cards. The pages are turned over one at a time, and in the first part, participants are asked to say ‘yes’ if the card is red and ‘no’ if it is black. The second part of the task involves a change of rule, such that they have to say ‘yes’ if the card is the same colour as the previous card, and ‘no’ if it is a different colour. Performance is graded according to a ‘profile score’ out of four, which reflects the numbers of errors made, plus a penalty for slow performance on part B. The cancellation tasks were from the Behavioural Inattention Test. The Star Cancellation task involved crossing out small stars from an array containing small and large stars, plus letters and numbers as distractors. The Letter Cancellation task involved an array of letters only, and the task was to cross out all the Es and Rs. Participants were asked to perform both tasks as quickly as possible without missing out any target items, and they were timed until they indicated they had finished.

7.1.2.3.3 Inhibition and strategy generation

Inhibition of a prepotent response is related to attention and set-shifting in that it also reflects flexibility of behaviour. The ability to generate and use strategies appropriately can aid problem-solving performance. Impairments in these related skills would be expected to lead to difficulties in generating ideas in real-life problem-solving. Therefore, in the Predicaments task, it would be predicted that the strongest relationships with these tests would be with the solution fluency measures, when participants were asked to generate as many solutions as they could.

Two measures were included measuring aspects of inhibition and strategy generation, Letter Fluency (Thurstone & Thurstone, 1962), and the Hayling Test (Burgess & Shallice, 1996a). The version of the Letter Fluency task that was administered required participants to write down as many words as they could beginning with the letter ‘S’. They were allowed five minutes to do this, but had to obey rules, such that they were not allowed to score for names of people or places,
numbers or days of the week, or more than one word from the same root. The Hayling test consists of two parts, which both involve the verbal presentation of fifteen sentences which have the last word missing. In part A, participants are asked to complete the sentence with a sensible completion as quickly as they can. In the second part of the task, participants have to complete the sentences with words that made no sense in the context of the sentence. This therefore involves inhibition of prepotent, sensible completion words. Burgess and Shallice argued that the time taken on part A reflected initiation, while successful performance on part B often involved the effective use of strategies. The time taken to complete each task was measured, and error scores were given for any sensible completions in part B.

7.1.2.3.4 Multitasking
Multitasking performance has been related to planning and decision-making processes (e.g. Burgess 2000a; Burgess et al, 1998). Performance on measures of multitasking would therefore be expected to relate to decision-making in real-life-type problem-solving, including the selection of optimal and personal solutions, and Judgement of Alternatives in the Predicaments test.

The modified Six Elements Test from the BADS battery was administered (Wilson et al, 1996). In this test participants are presented with three different types of tasks, all of which have two parts. Their instructions are to complete something from all subtasks within ten minutes, but without ever attempting two parts of the same task consecutively. They are awarded a ‘profile score’ out of four to reflect how many tasks they attempted, with deductions for rule breaks.

7.1.2.3.5 Strategic encoding/retrieval
In terms of real-life problem-solving, strategic encoding and retrieval might be expected to be related to the generation of problem-solving ideas, since one method of achieving this would be to search memory for experience of similar situations, in order to evaluate what courses of action were taken. In addition, retrieving information about how successful previous strategies were might contribute to the adequate selection of appropriate actions.
The Story Recall Test from the Adult Memory and Information Processing Battery was administered (Coughlan & Hollows, 1985). A prose passage was read to participants, and they were then asked to recall as much of it as they could (Immediate recall). After a thirty minute delay, they were asked again to recall as much of the story as possible (Delayed recall).

7.1.2.3.6 Dysexecutive Questionnaire
In addition, participants filled out the Dysexecutive Questionnaire (DEX) from the BADS (Wilson et al, 1996), and they were also asked to obtain a rating from a relative or friend who knew them well. Two of the participants within the focal lesion groups gained ratings from professional staff (one occupational therapist, one care worker), in the absence of an appropriate family member. This questionnaire was intended to give some information about everyday life dysexecutive problems including emotion and personality, motivation, behaviour and cognition. Thus, scores on this measure may give some reflection of the difficulties participants have in their daily lives, including in their interpersonal relationships. Therefore, although DEX scores might be related to all aspects of real-life problem-solving in the Predicaments test, they may be expected to be most strongly related to participants' ability to appreciate the important details of the problem, and select socially appropriate solutions.

7.1.3 RESULTS

7.1.3.1 Statistical analysis
Parametric analyses were carried out where possible, since they have greater power to reject a false null hypothesis than non-parametric tests (e.g. Howell, 1997). Parametric tests also enable multivariate analyses to be carried out, which are appropriate when measures contain more than one subtest, such as the Hayling and Trail Making tests. The main restriction on the use of parametric tests is that they require the underlying distribution of the data to approximate to the normal distribution. It is therefore important to check whether these assumptions of
normality are valid for the data in question. In the current study, the data were initially examined for skewness and outliers, following the methods described by Tabachnick and Fidell (1983). They state that the standard error for skewness is:

\[ s_s = \sqrt{\frac{6}{N}} \quad (N = \text{number of cases}) \]

This value can then be put into the equation below, using the z distribution:

\[ z = \frac{S - 0}{s_s} \quad (S = \text{computed value for skewness}) \]

If the data are from a normal distribution then a z-value in excess of ±2.58 would lead to the rejection of the assumption of normality of the distribution at \( p \leq .01 \). Thus, in the current study, the data were considered to be skewed beyond that necessary for the assumption of being normally distributed if \( S > 2.58\sqrt{(6/n)} \) or \( S < -2.58\sqrt{(6/n)} \). For the control group, \( n=26 \) and therefore \( S=1.239 \), for the anterior group, \( n=16 \), and therefore \( S=1.580 \), and for the posterior group, \( n=9 \), and therefore \( S=2.107 \). The variables were also checked for outliers. This was done by converting each variable into a standard score (z-score), and checking that these did not exceed ±3.

On the Predicaments task, three of the four ratings of satisfaction were negatively skewed for the control group, one of which (others’ satisfaction with personal solutions) also had outliers. No Predicaments variables failed to meet assumptions of normality for the anterior and posterior groups. On the executive battery, the control group had positively skewed data for time taken on Hayling parts A and B, and for Letter Cancellation time, which also contained outliers. For the anterior group, time taken on Hayling part A was positively skewed, as was Star Cancellation time, which also contained outliers. No variables within the executive battery failed to meet assumptions of normality for the posterior group. Multivariate analyses were applicable for all the variables that were not within acceptable limits for normality. One method of adjusting data to reduce the amount of skewness and the impact of outliers is to transform the data, enabling all data points to remain in the data set. This was done using Tukey’s ‘ladder of transformations’ as described...
in Erickson and Nosanchuk (1977). Logarithmic transformations corrected the skewness for the Cancellation variables, while negative reciprocal transformations were required for the Hayling Test, and squared transformations for the satisfaction ratings.

A 5% significance level was adopted throughout to compare the groups. There were small amounts of missing data due to administrative errors; where numbers fell below maximum these are shown in the tables. When t-tests were performed, the results for separate variance estimates rather than pooled variance estimates are reported whenever the variances of the groups were significantly different from each other (p<.05).

In order to examine performance, analyses were initially carried out to compare the anterior and posterior groups. If these two groups differed, each was compared separately with the control group; otherwise, the anterior and posterior lesion groups were combined, and then compared with the control group.

7.1.3.2 Predicaments test
Table 7.3 shows the mean scores, standard deviations, and significance tests for the anterior versus posterior lesion groups.

7.1.3.2.1 Factual account of the Predicaments
A t-test was initially carried out for the total number of prompts needed (0-3) to give an adequate response in recounting the factual details of the situations. Comparison of the lesion groups based on site of lesion (anterior or posterior) showed no significant effects (t=0.78, df=23, p=.444). A comparison was therefore carried out between the control group and the group with focal lesions, collapsing across site of lesion. A t-test using separate variance estimates showed no significant group difference (t=0.47, df=37, p=.644). Control group means and standard deviations, plus comparisons between the combined lesion group and control group where applicable, are shown in Table 7.4.
Table 7.3  Mean scores and standard deviations for the Predicaments test: anterior versus posterior groups.

<table>
<thead>
<tr>
<th></th>
<th>Anterior</th>
<th>Posterior</th>
<th>Test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average number of Prompts</strong></td>
<td>0.98 (0.53)</td>
<td>1.16 (0.63)</td>
<td>t=0.78</td>
<td>.444</td>
</tr>
<tr>
<td><strong>Awkwardness Ratings /100%</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main character</td>
<td>70.85 (12.39)</td>
<td>71.47 (17.27)</td>
<td>F=0.29</td>
<td>.596</td>
</tr>
<tr>
<td>Personal</td>
<td>56.51 (20.75)</td>
<td>63.19 (18.15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Solution Generation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Solutions</td>
<td>38.44 (11.01)</td>
<td>51.33 (16.96)</td>
<td>t=2.31</td>
<td>.030*</td>
</tr>
<tr>
<td>Average Solution Quality</td>
<td>2.05 (0.23)</td>
<td>1.92 (0.13)</td>
<td>t=1.47</td>
<td>.156</td>
</tr>
<tr>
<td><strong>Optimal (O) and Personal (P) Solution Quality</strong></td>
<td>group x perspective</td>
<td>F=6.27</td>
<td>.020*</td>
<td></td>
</tr>
<tr>
<td>Solution Quality (O)</td>
<td>36.87 (4.73)</td>
<td>37.11 (2.76)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solution Quality (P)</td>
<td>35.38 (4.73)</td>
<td>37.89 (1.69)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem Appreciation (O)</td>
<td>14.13 (1.31)</td>
<td>13.56 (1.13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Appropriateness (O)</td>
<td>10.94 (2.21)</td>
<td>11.00 (1.32)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectiveness (O)</td>
<td>11.81 (2.20)</td>
<td>12.56 (1.51)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem Appreciation (P)</td>
<td>13.69 (1.45)</td>
<td>14.22 (0.97)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Appropriateness (P)</td>
<td>10.37 (2.03)</td>
<td>11.11 (0.93)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectiveness (P)</td>
<td>11.31 (1.96)</td>
<td>12.56 (1.01)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Satisfaction Ratings/100%</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimal own</td>
<td>79.45 (11.42)</td>
<td>81.04 (10.25)</td>
<td>F=0.03</td>
<td>.869</td>
</tr>
<tr>
<td>Optimal others'</td>
<td>69.81 (12.03)</td>
<td>71.11 (9.12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal own</td>
<td>82.47 (12.06)</td>
<td>84.65 (9.47)</td>
<td></td>
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</tr>
<tr>
<td>Personal others'</td>
<td>71.95 (13.71)</td>
<td>71.03 (10.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Judgement of Alternatives</strong></td>
<td>266.38 (13.57)</td>
<td>266.22 (8.57)</td>
<td>t=0.03</td>
<td>.976</td>
</tr>
</tbody>
</table>

* p<.05
Table 7.4  Mean scores and standard deviations for the Predicaments test: lesion participants versus the control group.

<table>
<thead>
<tr>
<th></th>
<th>Lesion group</th>
<th>Control group</th>
<th>Test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average number of Prompts</strong></td>
<td>1.04 (0.56)</td>
<td>0.98 (0.31)</td>
<td>t=0.47</td>
<td>.644</td>
</tr>
<tr>
<td><strong>Awkwardness Ratings /100%</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main character</td>
<td>71.07 (13.98)</td>
<td>70.95 (9.08)</td>
<td>F=0.03</td>
<td>.860</td>
</tr>
<tr>
<td>Personal</td>
<td>58.92 (19.74)</td>
<td>60.40 (14.09)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Solution Generation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Solutions</td>
<td>52.62 (15.38)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Solution Quality</td>
<td>2.00 (0.21)</td>
<td>2.08 (0.25)</td>
<td>t=0.14</td>
<td>.259</td>
</tr>
<tr>
<td><strong>Optimal (O) and Personal (P) Solution Quality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solution Quality (O)</td>
<td>41.38 (3.46)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Solution Quality (P)</td>
<td>40.54 (3.72)</td>
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<tr>
<td>Problem Appreciation (O)</td>
<td>14.96 (1.00)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Appropriateness (O)</td>
<td>12.72 (1.85)</td>
<td></td>
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<tr>
<td>Effectiveness (O)</td>
<td>13.69 (1.12)</td>
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<td>Problem Appreciation (P)</td>
<td>14.81 (1.13)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Appropriateness (P)</td>
<td>12.65 (1.77)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Effectiveness (P)</td>
<td>13.08 (1.35)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Satisfaction Ratings/100%</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimal own</td>
<td>80.02 (10.82)</td>
<td>78.79 (8.84)</td>
<td>F=0.81</td>
<td>.372</td>
</tr>
<tr>
<td>Optimal others'</td>
<td>70.28 (10.69)</td>
<td>68.24 (10.02)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal own</td>
<td>83.26 (11.04)</td>
<td>80.33 (11.01)</td>
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<td></td>
</tr>
<tr>
<td>Personal others'</td>
<td>71.62 (12.30)</td>
<td>68.61 (12.18)</td>
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<td></td>
</tr>
<tr>
<td><strong>Judgement of Alternatives</strong></td>
<td>266.32 (11.81)</td>
<td>273.54 (9.87)</td>
<td>t=2.37</td>
<td>.022*</td>
</tr>
</tbody>
</table>

* p<.05
7.1.3.2.2 Ratings of awkwardness

One participant in the posterior group could not be persuaded to give ratings of awkwardness for one of the 16 situations, and his score was therefore derived from the average of the remaining items. Comparison of ratings of the degree of awkwardness was made using ANOVA with one between-group factor (group: anterior or posterior), and one within-group factor (perspective: main character or self). This showed no significant effect of site of lesion (F=0.29, df=1,23, p=.596). The effect of task was significant (F=22.08, df=1,23, p=.0001), but the group by task interaction was not (F=1.59, df=1,23, p=.220). Examination of the mean scores showed that the significant effect of task was due to both groups rating the situations as more awkward for the main character than for themselves. The same method was used to compare the combined lesion group with the control group. There was no significant difference between the groups (F=0.03, df=1,49, p=.860), nor a group by task interaction (F=0.32, df=1,49, p=.574). Again, the type of task was significant because all groups rated the situations as more awkward for the main character than for themselves (F=64.54, df=1,49, p=.0001).

7.1.3.2.3 Solution Generation

Before selecting their best Optimal and Personal solutions, participants had been asked to generate as many solutions as possible to each problem situation. Fluency of solution generation was assessed by counting the total number of solutions generated across all problem situations (Number of Solutions), regardless of quality, since participants were not specifically asked only for good solutions at this stage. The mean scores for each group are shown in Figure 7.1.

A t-test of the number of solutions generated showed a significant difference between the groups with anterior and posterior lesions (t=2.31, df=23, p=.030). Comparison of the anterior and control groups showed that the anterior participants produced fewer solutions (t=3.21, df=40, p=.003), whereas the posterior group did not differ significantly from the control group (t=0.21, df=33, p=.835). Table 7.5 shows the comparisons between the control group and the individual lesion groups.
In order to examine the quality of the solutions generated, each solution was rated for Problem Appreciation, Social Appropriateness and Effectiveness, to calculate Solution Quality scores as described above. The Solution Quality scores were added for all fluency solutions given, and divided by Number of Solutions, to derive an Average Solution Quality score per solution. This did not show any significant effects involving site of lesion (t=1.47, df=23, p=.156); nor was there a significant difference in Average Solution Quality between the combined lesion group and the control group (t=1.14, df=49, p=.259). The mean scores for each group are shown in Figure 7.2.
Table 7.5  Predicaments test: anterior group (A) versus control group (C); posterior group (P) versus C

<table>
<thead>
<tr>
<th></th>
<th>A vs C</th>
<th>P vs C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test</td>
<td>p</td>
</tr>
<tr>
<td>Solution Generation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Solutions</td>
<td>t=3.21</td>
<td>.003**</td>
</tr>
<tr>
<td>Solution Quality</td>
<td>F=36.81</td>
<td>.0001**</td>
</tr>
<tr>
<td>Problem Appreciation (O)</td>
<td>t=2.34</td>
<td>.024</td>
</tr>
<tr>
<td>Social Appropriateness (O)</td>
<td>t=2.64</td>
<td>.007**</td>
</tr>
<tr>
<td>Effectiveness (O)</td>
<td>t=3.18</td>
<td>.005**</td>
</tr>
<tr>
<td>Problem Appreciation (P)</td>
<td>t=2.80</td>
<td>.008**</td>
</tr>
<tr>
<td>Social Appropriateness (P)</td>
<td>t=3.84</td>
<td>.0001**</td>
</tr>
<tr>
<td>Effectiveness (P)</td>
<td>t=3.17</td>
<td>.004**</td>
</tr>
</tbody>
</table>

*p<.05  **p<.01

Figure 7.2: Mean scores for average quality of solutions for the control, anterior and posterior groups
7.1.3.2.4 Selection of optimal and personal solutions

For each problem situation, participants were asked to select an optimal solution from the perspective of the main character, and then to give their own personal solution, and these were rated on Problem Appreciation, Social Appropriateness and Effectiveness, to give a combined Total Solution Quality score, as described above. Optimal and Personal Solution Quality scores were compared using ANOVA for the anterior and posterior groups, with one between-groups factor (group: anterior or posterior), and one within-groups factor (perspective: optimal or personal). Neither the effect of group (F=0.72, df=1,23, p=.406), nor the effect of perspective (F=0.63, df=1,23, p=.435) were significant, although there was a significant group by perspective interaction (F=6.27, df=1,23, p=.020). Examination of the mean scores showed that the anterior group gained slightly higher scores for optimal solutions compared with personal solutions, while the posterior group showed the reverse pattern. The two groups were compared individually with the control group. ANOVA showed that the anterior group gained poorer scores than the control group (F=36.81, df=1,40, p=.0001). The group by perspective interaction was not significant (F=0.03, df=1,40, p=.876), although perspective was significant (F=8.77, df=1,40, p=.005); examination of the mean scores showed that both groups gained slightly higher scores for optimal compared with personal solutions. ANOVA also showed that the posterior group scored significantly lower than the control group (F=8.20, df=1,33, p=.007). There was no effect of perspective (F=0.01, df=1,33, p=.939), although the group by perspective interaction approached significance (F=3.40, df=1,33, p=.074). The mean scores for the three groups are shown in Figure 7.3.
The anterior and posterior groups were also compared with the control group for the three submeasures, Problem Appreciation, Social Appropriateness and Effectiveness, for Optimal and Personal solutions. Using an adjusted significance level (.05/3= p<.0167) t-tests showed the anterior group to score significantly lower than the control group on five out of six of the measures, as shown in Table 7.5. The sixth measure, Problem Appreciation for Optimal solutions, approached significance (t=2.34, df=40, p=.024). The posterior group scored significantly lower than the control group on Problem Appreciation and Social Appropriateness for Optimal solutions as shown in Table 7.5. The differences between the posterior and control groups also approached significance for Optimal Effectiveness (t=2.39, df=33, p=.023) and Personal Social Appropriateness (t=2.49, df=33, p=.018), although the results for Personal Problem Appreciation and Effectiveness were not significant. The mean scores for the three groups for Optimal solutions are shown in Figure 7.4, and for Personal solutions in Figure 7.5.
Figure 7.4 Mean optimal solution scores: control, anterior and posterior groups

Figure 7.5 Mean personal solution scores: control, anterior and posterior groups
7.1.3.2.5 Ratings of satisfaction

For each problem situation, participants were also asked to rate their own percentage satisfaction with their best Optimal and Personal solutions, and to rate how many people out of 100 would be satisfied with their Optimal and Personal solutions. The anterior and posterior groups were compared using ANOVA on the transformed data, with one between-groups factor (group: anterior or posterior) and two within-groups factors (task: optimal or personal; perspective: self or other). This showed no significant effect of group (F=0.03, df=1,23 p=.869), nor any interactions between group and task and/or perspective (p>.05). The effects of both task and perspective were significant, and examination of the mean scores showed that both groups tended to rate their satisfaction with their personal solutions as higher than that with their optimal solutions, and both gave higher ratings for their own perspective than for how many other people they thought would be satisfied with their answers. Comparison of the combined lesion group with the control group revealed a similar pattern of results, and again, there was no effect of group (F=0.81, df=1,49, p=.372).

7.1.3.2.6 Judgement of alternative solutions

In order to examine whether participants showed any difficulties in judging the adequacy of solutions even when they were not required to generate them, participants’ rankings of 5 alternative solutions for each problem situation were examined. T-test comparison of the anterior and posterior groups showed no significant effect of site of lesion (t=0.03, df=23, p=.976). Comparison of the combined lesion participants with the control group showed that the lesion group gained significantly lower scores (t=2.37, df=49, p=.022).

7.1.3.3 Executive battery

Mean scores, standard deviations and significance tests for the groups are shown in Table 7.6.
<table>
<thead>
<tr>
<th>Table 7.6</th>
<th>Mean scores and standard deviations for the executive battery: anterior versus posterior groups.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Anterior Mean (SD)</td>
</tr>
<tr>
<td>Deductive reasoning</td>
<td></td>
</tr>
<tr>
<td>Raven's Matrices</td>
<td>10.50 (2.97)</td>
</tr>
<tr>
<td>Attention and set-shifting</td>
<td></td>
</tr>
<tr>
<td>BIT¹</td>
<td></td>
</tr>
<tr>
<td>Star time</td>
<td>47.40 (32.96)</td>
</tr>
<tr>
<td>Letter time</td>
<td>78.93 (34.77)</td>
</tr>
<tr>
<td>Trail-making test</td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>44.25 (21.58)</td>
</tr>
<tr>
<td>Time B</td>
<td>109.44 (80.31)</td>
</tr>
<tr>
<td>Rule Shift Cards</td>
<td>3.06 (0.77)</td>
</tr>
<tr>
<td>Inhibition and strategy generation</td>
<td></td>
</tr>
<tr>
<td>Hayling test</td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>28.13 (20.79)</td>
</tr>
<tr>
<td>Time B</td>
<td>63.63 (63.74)</td>
</tr>
<tr>
<td>B Errors</td>
<td>3.31 (3.74)</td>
</tr>
<tr>
<td>Letter fluency</td>
<td>35.19 (18.59)</td>
</tr>
<tr>
<td>Multitasking</td>
<td></td>
</tr>
<tr>
<td>Six Elements</td>
<td>3.31 (0.87)</td>
</tr>
<tr>
<td>Executive memory</td>
<td></td>
</tr>
<tr>
<td>Story Recall</td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>33.56 (8.66)</td>
</tr>
<tr>
<td>Delayed</td>
<td>28.88 (11.64)</td>
</tr>
<tr>
<td>Dysexecutive behaviours (DEX)</td>
<td></td>
</tr>
<tr>
<td>Self rating</td>
<td>17.50 (9.08)</td>
</tr>
<tr>
<td>Other rating²</td>
<td>25.08 (16.49)</td>
</tr>
</tbody>
</table>

¹N=15 anterior, 9 posterior ²N=13 anterior, 9 posterior
T-tests were initially carried out for each of the neuropsychological tests, or ANOVA for tests involving two tasks (BIT, Trail-making, Hayling and Story Recall). This showed no significant effects involving site of lesion (anterior or posterior) (p>.05) for any of the tests. Comparison was therefore carried out between the control and lesion participants, collapsing across site of lesion. Mean scores, standard deviations, and significance tests are shown in Table 7.7.

The combined lesion participants gained significantly poorer scores than the control participants on the three measures of attention and set-shifting: speed of performance on the Cancellation tasks (F=5.78, df=1,48, p=.020), and the Trail Making Test (F=6.18, df=1,49, p=.016), and overall scores on the Rule Shift Cards Test (t=2.57, df=49, p=.013). The two groups also differed on all of the measures of inhibition and strategy generation, including speed of performance on the Hayling Test (F=2.11, df=1,48, p=.042); part B error scores on the Hayling Test (t=2.57, df=48, p=.015), and number of words generated on the Letter Fluency test (Letter Fluency (t=2.28, df=49, p=.027). The combined lesion group also scored more poorly than the control group on the measures of multitasking (Six Elements Test: t=2.22, df=49, p=.033), deductive reasoning (Raven’s matrices: t=2.45, df=49, p=.018), and executive memory (Story Recall: F=6.10, df=1,49, p=.017). Of the tests containing two tasks, only the Trail Making Test had a significant group by task interaction (F=4.64, df=1,49, p=.036); examination of the mean scores showed that the difference between the groups tended to be more marked on part B of the test.
<table>
<thead>
<tr>
<th>Table 7.7</th>
<th>Mean scores and standard deviations for the executive battery: lesion participants versus the control group.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lesion group</td>
</tr>
<tr>
<td></td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Deductive reasoning</td>
<td></td>
</tr>
<tr>
<td>Raven's Matrices</td>
<td>10.80 (3.03)</td>
</tr>
<tr>
<td>Attention and set-shifting</td>
<td></td>
</tr>
<tr>
<td>BIT(^1)</td>
<td></td>
</tr>
<tr>
<td>Star time</td>
<td>44.92 (27.42)</td>
</tr>
<tr>
<td>Letter time</td>
<td>71.29 (31.10)</td>
</tr>
<tr>
<td>Trail Making Test</td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>40.92 (19.91)</td>
</tr>
<tr>
<td>Time B</td>
<td>111.12 (81.72)</td>
</tr>
<tr>
<td>Rule Shift Cards</td>
<td>3.04 (0.93)</td>
</tr>
<tr>
<td>Inhibition and strategy generation</td>
<td></td>
</tr>
<tr>
<td>Hayling Test(^2)</td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>24.84 (17.33)</td>
</tr>
<tr>
<td>Time B</td>
<td>61.08 (57.01)</td>
</tr>
<tr>
<td>B Errors</td>
<td>3.84 (3.98)</td>
</tr>
<tr>
<td>Letter fluency</td>
<td>36.32 (16.04)</td>
</tr>
<tr>
<td>Multitasking</td>
<td></td>
</tr>
<tr>
<td>Six Elements Test</td>
<td>3.24 (1.01)</td>
</tr>
<tr>
<td>Executive memory</td>
<td></td>
</tr>
<tr>
<td>Story Recall</td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>33.68 (8.64)</td>
</tr>
<tr>
<td>Delayed</td>
<td>29.68 (11.00)</td>
</tr>
<tr>
<td>Dysexecutive behaviours (DEX)</td>
<td></td>
</tr>
<tr>
<td>Self rating</td>
<td>19.24 (8.49)</td>
</tr>
<tr>
<td>Other rating(^3)</td>
<td>22.45 (15.85)</td>
</tr>
</tbody>
</table>

\(* p<.05\)  \(^1\)N=24 lesion, 26 control  \(^2\)N=25 lesion, 25 control  \(^3\)N=22 lesion, 25 control
For the DEX questionnaire, all participants filled out self-ratings, and other-ratings were returned for all except 1 control participant and 2 of the participants with anterior lesions. Behaviour during the session and information from the history for the 2 participants with anterior lesions indicated marked behavioural difficulties, suggesting that each would have received high DEX scores. One relative provided a rating of 0 for a participant with an anterior lesion (lower than any ratings for participants in the control group). This score was not included in the analysis, since behaviour during the session made it clear that there were in fact marked difficulties, and that a score of 0 would have been misrepresentative. Comparison of the lesion participants showed no significant effects of site of lesion for either self-ratings or other-ratings, and the combined lesion group did not differ significantly from the control group on either of these measures (p>.05).

7.1.3.4 Site and size of lesion in the anterior participants

Only limited comparisons could be carried out within the anterior group examining site and size of lesion, since sample sizes were extremely small once the groups were subdivided, and statistical power was low. Meaningful comparisons of this type could not be carried out for the posterior group, in view of the smaller sample size.

Unilateral left-sided (LA, N=5) and right-sided (RA, N=11) anterior participants were compared to examine any effects of side of lesion for the measures which significantly differentiated the anterior and posterior lesion groups, and also the combined lesion and control groups. For the executive battery, t-tests showed participants with left-sided lesions to be significantly poorer than those with right-sided lesions on Letter Fluency (t=2.56, df=14, p=.024) (LA mean 20.20, sd 17.28; RA mean 42.00, sd 15.36). In addition, the difference for Story Recall approached significance (F=3.30, df=1,14, p=.091). On the Predicaments test, participants with left-sided anterior lesions generated significantly fewer solutions than those with right-sided anterior lesions (t=2.28, df=14, p=.039) (LA mean 30.20, sd 6.18; RA mean 42.18, sd 10.82). The left-sided group also gained poorer scores on Optimal Solution Quality (t=2.23, df=14, p=.043) (LA mean 33.40, sd 2.97; RA mean
38.45, sd 4.61); Personal Solution Quality scores approached significance (t=1.82, df=14, p=.090).

When anterior lesions were divided into small, moderate and large in overall size, no significant effects of size were found (p>.05) on any of the neuropsychological tests or on the Predicaments test. A comparison of those with lesions confined to the frontal lobes versus those with both frontal and non-frontal involvement revealed no significant differences (p>.05). Since all but one of the anterior group had lesions involving lateral frontal cortex, it was not possible to make meaningful statistical comparisons of the effects of pure lateral versus orbital versus medial frontal lesions. Individual scores on the Predicaments test were therefore inspected in relation to frontal lesion site for the measures of greatest interest (Number of Solutions, Optimal and Personal Solution Quality). Rank ordering of scores for each measure for individuals in the anterior group did not reveal any obvious patterns related to lesion site, other than side of lesion. For Number of Solutions, 4 of the 5 lowest scorers had left-sided lesions. Similarly, 4 of the 6 lowest scorers for Optimal Solution Quality had left-sided lesions, as did 4 of the 5 lowest scorers for Personal Solution Quality. As Table 7.1 shows, 5 of the anterior group had left-sided lesions, one confined to the lateral area, one lateral plus orbital, one lateral, orbital plus medial, and two lateral plus temporal. The 4 low scoring individuals within the left-sided subgroup were not the same for each of the three measures.

7.1.3.5 Mode of presentation
Within each group, half the participants received Set A as stories and Set B as videos; the other half received the video version of Set A and the story version of Set B. Analyses were carried out using ANOVA to compare the anterior and posterior groups, and then to compare the combined lesion group with the control group, in performance on Sets A and B for each of the variables measured in the Predicaments test. There was no significant effect of version (story versus video) for any of these variables, or significant interactions between group and version (p>.05).
7.1.3.6 Sex
Similar analyses were carried out to examine any effects of sex on the variables that significantly differentiated the groups on the Predicaments test. There was no significant effect of sex for any of these variables, nor any significant interactions between group and sex (p>.05).

7.1.3.7 Correlations between Predicaments measures
Pearson product moment correlations were calculated between the Predicament measures for the main comparison of interest, the anterior and control groups. Correlations between the Predicaments measures that significantly differentiated the groups (using a 5% significance level) are shown in Table 7.8.

For the anterior group, Number of Solutions correlated significantly with Optimal and Personal Solution Quality, and Optimal and Personal Solution Quality correlated significantly with each other; there were no other significant intercorrelations between these measures. For the control group, there was a significant negative correlation between Number of Solutions and Average Solution Quality, i.e. control participants who generated more solutions tended to score lower in the average quality of those solutions. Average Solution Quality correlated significantly with Optimal and Personal Solution Quality, and Optimal Solution Quality correlated significantly with Personal Solution Quality and with Judgement of Alternatives scores. The number of prompts needed did not correlate significantly with any other Predicaments measures for the anterior or control groups. The Awkwardness ratings for Main Character and Self did not correlate significantly with measures of Solution Quality for either group. Satisfaction ratings for Optimal solutions did not correlate significantly with Optimal Solution Quality; nor did Satisfaction ratings for Personal solutions correlate significantly with Personal Solution Quality for either group.
Table 7.8 Intercorrelations between Predicaments measures for the anterior and control groups.

<table>
<thead>
<tr>
<th></th>
<th>Number of Solutions</th>
<th>Average Solution Quality</th>
<th>Optimal Solution Quality</th>
<th>Personal Solution Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anterior Group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Solution</td>
<td>r=-.06</td>
<td>r=.34</td>
<td>r=.45</td>
<td>r=.48</td>
</tr>
<tr>
<td>Quality</td>
<td>p=.833</td>
<td>p=.195</td>
<td>p=.084</td>
<td>p=.061</td>
</tr>
<tr>
<td>Optimal Solution</td>
<td>r=.80</td>
<td>r=.34</td>
<td>r=.45</td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td>p=.001 **</td>
<td>p=.921</td>
<td>p=.0001 **</td>
<td></td>
</tr>
<tr>
<td>Personal Solution</td>
<td>r=.74</td>
<td>r=.74</td>
<td>r=.88</td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td>p=.001 **</td>
<td>p=.921</td>
<td>p=.0001 **</td>
<td></td>
</tr>
<tr>
<td>Judgement of</td>
<td>r=.34</td>
<td>r=.45</td>
<td>r=.48</td>
<td>r=.40</td>
</tr>
<tr>
<td>Alternatives</td>
<td>p=.195</td>
<td>p=.084</td>
<td>p=.061</td>
<td>p=.124</td>
</tr>
<tr>
<td><strong>Control Group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Solution</td>
<td>r=-.44</td>
<td>r=.06</td>
<td>r=.35</td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td>p=.026 *</td>
<td>p=.765</td>
<td>p=.080</td>
<td></td>
</tr>
<tr>
<td>Optimal Solution</td>
<td>r=.09</td>
<td>r=.51</td>
<td>r=.79</td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td>p=.664</td>
<td>p=.008 **</td>
<td>p=.0001 **</td>
<td></td>
</tr>
<tr>
<td>Personal Solution</td>
<td>r=.19</td>
<td>r=.51</td>
<td>r=.79</td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td>p=.359</td>
<td>p=.008 **</td>
<td>p=.0001 **</td>
<td></td>
</tr>
<tr>
<td>Judgement of</td>
<td>r=.06</td>
<td>r=.35</td>
<td>r=.44</td>
<td>r=.33</td>
</tr>
<tr>
<td>Alternatives</td>
<td>p=.765</td>
<td>p=.080</td>
<td>p=.025 *</td>
<td>p=.100</td>
</tr>
</tbody>
</table>

* p<.05 ** p<.01

7.1.3.8 Correlations with executive battery and DEX

Pearson product moment correlations were also calculated for the anterior and control groups between the Predicaments variables (excluding the percentage
ratings) and each of the tests used in the executive battery. As there were no group
by task interactions for time taken on the Cancellation or Hayling tasks, nor for
Story Recall, the two parts of these tests were summed for these comparisons. All
correlations that reached the 5% significance level are described below. All
significant correlations were in the expected direction, i.e. poorer performance on
one task was associated with poorer performance on the other, unless indicated.

For the anterior group, Number of Solutions generated correlated significantly with
Letter Fluency \( (r=-.66) \), Hayling time \( (r=-.59) \), Cancellation time \( (r=-.52) \) and Trail
Making time A \( (r=-.58) \). Optimal Solution Quality scores correlated significantly
with Rule Shift Cards \( (r=.53) \), Letter Fluency \( (r=.57) \), Cancellation time \( (r=-.61) \)
and Trail-making part A \( (r=-.65) \). Personal Solution Quality scores correlated
significantly with Cancellation time \( (r=-.52) \), as did Judgement of Alternatives
score \( (r=-.60) \). There were no other significant correlations for this group.

For the control group, the number of prompts needed in the Predicaments test
correlated significantly with Letter Fluency \( (r=-.47) \) and Trail Making time B
\( (r=.56) \). Number of Solutions generated correlated significantly with Rule Shift
Cards \( (r=.41) \), Trail Making time B \( (r=-.48) \), and Story Recall \( (r=.42) \). Average
Solution Quality correlated significantly with Rule Shift Cards \( (r=-.45) \), such that
better Rule Shift Cards scores were associated with poorer Average Solution
Quality (but also with a higher number of solutions) for this group. Personal
Solution Quality scores correlated significantly with Trail Making time A \( (r=.44) \),
such that better Solution Quality scores were associated with poorer Trail Making
performance. Judgement of Alternatives correlated significantly with Letter
Fluency \( (r=.40) \) and the Six Elements Test \( (r=.44) \).

For the anterior group, correlations between the DEX and performance were
examined. DEX self-ratings did not correlate significantly with either the
Predicaments test or the executive measures. For DEX-other, scores correlated
significantly only with Judgement of Alternatives of the Predicaments measures
\( (r=-.65) \), and only with Rule Shift Cards for the standardised tests \( (r=-.56) \).
7.1.4 DISCUSSION

7.1.4.1 Summary of results
Overall, the results of the Predicaments test suggested that as predicted, participants with anterior lesions showed more extensive impairment in problem-solving than those with posterior lesions, who were nevertheless impaired relative to the control group in selecting appropriate problem solutions. Those with left-sided anterior lesions were poorer than those with right-sided anterior lesions on several measures. Contrary to predictions, the anterior group did not show impairments relative to the posterior group on any of the executive measures, although when these two groups were combined, they performed more poorly than the control group on all of the measures in the executive battery.

Participants with anterior lesions generated fewer solutions to the Predicaments scenarios than both the group with posterior lesions and the control group. The anterior group also showed a wider range of difficulties in the quality of the optimal and personal solutions they selected. They showed deficits in all three aspects of performance, ability to appreciate the pertinent interpersonal/practical aspects of the situations, and to devise solutions judged likely to be socially appropriate and effective. For instance, when presented with a situation in which a neighbour fails to return a borrowed lawnmower despite repeated requests, the optimal solution chosen by one participant in the anterior group was “threaten him with legal action”, an option not typically suggested by participants in the control group even during the solution generation part of the test. The posterior group showed fewer impairments than the anterior group, and those they did show were in relation to optimal but not personal solutions.

When asked to judge given solutions rather than generate them, participants with focal lesions were again found to perform significantly worse than participants in the control group, although site of lesion did not influence this significantly. The judgement of alternatives task was probably less sensitive a measure than the selection of optimal and personal solutions. This was in part because the
alternatives presented for each problem reflected relatively large differences in quality, such that at least one or two of the five solutions could readily be judged to be very poor; the presentation of alternative solutions which all provided at least partially acceptable solutions would have offered a subtler test of comparative judgements. The present findings may therefore underestimate the extent of decision-making difficulties in making such judgements in the lesion groups.

7.1.4.2 Awareness of deficits

Both optimal and personal perspectives were included in the measure in order to determine whether the anterior group would respond differently to the two perspectives, in the light of previous work showing that self-awareness of difficulties in people with anterior lesions can be altered if they consider the same information from a different point of view (Stuss, 1991b). However, the anterior and control groups showed the same pattern of responses to the two perspectives, with both gaining higher scores for Optimal Solution Quality than for Personal Solution Quality. This indicated that the course of action they sometimes chose for themselves was not rated to be as advantageous as the solutions they selected for the main character. For instance, one problem situation involved resisting group pressure to join in a celebration by drinking champagne, because the main character was taking antibiotics. Some individuals gave optimal solutions that involved joining in the celebration without drinking alcohol, but said that they themselves would have an alcoholic drink in that situation, although they knew that they should not.

The percentage ratings were also intended to provide an indication of self-awareness of any difficulties. No differences were found between the groups on the ratings of awkwardness and satisfaction. In light of the poorer quality of the lesion groups' optimal and personal solutions, it might have been expected that they would rate the situations as more awkward, and their responses as less satisfactory than the control group. Previous work has linked frontal lobe lesions in particular to impairments in self-awareness (e.g. Stuss, 1991a, Markowitsch & Kessler, 2000),
and the failure to find group differences on these measures may thus reflect a subtle degree of impairment in awareness or judgement of one’s own performance.

7.1.4.3 Relationships between Predicaments measures
In terms of correlations between the Predicaments measures, the number of possible solutions generated correlated significantly with quality of those selected as optimal and personal solutions for the anterior group, but not for the control group, who tended to select higher quality solutions regardless of the number of possible solutions generated. Moreover, control participants who generated more solutions tended to score lower in the average quality of those solutions, perhaps because they may have exhausted the possible range of good solutions to the problems in generating higher numbers of ideas. The anterior participants, who generated fewer solutions than the control participants, did not show a significant correlation between number of solutions generated and average solution quality, probably because they were less likely to have exhausted the possible range of good solutions. Thus, ability to generate a range of possible solutions appears to have been an important source of difficulty for the anterior participants, since failure to generate adequate solutions could clearly contribute to poor selection of optimal and personal solutions. It is obviously possible to generate a moderately low number of possible solutions, and nevertheless to score well on the solution quality measures. This can be achieved by ignoring the instructions to give as many solutions as possible, and generating and/or reporting only those that are high in quality, or by not searching for more ideas once a satisfactory one has been generated. However, there was no evidence that the anterior group did this in the present study, since every individual in this group with a low score for number of solutions also scored at least one standard deviation below the control mean on the optimal and personal solution quality measures.

7.1.4.4 Contributions to impairments on the Predicaments test
Could factors such as memory or language impairment have contributed to the difficulties shown by the participants with focal lesions on the Predicaments test? Impairments shown could not be accounted for in terms of poor memory for the
scenarios, since all participants were given the opportunity to see the video/story again if they so wished in order to reduce the effects of any memory problems. In addition, the groups did not differ on the number of prompts needed to give a full account of the factual details of the situation. The greater levels of impairment seen in the left-sided anterior participants relative to the right-sided subgroup could lead to speculation that poor language processing was a relevant factor. However, intact language comprehension was a criterion for inclusion in the study, and the TROG was used as a screening measure, on which all participants scored within the normal range. Thus, any difficulties seen in the lesion participants were not likely to be due to impairments in memory or language comprehension.

7.1.4.4.1 The role of executive processes
Problem-solving in everyday life situations involves selecting which information to attend to, identifying appropriate goals, looking ahead to potential future consequences of different courses of action, making reasoned comparative judgements about them, and evaluating performance. These are likely to depend heavily on executive processes, and the standardised executive tests selected for the study were intended to reflect a range of postulated subprocesses. The participants with focal lesions showed impairments relative to the control group on all the categories of measures, including attention and set-shifting, inhibition and strategy generation, multitasking, deductive reasoning and executive memory. None of these measures was differentially sensitive to anterior versus posterior lesions, in contrast to the Predicaments test, and against expectations. Small sample sizes may have contributed to the pattern of findings, however it is also known that performance on executive tests is dependent on other, non-executive processes, and that people with non-frontal lesions can therefore perform badly on them in spite of intact executive function (Burgess, 1997). There were a number of significant correlations between performance on the executive tests and the Predicaments measures that differentiated the groups for the anterior group, suggesting that executive processes are likely to play an important role in a problem-solving task of this nature. This applied particularly to the Number of Solutions generated with tasks thought to involve set-shifting, response inhibition and strategy generation. It was anticipated
above, in section 7.1.2.3, that these types of measures would be most strongly related to generation of solutions. There were additional correlations between measures in these categories, and the optimal and personal solution quality scores, although this may be due to the fact that the number of solutions generated also correlated with the final solution quality scores.

The number of solutions generated correlated most highly for the anterior group with aspects of the Hayling and Letter Fluency tasks. Burgess and Shallice (1996) argued that one possible source of difficulty for participants with anterior lesions on the Hayling test was an inability to generate and use strategies. Other studies have also concluded that participants with frontal lobe lesions have difficulty in spontaneously adopting efficient performance strategies (e.g. Owen et al, 1990). Letter fluency tasks are also likely to involve strategic processes, although generating words beginning with certain letters is likely to rely on better rehearsed strategies (such as semantic and alphabetic search) than strategies for generating appropriate solutions to problem situations. Although formal debriefing was not carried out, it was noted informally from comments made by some individuals that they used a strategy to generate solutions to the Predicaments situations, such as thinking of the best and worst types of approach, and then trying to fill in more intermediate positions. Although the executive measures that correlated with solution fluency also have inhibitory components, it has been argued that there is a reciprocal link between inhibition and strategy use (Burgess, 1997). Impoverished solution generation by the lesion participants in the present study may therefore be related to their failure to generate, or make use of, appropriate performance strategies in searching for relevant past experience and integrating this effectively with the demands of the current problem situation. In spite of the small sample sizes when examining the effects of side of lesion, participants with left-sided anterior lesions were impaired relative to those with right-sided lesions on both solution fluency in the Predicaments test, and Letter Fluency in the executive battery. Both Letter Fluency and the Hayling test have been linked particularly to areas of the left prefrontal cortex (e.g. Paulesu et al 1997; Baldo et al, 2001; Collette et al, 2001), and it is therefore plausible that strategic processing is more
disrupted in those with left-sided lesions. Strategy generation processes are thought to be relevant in novel problem-solving situations in the model of the supervisory system outlined by Shallice and Burgess (1996).

7.1.4.4.2 The role of interpersonal factors
The anterior group showed differential impairment on aspects of the Predicaments test, compared with the executive battery, indicating that other factors may have contributed to their difficulties in addition to executive dysfunction.

Frontal lobe lesions have been linked with difficulties in interpreting nonverbal interpersonal cues such as face perception or voice intonation (Hornak, et al 1996). However, these factors could only apply to video presentation, and there were no significant effects of mode of presentation. It was clear from people's informal comments that video rather than written presentation made the task more enjoyable, but there was little evidence to suggest that this significantly altered the nature of the results compared to more traditional story-type tasks. The evidence therefore indicates that impairments in interpreting nonverbal cues were not likely to be a particular source of difficulty on the Predicaments test for anterior participants in the current study.

There is some evidence from previous studies of altered empathic ability associated particularly with areas of the frontal lobe (e.g. Grattan et al, 1994; Eslinger, 1998; Farrow et al, 2001), although studies have also found that posterior lesions can be associated with similar decrements on measures of empathy (Eslinger, 1998). Performance on theory of mind tasks has also been linked to areas of the frontal lobes (e.g. Stuss et al, 2001). Everyday problem-solving commonly involves interpersonal interactions, as in the present study when it was usually important in the Predicaments test to take into account the motivations and the sensibilities of the various characters in the situations. It is possible that failure to consider the situation from others' perspectives is a relevant factor affecting solution quality for the anterior group. However, they showed impairment both in considering situations from the perspective of the main character, and from their own
perspective. There is more evidence that these factors may have been relevant for the posterior group, who showed significant impairment on aspects of Optimal Solution Quality, but not Personal Solution Quality, when the individual subscales were examined. Nevertheless, difficulties in interpersonal relationships were central to many of the awkward situations, and participants with anterior lesions showed impairment in selecting solutions that were socially appropriate. It is beyond the scope of the current study to determine whether specific difficulties in comprehending and judging interpersonal issues contributed markedly to the anterior group's deficits.

7.1.4.4.3 The role of previous experience

Although the fact that the anterior group generated fewer solutions overall may contribute to their poorer optimal and personal scores, this cannot give a complete account of these differences, since the average solution quality of their answers did not differ from those of the control participants. One possibility is that the anterior group also had difficulty in applying their prior knowledge to the situations, in order to guide their judgement and decision-making. This may have affected their ability to appreciate the pertinent aspects of the Predicaments (Problem Appreciation), leading to inappropriate goal setting. It might also have affected their ability to monitor how socially appropriate and effective their solutions were for each problem situation, and to look ahead to the possible consequences of their actions. This is consistent with previous work, suggesting that patients with frontal lobe lesions have difficulty in using their prior knowledge to guide planning (e.g. Goel et al, 1997). The Shallice and Burgess model (1996) emphasises the dynamic nature of problem solving processes, involving the construction, implementation, and ongoing monitoring of temporary new schemas. Thus, selection of poorer quality solutions in the Predicaments test could reflect construction of inadequate schemas, and poor monitoring of these schemas.

7.1.4.4.4 The role of emotional processes

The findings of impaired solution fluency and decision-making in the present study therefore appear to be consistent with the model of the supervisory processes
outlined by Shallice and Burgess (1996). However, this model does not attempt to address the question of emotional in addition to cognitive contributions to performance. Damasio and colleagues (e.g. Damasio et al, 1990; Bechara et al 1994; Bechara et al, 1997) postulate that somatic/emotional markers may play a crucial role in supporting cognitive decision-making processes, and that these are compromised in patients with bilateral ventromedial lesions. These markers are said to provide cues based on previous learning of reward or punishment from prior experience, and these cues influence performance before conscious knowledge is available to guide reasoning. It has been argued that the knowledge base itself may be intact in these patients, and that the deficit is specifically in terms of decision-making (Saver & Damasio, 1991). Rolls (e.g. Rolls, 1996; Rolls et al, 1994) also argues that areas of frontal cortex, particularly orbital regions, are involved in modulating behaviour according to previous experience of reward and punishment; for instance, patients with frontal lesions have been found to be impaired in reversal learning (e.g. Daum, Schugens, Channon, Polkey & Gray, 1991). Although none of the participants in the current study had bilateral lesions, it is possible that emotional/somatic factors may have contributed to their difficulties in addition to cognitive factors, although no direct evidence was available to evaluate this. However, while the somatic marker hypothesis might predict selection of poor choices for optimal and personal solutions, it cannot account for the reduced solution fluency in the anterior group. The somatic marker theory has similarities with some of the other theories discussed, in arguing that there is a failure to use prior knowledge appropriately in anterior participants, but it emphasises an emotional rather than a cognitive mechanism. It has been argued that the different emphases of the Shallice & Burgess and Damasio models are probably complementary rather than in competition (Burgess et al, 2000).

7.1.4.5 The validity of the Predicaments test
To what extent can it be inferred that performance on the Predicaments test predicts real-life problem-solving behaviour? Experimental tests might potentially underestimate, or indeed overestimate, the extent of everyday difficulties shown by people with brain lesions. Underestimation on the basis of laboratory performance
may stem from factors such as the structuring cues provided by tests compared to the lack of clear structure in everyday life, and the provision of all the relevant information together, which is often not available in real life. The Predicaments test attempted to avoid these issues by using open-ended problem situations and minimising the use of questions and prompts. Overestimation of real-life problems might result because people have difficulties in imagining the situations in reality, or are less motivated by a personal need to resolve the problems. The problem situations in the Predicaments test were hypothetical, and were solved verbally rather than carried out in real life. However, several factors suggested their relevance for everyday behaviour. Their ecological validity was thought to be high since they were based on real-life situations that most people might encounter either personally or through others, and the video versions were presented in real time. Moreover, the anterior group, who showed the greatest level of impairment, were also characterised by real-life difficulties such as disinhibited behaviour. It therefore seems plausible that impairment both in generating and selecting appropriate problem solutions as demonstrated on the Predicaments test is likely to reflect potential difficulties in dealing with real-life problem situations, although this cannot be established beyond doubt. Nevertheless, the development of tests such as this appear to offer an intermediate step in the assessment of real-life problems compared to conventional abstract tasks or lengthy observation of everyday behaviour.

The DEX questionnaire was included to give an indication of everyday life behaviour, and the lack of significant group differences on the DEX questionnaire was surprising. Selection of patients for the study was based on the presence of a circumscribed brain lesion involving (or not involving) the frontal cortex, rather than on behavioural criteria. However, disinhibited or other inappropriate behaviour during testing revealed significant abnormalities in some although not all of the anterior participants, and clinical information available for some of them confirmed that this was also an issue in everyday life. Another important factor may be the way that the DEX rating scale was interpreted by individuals, and possible group differences in this. The range of behaviour used for comparison for the normal
participants was probably narrower than for the lesion participants, who may have had considerably greater experience of behavioural problems associated with brain injury, whether in themselves or others. Moreover, ratings made by patients and by relatives on different scales have previously been reported to underestimate the extent of problem behaviour, as assessed by professionals (e.g. Fordyce & Roueche 1986). Ratings from professionals would probably have provided a more accurate assessment, especially if the same individuals rated all the participants. Additional information available for two cases in the present study lent some support to this, since both received low DEX ratings, but were known to have severe problems in everyday behaviour. Further information about everyday problem-solving performance could be gained in future work by asking patients and relatives to describe any specific real-life difficulties encountered in a range of common situations.

7.1.4.6 Summary

In summary, the findings showed that participants with anterior brain lesions were impaired in aspects of real-life-type problem-solving performance, as predicted in Hypothesis 1, and that impairment was more extensive for participants with left-sided lesions. Participants with posterior lesions also showed impairments on the Predicaments test, although these were less marked than those in the anterior group, as predicted in Hypothesis 2. The pattern of results suggests that brain damage may disrupt ability both to generate solutions and to select socially appropriate and effective practical solutions. Contrary to the prediction in Hypothesis 3, the anterior and posterior groups did not differ from each other on the measures in the executive battery. It was speculated that a range of non-executive processes might be relevant to performance on these tasks, in addition to executive skills. The findings suggest that the Predicaments test is more sensitive to the deficits shown by participants with anterior lesions than many abstract, standardised measures. However, as predicted in Hypothesis 4, there were significant correlations between some of the executive measures and the Predicaments measures. A range of factors potentially contributed to the impairments shown by the anterior group, including deficits in executive function, poorer judgment of interpersonal issues, adequate application of
prior knowledge to guide performance, and disrupted emotional processes. The study described in Part B goes on to detail the adaptation of this measure, with the intention of providing a test that is both more sensitive to the deficits shown by participants with frontal lobe lesions, and is more user-friendly.
7.2 PART B

7.2.1 INTRODUCTION

The findings reported above showed that multiple dimensions of problem-solving could be assessed using the Predicaments task. However, the measure was time-consuming to administer and score, and there were no differences in performance according to mode of presentation. Therefore, it was decided to develop a shorter form of the test, which could be presented solely on video in order to retain ecological validity, or alternatively, could be presented as stories for ease of testing in any setting. This section describes the development of a shorter, sharper version of the Predicaments test using eight of the original sixteen items. The purpose was to create a measure that was more sensitive to the effects of anterior lesions, but with a smaller number of scenarios. The intention was to administer this shorter measure to other groups of participants with postulated frontal lobe involvement, and compare the profiles seen with those of participants with structural frontal lobe lesions. For this purpose, only the performance of the anterior group relative to the control group was considered pertinent. Therefore, eight scenarios were selected as described below. Analyses were performed in order to ensure that the lower power did not reduce the sensitivity. In addition, in order to allow for easier comparison of the profile of results with other groups with potential frontal lobe dysfunction, analyses were also carried out for the measures in the executive battery comparing the anterior and control groups.

7.2.1.1 Hypotheses

1) It was hypothesised that the anterior group would remain impaired on the shorter Predicaments measure relative to the control group.

2) It was hypothesised that for the measures in the executive battery that significantly differentiated the lesion and control groups in Part A, the anterior group would differ significantly from the control group when the posterior participants were not included.
7.2.2 METHOD

7.2.2.1 Selection of items

The aims in choosing a reduced set of items were to retain sensitivity to the differences between the anterior and control groups, while keeping easily understood scenarios reflecting a range of different types of relationships and situations. Firstly, the quality of final solutions was examined. As described above, participants' optimal and personal solutions were originally scored out of three points. These scores were added together for the sixteen original items to create a score out of six for each. The mean scores were examined for the two groups, and four of the sixteen items were rejected on the basis that the anterior group gained higher scores than the control group, although none of these differences approached significance. Secondly, the number of solutions generated for each item was examined. On all sixteen items, the mean score for the control group was higher than that for the anterior group. Examination of individual t-tests showed that on four of the twelve items, the control group gained higher scores than the anterior group on both the generation and selection aspects of the task (p<.10); these four items were therefore selected for the shorter measure (two from each of sets A and B).

As there was little to choose in terms of relative sensitivity between the remaining four items, it was decided to reject those in which the mean number of prompts needed for the control group was greater than one, as the number of prompts was an indirect measure of how easily participants could understand the scenarios. This left five items, three from set A and two from set B, from which to choose four. In order to keep even numbers from the two sets, the two scenarios from set B were retained. The choice between the three items from set A was made with the aim of retaining a wide variety of types of problem within the test. The final set of eight Predicaments is shown in Appendix C.
7.2.2.2 Participants and procedure
The participants were the same anterior and control groups described above. The procedure is also as described above.

7.2.3 RESULTS

7.2.3.1 Statistical analysis
The original analysis of the Predicaments test contained a large number of variables. Many of the items asked similar questions from different perspectives, in order to ascertain whether participants would adopt different strategies and priorities when considering another person’s view rather than their own; this applied to ratings of awkwardness and satisfaction, and to the choice of optimal and personal solutions. However, as described above, the evidence indicated that the anterior and control groups did not show different patterns of findings across perspective. In addition, a number of participants in all groups questioned some of the satisfaction ratings, in that they found it conceptually difficult to rate how many other people would be satisfied with their solutions. It was therefore decided to exclude the other-satisfaction ratings from the current analysis, and combine the other variables across perspective, in order to reduce the number of different variables being considered.

Following the processes described in the previous chapter, the variables of interest were initially examined for outliers and skewness. This showed that for the control group, both number of prompts and average satisfaction ratings for the Predicaments test had outliers. As multivariate analyses were not necessary for either variable, both were analysed non-parametrically, using Mann Whitney U tests. All variables that met assumptions of normality were analysed parametrically, using t-tests. A 5% significance level was adopted throughout to compare the two groups.
### 7.2.3.2 Predicaments test

Mean scores, standard deviations and results of statistical tests are shown in Table 7.9.

**Table 7.9** Mean scores and standard deviations for the Predicaments test: anterior participants versus the control group.

<table>
<thead>
<tr>
<th></th>
<th>Anterior group</th>
<th>Control group</th>
<th>Test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average number of Prompts</td>
<td>0.85 (0.57)</td>
<td>0.88 (0.40)</td>
<td>z=0.27</td>
<td>.784</td>
</tr>
<tr>
<td>Average Awkwardness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratings /100%</td>
<td>63.90 (14.48)</td>
<td>65.02 (11.26)</td>
<td>t=0.28</td>
<td>.781</td>
</tr>
<tr>
<td>Solution Generation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Solutions</td>
<td>19.56 (5.74)</td>
<td>27.04 (7.29)</td>
<td>t=3.49</td>
<td>.001**</td>
</tr>
<tr>
<td>Average Solution Quality</td>
<td>1.90 (0.25)</td>
<td>1.96 (0.29)</td>
<td>t=0.68</td>
<td>.503</td>
</tr>
<tr>
<td>Solution Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final (Optimal plus Personal)</td>
<td>32.31 (6.06)</td>
<td>41.12 (3.36)</td>
<td>t=5.33</td>
<td>.001**</td>
</tr>
<tr>
<td>Final Problem Appreciation</td>
<td>12.94 (2.02)</td>
<td>15.15 (1.05)</td>
<td>t=4.07</td>
<td>.001**</td>
</tr>
<tr>
<td>Final Social Appropriateness</td>
<td>9.75 (2.08)</td>
<td>12.88 (1.53)</td>
<td>t=5.61</td>
<td>.0001**</td>
</tr>
<tr>
<td>Final Effectiveness</td>
<td>9.88 (2.90)</td>
<td>13.42 (1.55)</td>
<td>t=4.52</td>
<td>.0001**</td>
</tr>
<tr>
<td>Average Satisfaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratings/100%</td>
<td>79.33 (11.27)</td>
<td>77.70 (12.01)</td>
<td>z=0.49</td>
<td>.698</td>
</tr>
<tr>
<td>Judgement of Alternatives</td>
<td>132.00 (9.61)</td>
<td>135.85 (7.15)</td>
<td>t=1.48</td>
<td>.146</td>
</tr>
</tbody>
</table>

** p<.01
7.2.3.2.1 Factual account of the Predicaments
The two groups did not differ significantly on the number of prompts needed to recount the factual details of the situations (z=0.27, p=.784).

7.2.3.2.2 Awkwardness ratings
A t-test was performed on the average awkwardness ratings, and showed that the anterior and control groups did not differ significantly (t=0.28, df=40, p=.781).

7.2.3.2.3 Solution generation
A t-test comparing the total numbers of solutions generated by the two groups showed that the control group generated significantly more solutions than the anterior group (t=3.49, df=40, p=.001); the mean scores are shown in Figure 7.6. When Average Solution Quality scores were examined (Figure 7.7.), a t-test showed that there was no difference between the groups (t=0.68, df=40, p=.503). Thus, although the control participants produced more ideas, these were not necessarily of higher quality.

Figure 7.6: Mean scores for Number of Solutions for the anterior and control groups
3.00
2.00
1.00
0.00
0.50
1.50
2.50
3.00
average solution quality

control
anterior

group

Figure 7.7: Mean scores for Average Solution Quality of solutions for the anterior and control groups

7.2.3.2.4 Selection of final solutions
For each problem situation, participants were asked to select an optimal solution from the perspective of the main character, and then to give their own personal solution. These were rated on Problem Appreciation, Social Appropriateness and Effectiveness, and combined, to give a score out of six for each scenario (Final Solution Quality). A t-test using separate variance estimates showed that the anterior group gained significantly lower scores than the control group (t=5.33, df=20.77, p=.0001); mean scores are shown in Figure 7.8.
When the subscales were examined individually using an adjusted significance level (.05/3=.017), the anterior group were found to have gained significantly poorer scores on all three measures: Problem Appreciation ($t=4.07$, $df=20.06$, $p=.001$), Social Appropriateness ($t=5.61$, $df=40$, $p=.0001$) and Effectiveness ($t=4.52$, $df=20.40$, $p=.0001$); these results are shown in Figure 7.9.
7.2.3.2.5 Satisfaction ratings

A Mann Whitney U test comparing satisfaction ratings showed no significant differences between the anterior and control groups (z=0.49, p=.698).

7.2.3.2.6 Judgement of alternative solutions

In order to examine whether participants showed any difficulties in judging the adequacy of solutions even when they were not required to generate them, participants’ rankings of 5 alternative solutions for each problem situation were examined. T-test comparison of the groups showed no significant differences in Judgement of Alternatives scores (t=1.48, df=40, p=.146).
7.2.3.3 Site of lesion

Unilateral left-sided (LA, n=5) and right sided (RA, n=11) participants were compared on the Predicaments measures. Participants with left-sided lesions generated significantly fewer solutions than those with right-sided lesions (t=2.33, df=14, p=.035) (LA mean 15.20, sd 4.20; RA mean 21.55, sd 5.34), and their scores were poorer on Final Solution Quality (t=2.41, df=14, p=.030) (LA mean 27.60, sd 3.05; RA mean 34.45, sd 5.94).

7.2.3.4. Mode of presentation

Within each group, half of the participants received Set A as stories and Set B as videos, with the pattern reversed for the other half of the group. Analyses were carried out for each of the Predicaments variables using ANOVA with two between-groups factors (group: anterior or control; set: A or B). There was only one significant main effect of set (p<.05), which occurred for total Problem Appreciation (F=5.24, df=1,38, p=.028). However, the group by mode of presentation interaction was not significant (F=1.72, df=1,38, p=.197), suggesting that this applied to both the anterior and control groups. Correlations indicated that story presentation tended to be associated with higher scores on this measure than video presentation.

7.2.3.5 Sex

Similar analyses were carried out to investigate the effects of sex on the Predicaments variables. There was no significant effect of sex for any of the variables, nor any significant group by sex interactions (p>.05).

7.2.3.6 Correlations between Predicaments measures

Pearson product moment correlations were calculated for each group between the following Predicaments measures: Number of Solutions generated, Average Solution Quality, Final Solution Quality, and Judgement of Alternatives scores. All correlations that were significant (p<.05) are listed below, and all were in the expected direction, such that poor performance on one task was associated with
poor performance on the other task. For the anterior group, number of solutions generated correlated with Final Solution Quality scores ($r=.68$, $p=.004$), and Final Solution Quality scores correlated with Judgement of Alternatives score ($r=.63$, $p=.009$). For the control group, Number of Solutions generated correlated with Average Solution Quality ($r=-.52$, $p=.006$), in that producing a larger number of solutions was associated with poorer overall quality of those solutions. Average Solution Quality also correlated with Final Solution Quality scores ($r=.47$, $p=.015$). This pattern of results was similar to that reported previously in Table 7.8. The exceptions were that the Final Solution Quality scores did not correlate with Judgement of Alternatives scores for the control group in this shorter version of the test, although in the original version there were correlations between Judgement of Alternatives and Optimal Solution Quality scores for this group. By contrast, in this shortened version of the test, there was a correlation between Judgement of Alternatives and Final Solution Quality scores for the anterior group, that was not seen for either Optimal or Personal Solution Quality in the original analysis.

7.2.3.7 Executive Battery

Mean scores, standard deviations and significance tests for the groups are shown in Table 7.10.
Table 7.10. Mean scores and standard deviations for the executive battery: anterior participants versus the control group.

<table>
<thead>
<tr>
<th></th>
<th>Anterior group</th>
<th>Control group</th>
<th>Test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deductive reasoning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raven’s Matrices</td>
<td>10.50 (2.97)</td>
<td>12.69 (2.48)</td>
<td>t=2.58</td>
<td>.014*</td>
</tr>
<tr>
<td>Attention and set-shifting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIT&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Star time</td>
<td>47.40 (32.96)</td>
<td>35.69 (9.46)</td>
<td>F=7.44</td>
<td>.010*</td>
</tr>
<tr>
<td>Letter time</td>
<td>78.93 (34.77)</td>
<td>51.92 (9.94)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trail Making Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>44.25 (21.58)</td>
<td>30.19 (12.29)</td>
<td>F=6.13</td>
<td>.018*</td>
</tr>
<tr>
<td>Time B</td>
<td>109.44 (80.31)</td>
<td>70.65 (27.17)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rule Shift Cards</td>
<td>3.06 (0.77)</td>
<td>3.58 (0.50)</td>
<td>t=2.62</td>
<td>.012*</td>
</tr>
<tr>
<td>Inhibition and strategy generation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hayling Test&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>28.13 (20.79)</td>
<td>19.72 (7.82)</td>
<td>F=3.51</td>
<td>.069</td>
</tr>
<tr>
<td>Time B</td>
<td>63.63 (63.74)</td>
<td>31.32 (19.03)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E Errors</td>
<td>3.31 (3.74)</td>
<td>1.64 (1.58)</td>
<td>t=1.70</td>
<td>.107</td>
</tr>
<tr>
<td>Letter fluency</td>
<td>35.19 (18.59)</td>
<td>46.04 (14.43)</td>
<td>t=2.12</td>
<td>.040*</td>
</tr>
<tr>
<td>Multitasking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Six Elements Test</td>
<td>3.31 (0.87)</td>
<td>3.73 (0.45)</td>
<td>t=1.78</td>
<td>.091</td>
</tr>
<tr>
<td>Executive memory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story Recall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>33.56 (8.66)</td>
<td>38.96 (8.43)</td>
<td>F=5.48</td>
<td>.024*</td>
</tr>
<tr>
<td>Delayed</td>
<td>28.87 (11.64)</td>
<td>36.69 (8.36)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dysexecutive behaviours (DEX)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self rating</td>
<td>17.50 (9.08)</td>
<td>20.77 (7.12)</td>
<td>t=1.30</td>
<td>.201</td>
</tr>
<tr>
<td>Other rating&lt;sup&gt;3&lt;/sup&gt;</td>
<td>23.29 (17.21)</td>
<td>17.12 (10.26)</td>
<td>t=1.41</td>
<td>.168</td>
</tr>
</tbody>
</table>

* p<.05  
<sup>1</sup>N=15 anterior, 26 control  
<sup>2</sup>N=16 anterior, 25 control  
<sup>3</sup>N=14 anterior, 25 control
T-tests were initially carried out for each of the neuropsychological tests, or ANOVA for tests involving two tasks (BIT, Trail Making, Hayling time and Story Recall). Comparison of the two groups showed that the anterior group gained significantly poorer scores than the control group on a number of tests. On the attention and set-shifting measures, they were significantly slower than the control group on the Cancellation tasks (F=7.44, df=1,39, p=.010) and on the Trail Making Test (F=6.13, df=1,40, p=.018), and their scores were poorer on the Rule Shift Cards Test (t=2.62, df=40, p=.012). On the inhibition and strategy generation measures, they showed reduced Letter Fluency (t=2.12, df=40, p=.040), and time taken on the Hayling Test approached significance (F=3.51, df=1,39, p=.069), although the difference in terms of Hayling error scores was not significant (t=1.70, df=18.47, p=.107). On the other measures, they performed more poorly than the control group on Raven’s matrices (t=2.58, df=40, p=.014), and Story Recall (F=5.48, df=1,40, p=.024), and the group difference approached significance for the Six Elements test (t=1.78, df=20.04, p=.091). Group by task interactions for the BIT, Trail Making and Story Recall approached, but did not reach, significance. For the DEX questionnaire, neither self- nor other ratings were significant (self: t=1.30, df=40, p=.201; other: t=1.41, df=37, p=.168).

7.2.3.8 Analysis of covariance with executive battery
The correlations reported above in section 7.1.3.7 revealed that there were some relationships between performance on tests in the executive battery and variables within the original version of the Predicaments test. In order to investigate these relationships further, the Predicaments measures that significantly differentiated the groups, Number of Solutions and Final Solution Quality, were each examined using the five sets of executive measures and the DEX as covariates. The results are shown in Table 7.11.
Table 7.11 Analyses of covariance between the Predicaments measures and executive battery

<table>
<thead>
<tr>
<th>Significance of group difference</th>
<th>Number of Solutions p</th>
<th>Final Solution Quality p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without covariates</td>
<td>.001</td>
<td>.0001</td>
</tr>
<tr>
<td>With executive measures used as covariates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deductive reasoning</td>
<td>.017*</td>
<td>.0001**</td>
</tr>
<tr>
<td>Attention and set-shifting</td>
<td>.116</td>
<td>.001**</td>
</tr>
<tr>
<td>Inhibition and strategy generation</td>
<td>.026*</td>
<td>.0001**</td>
</tr>
<tr>
<td>Multitasking</td>
<td>.005**</td>
<td>.0001**</td>
</tr>
<tr>
<td>Executive memory</td>
<td>.018*</td>
<td>.0001**</td>
</tr>
<tr>
<td>DEX</td>
<td>.003**</td>
<td>.0001**</td>
</tr>
</tbody>
</table>

* p<.05  **p<.01

The results showed that the group difference for Number of Solutions remained significant when any of the categories of executive measures were used as covariates, with the exception of the attention and set-shifting variables (p=.116). When the Final Solution Quality scores were examined, the group difference remained highly significant when any of the measures were used as covariates.

7.2.4 DISCUSSION

The results showed that the anterior group were impaired relative to the control group on both number of solutions generated and the quality of the solutions they selected as their final options. Similar patterns of correlations between the Predicaments measures were seen in both studies. Differential left-sided
impairment was also demonstrated in both studies. These findings indicate that the shortened measure has similar qualities to the longer version of the task. Since the anterior and control groups were compared directly on solution generation and quality of final solutions in Part A, it was possible to compare the differences between the two versions of the test. This showed that the group difference for Number of Solutions generated on the shorter measure was of even greater magnitude than that seen in Part A. In addition, the three submeasures of Problem Appreciation, Social Appropriateness and Effectiveness were all highly significant in Part B. These findings indicate that the shorter measure is more sensitive to the deficits shown by the anterior participants. In addition, the revised version of the test is shorter to administer, and is therefore more user-friendly for participants.

The only measure from the original analysis that did not reach significance in this shorter version of the test was the Judgement of Alternatives score. As the posterior participants were included in the original analysis, it could be postulated that they were the crucial factor. However, examination of the mean scores suggested that the anterior and posterior groups were performing the task at a similar level (anterior mean 266.33, sd 8.57; posterior mean 266.38, sd 13.57). Therefore, the lack of significant findings could be due to the reduced power caused by the smaller sample sizes and shortened measure. This appears to be the most likely explanation given the strong correlation between Final Solution Quality and Judgement of Alternatives scores seen in the anterior group. As noted above, it is also likely that the Judgement of Alternatives was a less sensitive measure, given that some of the ideas could be easily judged as very poor in relation to the others.

The findings from the executive battery showed that the anterior group scored significantly more poorly than the control group on most of the measures, even though the initial study had shown that they did not differ significantly from the posterior group. Significant differences were seen within all the categories of tasks with the exception of multitasking, which approached significance. Analyses of covariance were carried out to investigate the relationships between the Predicaments measures and executive battery further. These showed that the group
difference for Final Solution Quality remained significant regardless of which executive measures were used as covariates. The number of solutions generated also remained significant when most of the categories of tests were used as covariates, with the exception of the attention and set-shifting variables. The finding that attention and set-shifting measures were related to generation of solutions was as predicted in section 7.1.2.3.2. It was perhaps surprising that the measures of inhibition and strategy generation were not also relevant to this aspect of the task, as the previous discussion argued that there might be relationships between these processes (section 7.1.4.4.1). However, it is likely that many components including both executive and non-executive processes contribute to generation of solutions. Overall, the results from the two parts of this study suggest that performance on the Predicaments test is related to executive processes, but that executive dysfunction cannot account for all the difficulties shown by the anterior participants. Additional relevant factors, as discussed above, include interpersonal processes, the strategic access of prior experience to guide problem-solving, particularly in terms of considering the possible consequences of actions, and the potential contribution of emotional processes.

In summary, the anterior group showed impairment on aspects of the shorter Predicaments test as predicted in Hypothesis 1. They also showed impairment on most of the measures in the executive battery, as predicted in Hypothesis 2. The findings indicated that the shortened form of the Predicaments test was more sensitive to the effects of anterior lesions, whilst also being more user-friendly. The analyses of covariance demonstrated that factors other than executive processes were contributing to performance, although determining the exact contributions of these was beyond the scope of the current study. The subsequent studies attempt to investigate these contributions in more detail. The sensitivity of the shorter measure indicates that it is appropriate for use with other groups with postulated frontal lobe involvement, in order to investigate the contribution of experience to problem-solving performance.
CHAPTER 8
REAL-LIFE-TYPE PROBLEM SOLVING AND TOURETTE'S SYNDROME

8.1 INTRODUCTION
The current study describes the performance of a group of adults with Tourette’s syndrome (TS) on the Predicaments test and a set of standardised executive measures, relative to a matched control group. The aim of the study was to discover more about the relative contributions of knowledge/experience and executive skills to real-life problem-solving.

The previous chapter described the development of a measure of social problem-solving, designed to have greater ecological validity than most abstract executive tests. The findings showed that aspects of the measure, such as generating a range of ideas, and selecting good quality ideas, were more sensitive to the effects of frontal lobe lesions than a battery of abstract measures. One of the differences between the Predicaments task and the tests in the standardised battery is the extent to which prior knowledge can be used to guide problem-solving. The findings of the previous study indicated that although participants with anterior lesions generated fewer solutions than participants in the control group, their ideas were not of lower overall quality. However, the ideas they selected as the best options for the main character and themselves were poorer than those of the control group. This discrepancy could be caused by poor judgement, or a lack of ability to use their prior experience to evaluate the solutions.

Assessing the amount of previous experience that people have with particular situations is complex. People can gain experience directly, by encountering problem situations themselves. Experience can also be acquired vicariously through word of mouth, and through media, such as television and newspapers. It is therefore difficult to evaluate, and there are no existing reliable methods to achieve this. Another possible method of investigating the role of experience in real-life problem-solving is to test groups of participants who would be predicted to have different levels of previous experience. It has been proposed that the impact of
frontal lobe lesions varies depending on the age of injury, and that damage occurring before maturity results in impairments in real-life that are attributable to inadequate social knowledge (Dimitrov et al, 1999).

Therefore, assessing a group with lesions acquired prior to adulthood could potentially elucidate the role of experience in real-life problem-solving. However, studies of people with developmentally acquired structural lesions have reported mixed results. Some single case studies have indicated that people who sustain frontal lobe damage in childhood may show similar impairments in their everyday lives to those with adult-acquired lesions, but sometimes to a qualitatively greater extent (Price et al, 1990; Anderson et al, 2000; Tranel & Eslinger, 2000). However, other studies have reported that the social deficits in those with developmentally acquired structural lesions may largely resolve over time, leaving only subtle impairments (e.g. Eslinger & Biddle, 2000). The different findings are likely to be attributable to such factors as age at injury, and location of lesion (see e.g. Kolb et al, 2000; Stuss 1992). These factors, plus the relative rarity of such cases, and the issue of individual differences in development, indicate that a group study of the effects of developmental structural lesions would be impractical to undertake.

An alternative method of examining the effects of developmental frontal lobe disruption would be to evaluate the performance of participants with biochemical dysfunction, such as that implicated in Tourette’s Syndrome (TS). The consequences of having a developmental disorder may have both direct and indirect effects on people’s experience of social problem-solving. Direct effects could be caused by the impact of the disorder on executive processes, which could lead to poorer problem-solving and monitoring throughout the life span, meaning that people with TS would have a reduced range of experience to draw upon. Indirect effects include the effects of social stigma and poor peer relations that again could limit the range of experience.

As discussed above in section 4.2, TS is linked with dysfunction in fronto-striatal circuits (Leckman et al, 1997), and imaging studies have reported abnormalities in the basal ganglia and frontal lobe areas (Hyde et al, 1995; Moriarty et al, 1997;
Chase et al, 1986; Peterson et al, 2001). The current evidence from both imaging and neurotransmitter studies indicates that the areas of the frontal lobe that are most likely to be affected in TS are the lateral and anterior cingulate areas (e.g. Eidelberg et al, 1997; Stern et al, 2000; Leckman et al, 1997). If lateral areas are differentially affected by TS then it would be anticipated that participants with TS would show impairment in performance on standardised measures of executive function, and aspects of everyday problem-solving that are related to executive skills. Anterior cingulate regions have also been implicated as important in some executive tasks, particularly those involving inhibition of a prepotent response (e.g. Carter et al, 1998).

There is evidence that TS is associated with impairments in aspects of executive function, as discussed above in section 3.3. Studies have linked TS with impairment on tests of attention and set-shifting (Channon et al, 1992), inhibition (Baron-Cohen et al, 1994; Georgiou et al, 1995) and initiation and strategy generation (Sutherland et al 1982), although these studies did not examine the effects of comorbid conditions such as ADHD and OCD, which can also be associated with executive impairments in their own right (e.g. Walker, Shores, Troller, Lee & Sachdev, 2000; Purcell, Maruff, Kyrios & Pantelis, 1998). Relatively few studies that have looked at the performance of participants with uncomplicated TS, but deficits have been reported in areas including inhibition and strategy generation (Schuerholtz et al, 1996), and executive memory (Stebbins et al, 1995). Another study indicated that severity of TS was related to impairments in inhibition (Sherman et al, 1998). Inhibitory processes have been proposed to be particularly relevant to TS, as it has been argued that the motor and vocal tics represent a failure of appropriate motor inhibition (e.g. Leckman et al, 1991). The evidence overall indicates that TS is associated with some executive impairments, although these are less pervasive than those seen in people with structural frontal lobe lesions, consistent with primate work indicating that biochemical disruption of prefrontal areas may lead to more selective effects on performance than structural lesions in the same areas (Robbins, 2000).
In terms of interpersonal factors, people with TS are often reported to show socially inappropriate behaviour in their daily lives, such as insulting other people (Kurlan et al, 1996; Demirkol et al, 1999), similar to behaviours commonly reported in people with structural frontal lesions. This may be related to inhibitory failures due to executive deficits, since the study reported by Kurlan et al found that participants reported that they often had urges to perform socially inappropriate actions, but were sometimes able to suppress these. There are also reports that children with TS have difficulties with their social interactions, in terms of finding it difficult to make friends, and not having empathy and flexibility in their peer relationships (Bawdon et al, 1998; Carter et al, 2000; Kadesjö & Gillbert, 2000). One study examined theory of mind ability in children with TS, and found that they did not differ from matched control participants (Baron-Cohen et al, 1997). However, deficits in theory of mind are only one potential source of difficulty in social interactions and everyday problem solving. There are very few studies that have examined the social difficulties seen in TS in a systematic way, using real-life materials.

The evidence presented above indicates that participants with TS might be expected to show deficits in real-life problem-solving. It has been suggested that having a developmental disorder that affects frontal lobe functioning may have had adverse effects on the development of knowledge and experience, which might contribute to real-life difficulties. The evidence also indicates that TS is associated with executive impairments, albeit less marked than those seen in patients with structural lesions, which in turn might contribute to deficits in real-life performance. In addition, there is some evidence that people with TS may show difficulties in their daily lives in their interpersonal interactions, although these may be secondary to their executive deficits.

The current study describes the performance of adults with TS on multiple aspects of real-life-type problem solving using the shortened version of the Predicaments measure, described in part B of the previous chapter. The battery of abstract tests of executive function was also included, and the relationships between performance on these and the Predicaments measures were examined. The group with TS was
compared with a matched healthy control group. Given the possible confounds of comorbid ADHD and OCD, TS participants with these diagnoses were excluded from the study.

8.1.1 Hypotheses

1) It was hypothesised that participants with TS would show deficits on the Predicaments test. This was predicted particularly because of the postulated effects of the disorder on their development of social knowledge, and their executive skills.

2) In relation to the executive battery, it was predicted that the group with TS would show deficits on some aspects of the attention and set-shifting tasks, the inhibition and strategy generation tasks, and the executive memory tasks from the executive battery. No specific predictions were made regarding multitasking and deductive reasoning, given the lack of suitable studies on which to base these.

8.2 METHOD

8.2.1 Participants and Procedure

Twenty-one participants (18m, 3f) who met DSM-IV TR criteria (American Psychiatric Association, 2000) for Tourette Syndrome and no other disorder took part in the study. In order to establish the diagnosis and rule out any comorbid disorders such as ADHD and OCD, participants were assessed using the National Hospital Interview Schedule for Gilles de la Tourette Syndrome (Robertson & Eapen, 1996) by a psychiatrist specialising in the field. Those who met DSM-IV TR criteria for ADHD, OCD or any other comorbid psychiatric disorder (e.g. psychosis) were excluded from the study, as were those with any history of neurological disorder (e.g. head injury).

Twenty-one healthy control participants (17m, 4f) also took part in the study. To be included in the study, participants had to be between 18 and 65 years of age, fluent in English, and have a verbal IQ score of 85 or above on the NART-II (Nelson, 1991). Exclusion criteria included significant neurological or psychiatric illness (other than
those specified above for the TS participants) and alcohol or drug dependence. The TS and control groups did not differ significantly in age (TS mean 32.90, sd 10.66; control mean 36.71, sd 11.86), years of education (TS mean 13.00, sd 2.30; control mean 13.57, sd 2.11); or NART IQ (TS mean 106.19, sd 11.50; control mean 108.29, sd 10.19). All participants gave written informed consent for the study, and were given breaks between tasks as necessary, to avoid fatigue.

8.2.2 Predicaments test

The shortened version of the Predicaments test was given, as detailed in the previous chapter. This contained eight brief scenarios featuring everyday awkward situations across a range of social relationships, as listed in Appendix C. As there were no marked differences between video and story presentation in the previous study, all participants in the current study received videotaped presentation of the scenarios in order to increase ecological validity, and because informal comments in the previous study indicated that this was more enjoyable for participants. The situations were presented in a fixed order. No practice item was included in this shortened version, as the informal observations in the previous study indicated that participants grasped the point of the task very quickly, and it was therefore considered unnecessary.

8.2.2.1 Procedure

At the beginning of the task, participants were given a description of the task as detailed below:

"I am going to show you a series of short videos. Each one contains an awkward situation that everyone might encounter in daily life. After you have seen the video, I am going to ask you some questions about the situation. Here is a list of the questions I will ask you for each situation, so that you can get familiar with them. Some of the questions have a time limit, shown on your sheet. If you do not answer within the limit, I will ask you to give me an answer immediately. When I ask you to tell me what happened in the scene (experimenter points to the relevant place on the question sheet), please make your answer as complete as you can."
Participants were asked to watch each scenario, and then to answer a series of questions. The questions participants were asked are listed in Appendix B with the exception that the two questions asking them how many other people out of 100 would be satisfied with their solutions were omitted.

The Predicaments measures obtained were the same as detailed previously:

1) Number of prompts (out of three) needed to recount the factual details of the awkward situation.

2) Ratings of the degree of awkwardness of the situation, both for the main character, and for themselves if they were in that situation (0-100%). These were combined to give an average score.

3) Total number of solutions generated within a two-minute period. As before, participants were not given any prompts for further information or clarification of their suggested solutions, to ensure that no cues were provided as to the adequacy of their responses.

4) Selection of optimal and personal solutions. These were the responses given when the participants were asked to select the best solution from the perspective of the main character (optimal solution), and then to state what they themselves would do if they were in that situation (personal solution). The results from the two perspectives were combined to give an overall Final Solution Quality score.

5) Their self-ratings of satisfaction (out of 100%) with their optimal and personal solutions. These were combined to give an average score.

6) Their judgement of alternative solutions, where they ranked five different suggestions for what the main character could do in the situation in order from best to worst.

8.2.2.2 Scoring of quality of problem solutions

Responses were scored according to whether they were judged to show adequate appreciation of the pertinent aspects of the problem (Problem Appreciation), to be socially appropriate (Social Appropriateness), and to provide effective practical means of resolving the problem (Effectiveness), using the scoring criteria outlined
in the previous chapter (see section 7.1.2.2.9). All responses for the study were rated by one rater who was blind as to the identity and group membership of the participants, and by a second rater who was not blind. The two raters agreed for 90.2% of ratings. All differences were resolved by reference to an additional blind rater.

8.2.2.3 Solution generation

To assess how efficiently people generated solutions, the number of ideas generated for each problem situation was added (Number of Solutions). Each of these ideas was scored for Problem Appreciation, Social Appropriateness and Effectiveness. These scores were then added together and divided by Number of Solutions, to provide an Average Solution Quality score, i.e. adjusted for the number of solutions given.

8.2.3 Executive Battery

A battery of standardised tests was selected in order to assess aspects of executive function. This included the same measures as those used in the previous study with focal lesion participants, including (i) deductive reasoning: Raven’s Advanced Progressive Matrices, Set I (Raven, 1976), (ii) attention and set-shifting: Trail Making Test (Reitan, 1958), Rule Shift Cards (BADS, Wilson et al, 1996) and Cancellation tasks (Star and Letter Cancellation from the Behavioural Inattention Test, Wilson et al, 1987); (iii) inhibition and strategy generation: Hayling test (Burgess & Shallice, 1996); Letter Fluency (Thurstone & Thurstone, 1962); (iv) multitasking: Six Elements Test (BADS, Wilson et al, 1996), (v) strategic encoding/retrieval: Story Recall (AMIPB, Coughlan & Hollows, 1985). In addition, participants filled out the Dysexecutive Questionnaire (DEX) from the BADS (Wilson et al, 1996), and they were also asked to obtain a rating from a relative or friend who knew them well. This was intended to give some information about dysexecutive behaviours in everyday life.
8.3 RESULTS

8.3.1 Statistical analysis
In order to examine the appropriateness of parametric tests, the variables of interest were initially inspected for outliers and skewness following the method described above in section 7.1.3.1. A logarithmic transformation was performed on the Cancellation variables, and a negative reciprocal transformation on the Hayling timed variables. Other variables that did not meet assumptions of normality did not require multivariate analyses, and were therefore analysed non-parametrically using Mann Whitney U tests. This applied to final Problem Appreciation scores on the Predicaments test, and to the Six Elements Test, and error scores on the Hayling Test from the executive battery. All other variables were analysed parametrically, using t-tests or ANOVA as detailed below. A 5% significance level was adopted throughout. There were occasional missing data points on some tests for individuals as a result of administrative errors; numbers for each group are shown in the Tables if these fall below maximum.

8.3.2 Predicaments test
Mean scores, standard deviations and results of significance tests for scores on the Predicaments test are shown in Table 8.1.

8.3.2.1 Factual account of the Predicaments
The number of prompts needed in order to recount the factual details of the situations was low for both groups, and they did not differ significantly (t=.075, df=35.88, p=.459).

8.3.2.2 Awkwardness ratings
One participant in the control group could not be persuaded to give percentage ratings for all of the eight situations, and the missing scores were put in as the average of the other ratings. A t-test on the average awkwardness ratings showed that the TS group rated the situations as significantly more awkward than the control group, as shown in Figure 8.1 (t=2.52, df=40, p=.016). The mean scores are shown in Figure 8.1.
Table 8.1 Mean scores and standard deviations for the Predicaments test: TS group versus control group.

<table>
<thead>
<tr>
<th></th>
<th>TS group</th>
<th>Control group</th>
<th>Test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of Prompts</td>
<td>0.57 (0.48)</td>
<td>0.47 (0.34)</td>
<td>t=0.75</td>
<td>.459</td>
</tr>
<tr>
<td>Average Awkwardness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratings /100%</td>
<td>64.52 (13.05)</td>
<td>53.57 (15.06)</td>
<td>t=2.52</td>
<td>.016*</td>
</tr>
<tr>
<td>Solution Generation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Solutions</td>
<td>27.05 (8.72)</td>
<td>33.71 (10.92)</td>
<td>t=2.19</td>
<td>.035*</td>
</tr>
<tr>
<td>Average Solution Quality</td>
<td>1.84 (0.25)</td>
<td>1.95 (0.20)</td>
<td>t=1.53</td>
<td>.133</td>
</tr>
<tr>
<td>Solution Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final (Optimal plus Personal)</td>
<td>36.43 (5.72)</td>
<td>41.33 (5.41)</td>
<td>t=2.86</td>
<td>.007**</td>
</tr>
<tr>
<td>Final Problem Appreciation</td>
<td>13.90 (1.70)</td>
<td>15.38 (1.24)</td>
<td>z=2.99</td>
<td>.003**</td>
</tr>
<tr>
<td>Final Social Appropriateness</td>
<td>10.95 (2.36)</td>
<td>12.67 (1.98)</td>
<td>t=2.55</td>
<td>.015*</td>
</tr>
<tr>
<td>Final Effectiveness</td>
<td>11.57 (2.42)</td>
<td>13.29 (2.72)</td>
<td>t=2.16</td>
<td>.035</td>
</tr>
<tr>
<td>Average Satisfaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratings/100%</td>
<td>83.67 (9.67)</td>
<td>78.81 (13.29)</td>
<td>t=1.35</td>
<td>.183</td>
</tr>
<tr>
<td>Judgement of Alternatives</td>
<td>126.00 (8.16)</td>
<td>127.62 (8.73)</td>
<td>t=0.60</td>
<td>.550</td>
</tr>
</tbody>
</table>

* p<.05  ** p<.01

8.3.2.3 Solution generation

A t-test showed that the TS group generated significantly fewer ideas than the control group (t=2.19, df=40, p=.035); these results are illustrated in Figure 8.2.

When the Average Solution Quality scores were examined using a t-test, the two groups did not differ significantly (t=1.53, df=40, p=.133); these results are shown in Figure 8.3.
Figure 8.1  Mean scores for average awkwardness ratings for the control and TS groups

Figure 8.2  Mean Numbers of Solutions generated for the control and TS groups
8.3.2.4 Selection of final solutions

For each problem situation, participants were asked to select an optimal solution from the perspective of the main character, and then to give their own personal solution. These were rated on Problem Appreciation, Social Appropriateness and Effectiveness, and then these scores were added together to give a final solution quality score out of 6 for each scenario. A t-test showed that the TS group gained significantly poorer scores than the control group ($t=2.86$, $df=40$, $p=.007$); mean scores are shown in Figure 8.4. Comparison of the individual subscales using an adjusted significance level ($0.05/3=0.017$) showed that the TS group scored lower than the control group on Problem Appreciation ($z=2.99$, $p=.003$) and Social Appropriateness ($t=2.55$, $df=40$, $p=.015$), although the difference for Effectiveness approached, but did not reach significance ($t=2.16$, $df=40$, $p=.037$); these results are shown in Figure 8.5.
Figure 8.4  Mean Final Solution Quality scores for the control and TS groups

![Bar chart showing mean solution quality scores for control and TS groups.](image)

Figure 8.5  Mean Problem Appreciation, Social Appropriateness and Effectiveness scores for the control and TS groups

![Bar chart showing mean scores for problem appreciation, social appropriateness, and effectiveness for control and TS groups.](image)
8.3.2.5 Satisfaction ratings
The groups were compared on their average ratings of satisfaction. One participant in the control group could not be persuaded to give percentage ratings for one of the eight situations, and the missing score was put in as the average of their other ratings. A t-test showed that the two groups did not differ significantly (t=1.35, df=40, p=.183).

8.3.2.6 Judgement of alternative solutions
In order to examine whether participants showed any difficulties in judging the adequacy of solutions even when they were not required to generate them, participants’ rankings of 5 alternative solutions for each problem situation were examined. T-test comparison of the two groups showed no significant difference (t=0.60, df=40, p=.550).

8.3.2.7 Effects of sex
Although there was only a small number of female participants in the study, analyses were carried out to examine whether there were any effects of sex on the Predicaments variables using ANOVA with two between-groups factors (group: TS or control, sex: male or female). These showed no significant effect of sex for any of these variables, nor any significant interactions between group and sex (p>.05).

8.3.2.8 Correlations between Predicaments measures
Pearson product moment correlations were calculated between the Predicaments measures for the two groups. Table 8.2. shows the correlations for the main Predicaments measures of interest. All correlations that were significant (p<.05) are reported below. The correlations were in the expected direction, i.e. poorer performance on one task was associated with poorer performance on the other. For the TS group, the only significant correlation was between Average Solution Quality and Final Solution Quality (r=.54, p=.001). For the control group, there was a significant negative correlation between Number of Solutions and Average Solution Quality (r=-.69, p=.001), indicating that the more solutions the participants generated, the lower the average quality of those solutions. In addition,
Final Solution Quality scores correlated significantly with Judgement of Alternatives scores ($r = .59$, $p = .005$).

Table 8.2  Intercorrelations between Predicaments measures for the TS and control groups.

<table>
<thead>
<tr>
<th></th>
<th>Number of Solutions</th>
<th>Average Solution Quality</th>
<th>Final Solution Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TS Group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Solution</td>
<td>$r = -.29$</td>
<td></td>
<td>$r = .02$</td>
</tr>
<tr>
<td>Quality</td>
<td>$p = .195$</td>
<td></td>
<td>$p = .943$</td>
</tr>
<tr>
<td>Final</td>
<td>$r = .54$</td>
<td></td>
<td>$p = .001^{**}$</td>
</tr>
<tr>
<td>Solution Quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judgement of</td>
<td>$r = -.04$</td>
<td>$r = -.17$</td>
<td>$r = -.05$</td>
</tr>
<tr>
<td>Alternatives</td>
<td>$p = .884$</td>
<td>$p = .495$</td>
<td>$p = .846$</td>
</tr>
<tr>
<td><strong>Control Group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Solution</td>
<td>$r = -.69$</td>
<td></td>
<td>$r = .37$</td>
</tr>
<tr>
<td>Quality</td>
<td>$p = .001^{**}$</td>
<td></td>
<td>$p = .095$</td>
</tr>
<tr>
<td>Final</td>
<td>$r = -.03$</td>
<td></td>
<td>$p = .887$</td>
</tr>
<tr>
<td>Solution Quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judgement of</td>
<td>$r = .39$</td>
<td>$r = -.20$</td>
<td>$r = .59$</td>
</tr>
<tr>
<td>Alternatives</td>
<td>$p = .079$</td>
<td>$p = .377$</td>
<td>$p = .005^{**}$</td>
</tr>
</tbody>
</table>

* $p < .05$  ** $p < .01$

8.3.3 Executive Battery

Mean scores, standard deviations and significance tests for the groups are shown in Table 8.3.
Table 8.3 Mean scores and standard deviations for the executive battery: TS participants versus the control group.

<table>
<thead>
<tr>
<th>Test</th>
<th>TS group Mean (SD)</th>
<th>Control group Mean (SD)</th>
<th>Test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deductive reasoning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raven's Matrices^1</td>
<td>12.00 (2.20)</td>
<td>13.10 (2.02)</td>
<td>t=1.66</td>
<td>.105</td>
</tr>
<tr>
<td>Attention and set-shifting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIT^1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Star time</td>
<td>48.95 (14.36)</td>
<td>35.85 (10.75)</td>
<td>F=6.45</td>
<td>.015*</td>
</tr>
<tr>
<td>Letter time</td>
<td>60.85 (16.04)</td>
<td>56.75 (12.10)</td>
<td>F=0.35</td>
<td>.557</td>
</tr>
<tr>
<td>Trail Making Test^1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>28.24 (11.48)</td>
<td>27.43 (10.19)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time B</td>
<td>68.75 (29.75)</td>
<td>63.50 (23.89)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rule Shift Cards^2</td>
<td>3.21 (0.92)</td>
<td>3.57 (0.68)</td>
<td>t=1.43</td>
<td>.162</td>
</tr>
<tr>
<td>inhibition and strategy generation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hayling Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>19.90 (4.43)</td>
<td>19.57 (5.00)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time B</td>
<td>37.71 (16.85)</td>
<td>33.24 (40.63)</td>
<td>F=4.35</td>
<td>.043*</td>
</tr>
<tr>
<td>B Errors</td>
<td>6.86 (6.09)</td>
<td>3.90 (0.30)</td>
<td>z=1.96</td>
<td>.050*</td>
</tr>
<tr>
<td>Letter fluency^3</td>
<td>39.15 (10.53)</td>
<td>46.52 (14.57)</td>
<td>t=1.85</td>
<td>.072</td>
</tr>
<tr>
<td>Multitasking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Six Elements Test</td>
<td>3.71 (0.72)</td>
<td>3.90 (0.30)</td>
<td>z=0.91</td>
<td>.362</td>
</tr>
<tr>
<td>Executive memory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story Recall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>37.57 (9.91)</td>
<td>42.71 (6.81)</td>
<td>F=6.11</td>
<td>.018*</td>
</tr>
<tr>
<td>Delayed</td>
<td>32.57 (12.22)</td>
<td>40.52 (7.19)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dysexecutive behaviours (DEX)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEX</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self rating</td>
<td>23.81 (9.10)</td>
<td>20.62 (8.34)</td>
<td>t=1.18</td>
<td>.243</td>
</tr>
<tr>
<td>Other rating^4</td>
<td>29.27 (14.85)</td>
<td>19.20 (9.65)</td>
<td>t=2.20</td>
<td>.036*</td>
</tr>
</tbody>
</table>

* p<.05
1^N=20 TS, 20 control 2^N=19 TS, 21 control 3^N=20 TS, 21 control 4^N=15 TS, 15 control
For tests involving two parts (BIT Cancellation time, Trail Making, Hayling time, Story Recall), ANOVA was used, with one between-groups factor (group: TS or control) and one within-groups factor (task: part 1 or 2). T-tests were used for all other parametric analyses; Hayling error scores and Six Elements test scores were analysed non-parametrically using Mann Whitney U tests.

On the attention and set-shifting variables the TS group did not differ from the control group on the Rule Shift Cards ($t=1.43$, $df=38$, $p=.162$) or Trail Making tests ($F=0.35$, $df=1,38$, $p=.557$), although on the Cancellation tests there was a significant effect of group ($F=6.45$, $df=1,38$, $p=.015$) and a group by task interaction ($F=7.93$, $df=1,38$, $p=.008$). Post-hoc t-tests using an adjusted significance level (.05/2=.025) showed that the groups did not differ on Letter Cancellation time ($t=0.91$, $df=38$, $p=.367$), but the TS group were significantly slower than the control group on Star Cancellation time ($t=3.27$, $df=38$, $p=.002$).

On the inhibition and strategy generation measures, the TS group were significantly slower than the control group on the Hayling test ($F=4.35$, $df=1,40$, $p=.043$), and there was also a group by task interaction ($F=6.29$, $df=1,40$, $p=.016$). Post-hoc t-tests using an adjusted significance level (.05/2=.025) showed that the two groups did not differ on time taken for part A ($t=0.49$, $df=40$, $p=.628$), but the TS group were significantly slower than the control group on the second part of the test, in which they had to inhibit prepotent responses ($t=2.75$, $df=40$, $p=.009$). The TS group also gained significantly higher error scores on the Hayling test ($z=1.96$, $p=.050$), and the difference between the groups approached, but did not reach, significance on the Letter fluency task ($t=1.85$, $df=39$, $p=.072$).

On the measure of multitasking, the Six Elements Test, the two groups did not differ ($z=0.91$, $p=.362$). They also did not differ on the measure of deductive reasoning, Raven's matrices ($t=1.66$, $df=39$, $p=.105$). The TS group gained significantly poorer scores on the Story Recall task ($F=6.11$, $df=1,40$, $p=.018$); there was no group by task interaction ($F=1.63$, $df=1,40$, $p=.209$), indicating that the deficit was likely to be equivalent on Immediate and Delayed recall.
For the DEX questionnaire, all participants filled out self-ratings, although the two groups did not differ significantly on these \((t=1.18, df=40, p=.243)\). Other-ratings were returned for fifteen of the twenty-one participants in each group. The TS group gained significantly higher scores than the control group \((t=2.20, df=28, p=.036)\), reflecting more dysexecutive behaviours.

### 8.3.4 Analysis of covariance with executive battery

Analysis of covariance was also conducted, to examine the effects of the executive battery and the DEX on the Predicaments measures of interest that differentiated the groups, Number of Solutions generated, and Final Solution Quality. The results are shown in Table 8.4.

<table>
<thead>
<tr>
<th>Significance of group difference</th>
<th>Number of Solutions</th>
<th>Final Solution Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without covariates</td>
<td>.035*</td>
<td>.007**</td>
</tr>
<tr>
<td>With executive measures used as covariates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deductive reasoning</td>
<td>.055</td>
<td>.014*</td>
</tr>
<tr>
<td>Attention and set-shifting</td>
<td>.075</td>
<td>.005**</td>
</tr>
<tr>
<td>Inhibition and strategy generation</td>
<td>.272</td>
<td>.017*</td>
</tr>
<tr>
<td>Multitasking</td>
<td>.061</td>
<td>.008**</td>
</tr>
<tr>
<td>Executive memory</td>
<td>.171</td>
<td>.018*</td>
</tr>
<tr>
<td>DEX</td>
<td>.330</td>
<td>.087</td>
</tr>
</tbody>
</table>

* *p<.05 ** p<.01
The results showed that for Number of Solutions generated the group difference was no longer significant when any of the categories of measures were used as covariates. By contrast, for Final Solution Quality scores, the only measures that made the group different non-significant when used as covariates were the DEX scores ($p=.087$).

8.3.5 Effects of medication
Thirteen of the TS group were taking medication at the time of testing. Eleven of them were taking antipsychotic preparations, 2 of these in combination with a tricyclic, 1 with an SSRI, 1 with an SSRI and benzodiazepine, and 1 with an anticholinergic. One TS participant was taking an SSRI alone, and 1 an antisympathetic drug alone. The effects of medication on performance were examined in relation to the measures that had significantly differentiated the TS group from the control group. There were no significant differences between the medicated and unmedicated TS participants on the relevant Predicaments or executive measures, although there was a near-significant task by medication effect on the Hayling test ($F=4.04$, df=1,19, $p=.059$), such that the medicated subgroup tended to be slower on Hayling part B than the unmedicated subgroup.

8.4. DISCUSSION

8.4.1 Summary of results
The findings on the Predicaments test showed that the TS group was significantly poorer than the control group in terms of the number of solutions they generated, and the quality of the solutions they selected as their final options. The TS participants also judged the scenarios to be more awkward than the control group, but did not differ in their satisfaction with their own performance. On the executive battery, the TS group showed impairment relative to the control group on aspects of attention and set-shifting, inhibition and strategy generation and executive memory. The relatives/friends of the TS group also rated them as displaying more dysexecutive behaviours than the control group on the DEX questionnaire.
Little work has been done on real-life-type problem-solving in TS, and many studies examining the effects of TS on other aspects of functioning have failed to consider the potentially confounding effects of comorbid conditions such as ADHD and OCD. The current study excluded participants who met diagnostic criteria for these conditions. The study could perhaps have been improved by the inclusion of measures of symptomatology of tic severity and ADHD and OCD-related behaviours, although previous work has suggested that tic severity is not related to performance (Silverstein et al., 1995). The current study also found little evidence for differences in the TS group according to whether or not they were taking medication, in keeping with previous findings (e.g. Bornstein 1991, Bornstein & Yang, 1991). Overall, the findings suggest that pure TS is associated with impairments in real-life-type problem-solving.

8.4.2 Comparison with findings seen previously in anterior participants

The results showed that, like the anterior group discussed in section 7.1.4.1, the main sources of difficulty for the TS participants were in generating a range of possible solutions and selecting good quality solutions as their final choices of preferred action. When the subscales of Final Solution Quality were examined, the TS group showed difficulties in appreciating the pertinent interpersonal/practical aspects of the situations (at which the control group were almost at ceiling level), and in choosing solutions that were socially appropriate, although the difference between the groups in terms of the practical effectiveness of their answers did not quite reach significance. On the same shortened version of the Predicaments test, the anterior group was markedly impaired relative to a matched control group on all three measures, as shown in section 7.2.3.2.4. This suggests that the difficulties shown by the TS group were not quite as marked as those seen between the anterior and control participants in the previous study.

When the percentage ratings scores were examined, participants with TS rated the scenarios as more awkward than the control participants did. It was clearly appropriate for them to judge the situations as more awkward than the control group, given their greater difficulties in analysing and solving them. It was speculated above in section 7.1.4.2 that the lack of difference between participants
with focal lesions and their matched controls on the percentage ratings might reflect a relative lack of awareness of their difficulties. The findings in the current study could therefore be interpreted as showing that people with TS may have intact awareness of their relative difficulties in social problem-solving situations. However, they did not differ from the control group on their ratings of satisfaction with their solutions, even though the quality of their solutions was poorer. This suggests that they may have subtle difficulties in monitoring the effectiveness of their performance, which may in turn be associated with similar failure to appreciate difficulties in everyday life.

8.4.3 Relationships between Predicaments measures
When correlations between the Predicaments measures were examined, the control group in the current study had a significant negative correlation between the number of solutions produced and their average quality, i.e. the more solutions they generated, the poorer the overall quality of those solutions. This pattern was also seen in the control group in the previous study (described in section 7.2.3.6), and suggests that the two control groups were applying similar strategies to their performance on the task. It was speculated in section 7.1.4.3 in the previous study that there might be a trade-off, such that generating large numbers of ideas may necessitate producing poorer quality solutions due to reaching the limit of the range of strong options. As in the previous study, Average Solution Quality did not correlate with Final Solution Quality scores for the control group, indicating that those participants who generated large numbers of ideas with lower overall quality were still able to select good quality final solutions.

This pattern of findings was reversed in the TS group, who showed no relationship between Number of Solutions and Average Solution Quality, but a strong correlation between Average Solution Quality and Final Solution Quality. Given that there were no overall group differences in terms of the average quality of the ideas they produced in the generation phase, this suggests that a proportion of the TS group generated small numbers of high quality solutions. The pattern of correlations in the TS group was also different from that seen in the anterior participants in the previous study. For the anterior group, it was the Number of
Solutions generated, rather than their average quality, which was related to Final Solution Quality scores (see section 7.2.3.6). The previous discussion noted that failure to generate solutions was likely to have been an important source of difficulty for the anterior participants, and this was linked to postulated deficits in generation and use of strategies (see section 7.1.4.4.1). The results of the current study indicate that the generation phase of the task was also important for the TS participants, in that those who generated a pool of lower quality ideas were unable to select strong options for their final solutions.

8.4.4 Executive battery

On the executive battery, it was predicted that the group with TS would show deficits on some aspects of the attention and set-shifting tasks, the inhibition and strategy generation tasks, and the executive memory tasks from the executive battery. The findings were as predicted, with the TS participants showing impairment relative to the control group on one of the measures of attention and set-shifting (Star Cancellation time) and on the measure of executive memory (Story Recall). On the measures of inhibition and strategy generation, they were slower than the control group on the Hayling test, and also gained higher error scores; the result for Letter Fluency approached significance. Previous work has questioned whether uncomplicated TS is associated with executive deficits, due to the mixed findings in the literature (e.g. Yeates & Bornstein, 1994; Ozonoff, 1997; Ozonoff & Jenson, 1999). The current study provides evidence for executive deficits in people with TS without comorbid conditions, although this only applied to a subset of the measures. The greatest range of impairment was seen in the tasks of inhibition and strategy generation, and it has been suggested that impairments on free recall tasks can also be due to deficits in strategic encoding and retrieval, involving the inhibition of irrelevant information (Shimamura et al, 1991; Henson et al, 1995). These findings are consistent with the conceptualisation of TS as a disorder of inhibition (Leckman et al, 1991).

8.4.5 Contributions to Predicaments impairments in the TS group

What other factors contribute to the impairments shown by the TS group on the Predicaments test, and are they equivalent to those seen in people with structural
lesions to the frontal lobes? The previous study linked impairment in the anterior group with executive deficits, poor selection of courses of action, specific difficulties with aspects of interpersonal relationships, and failures to use their prior experience to guide problem-solving according to the possible consequences of actions.

8.4.5.1 The role of executive factors

The fact that the TS group was impaired on a subset of the measures in the executive battery implies that executive processes could be important to their performance on the Predicaments test. Analysis of covariance indicated that executive processes did not seem to be relevant to their selection of their final solutions, but that these processes probably contributed to the number of ideas they generated. The executive measures that had the greatest effect on their solution fluency were the inhibition and strategy generation measures. As discussed above, inhibitory and strategy generation processes were implicated as an important source of reduced solution fluency in participants with frontal lobe lesions in the previous study (section 7.1.4.4.1). It was proposed that the anterior group had difficulties in generating, or making use of, appropriate performance strategies in searching for relevant past experience, and using this to guide problem solving. This is clearly also a potential source of difficulty in TS participants.

8.4.5.2 The role of previous experience

The TS group showed impairment in the same aspects of the Predicaments test as the anterior group, in the context of fewer executive impairments on the standardised measures. In addition, analysis of covariance indicated that executive processes did not seem to be particularly relevant to their selection of their final solutions. This suggests that other factors contributed to their difficulties in selecting between competing courses of action. One such factor is the possible contribution of previous experience to problem-solving performance. For example, their poorer solution generation may not be attributable to the strategic processes involved in accessing previous knowledge, but to aspects of the knowledge base itself. Thus, the TS participants might have a poorer knowledge base of experience to draw upon. Evidence reviewed above suggests that children with TS have poorer
peer relations and more difficulties in social interaction than their peers (e.g. Carter et al, 2000; Kadesjö & Gillbert, 2000, Bawden et al, 1998). Thus, their experience of social problem-solving may be more limited than that of their peers. It has been suggested that frontal lobe dysfunction that occurs before an adequate social knowledge base is built up, can have long-term effects on social behaviour (Dimitrov et al, 1999). In TS, both the primary effects of TS on frontal lobe functions and the secondary effects of having a developmental disorder, e.g. lack of acceptance within a peer group, could potentially contribute to them having a less extensive range of social experience to draw upon than control participants.

In the previous chapter it was postulated that impaired problem appreciation in people with focal brain lesions could reflect difficulties in using prior knowledge to grasp all the pertinent nuances of the situation, affecting participants’ abilities to identify appropriate goals, and monitor the likely outcomes of chosen actions (section 7.1.4.4.3). Failure to use prior knowledge effectively could also affect judgement of the appropriateness and effectiveness of a response. The difficulties shown by the TS participants in the quality of their final solutions could therefore be attributed to having a poorer set of relevant experiences to draw upon. The finding that adults with TS chose less socially appropriate answers than control participants is consistent with clinical reports that people with TS may show socially inappropriate behaviour in their daily lives (Kurlan et al, 1996; Demirkol et al, 1999).

**8.4.5.3 The role of interpersonal factors**

The socially inappropriate behaviour seen in people with TS is also consistent with an explanation in terms of specific difficulties with aspects of interpersonal problem-solving. Is there any evidence for deficits in interpersonal factors in TS? Frontal lobe dysfunction has been linked with deficits in theory of mind (e.g. Stone et al, 1992; Stuss et al, 2001), but previous work has indicated that participants with TS do not show impairment on theory of mind tasks (Baron-Cohen et al, 1997). This suggests that deficits in this area are an unlikely source of difficulty in people with TS, although this was not investigated in the current sample. There is little work on empathy, pragmatic language interpretation and interpretation of
nonverbal cues in TS. As all the scenarios were presented on videotape, it is possible that these factors could also be relevant to performance. Deficits in executive function and social knowledge appear to be the most likely reasons for the clinical reports of socially inappropriate behaviour in TS, but further work is needed before the role of specific interpersonal factors can be ruled out of contributing to their real-life problem-solving performance.

The DEX questionnaire was included in the study as an indication of everyday dysexecutive behaviours. The findings showed that although the TS group did not differ from the control group on their self-ratings, they were judged to show more dysexecutive behaviours on their ratings from relatives or friends. Other-ratings are often thought to be more reliable than self-ratings on such instruments, because people with executive deficits may show impairments in awareness of their difficulties (e.g. Stuss 1991a, 1991b; Sherer, Boake, Levin, Silver, Ringholz & High, 1998). When DEX scores were used as covariates, the group difference on both Number of Solutions generated and Final Solution Quality scores was no longer significant. Thus, there is some evidence that the TS group had dysexecutive difficulties in their daily lives, and that the Predicaments test may have been sensitive to these, although this finding should be treated with caution as there was some missing data for the other-ratings for both groups in the current study.

8.4.6 Summary
In summary, the findings showed that participants with TS were impaired in aspects of real-life-type problem-solving performance, as predicted in Hypothesis 1 above. The pattern of results suggests that people with TS may have difficulties in generating ideas, appreciating the pertinent aspects of problem situations, and selecting socially appropriate solutions. Participants with TS also had deficits in aspects of attention and set-shifting, inhibition and strategy generation, and executive memory from the battery of standardised measures, as predicted in Hypothesis 2. It was argued that the most likely contributions to the impairments seen on the Predicaments test were deficits in aspects of executive function, and a poorer knowledge base of relevant experience to draw upon in order to aid real-life problem-solving. Specific decision-making difficulties and poorer judgement of
interpersonal issues could not be ruled out as potential contributory factors, but were thought to be less pertinent than executive and knowledge-based deficits. In order to clarify the relative contributions of these factors further, it was decided that it would be appropriate to test a group of participants with postulated frontal lobe involvement who might be expected to have a greater amount of appropriate social experience, in order to compare and contrast the pattern of findings. The next study therefore describes the performance of a group of healthy older adults on the measures used in the current study.
CHAPTER 9
REAL-LIFE-TYPE PROBLEM SOLVING AND NORMAL AGEING

9.1 INTRODUCTION

The current study describes the performance of a group of healthy older participants on the Predicaments test and on a set of standardised executive measures, relative to a matched group of younger participants. The aim of the study was to investigate further the relative contributions of knowledge/experience and executive skills to real-life problem-solving. Whilst the older group would be likely to show deficits in executive function compared to the younger group, they differed from both those with anterior lesions and those with TS with respect to knowledge/experience, which were expected to be superior to the younger group.

Studies have shown that normal ageing is associated with decreases in brain volume, and while this may potentially affect many areas of the brain, it is thought to be especially pronounced in the frontal cortex (e.g. Haug & Eggers, 1991; Jernigan et al, 2001; Raz et al, 1998; Coffey et al, 1992). This has led to predictions that healthy older adults may show patterns of performance similar to those seen in patients with focal frontal lobe lesions, such as deficits in executive skills and real-life problem-solving.

Studies examining performance on standardised, abstract tests of executive function have shown that older adults score significantly more poorly than younger adults on a range of tests, as discussed in section 5.3. These include measures of set-shifting and attention (e.g. Wahlin et al, 1996; Daigneault et al, 1992), multitasking (e.g. Levine et al, 1998) and measures of deductive reasoning (e.g. Rabbitt et al, 1995). There is also evidence that older people may show memory impairments that are attributable to disrupted executive processes (Parkin, 1997). In addition, poorer performance on tests of inhibition and strategy generation has been reported on the Hayling test (Andrés & Van der Linden, 2000), and measures of verbal fluency (e.g.
Whelihan & Lesher, 1985; Tomer & Levin, 1993), although the findings on fluency measures are inconsistent (e.g. Bryan & Luszcz, 2000).

Overall, the findings indicate that older people show relatively poor performance compared to younger people on most types of abstract executive measures, and that this applies to a wider range of measures than the difficulties seen in people with Tourette's syndrome. Executive processes such as response inhibition, strategy-generation, planning and decision-making, and monitoring of behaviour would all be expected to be important in real-life problem-solving. Thus, the evidence from both organic changes and executive decrements in older people would lead to predictions that they should show similar difficulties on real-life-type problem solving as groups with anterior lesions and TS.

The evidence in terms of real-life behaviour leads to a different prediction. Both frontal lobe lesions and TS are associated with reports of socially inappropriate behaviour in daily life. In contrast, healthy people are not generally reported to show personality change or marked differences in behaviour as they get older. Indeed, increasing age has been associated with greater wisdom and deeper understanding of important issues through experience and self-reflection (Ardelt, 2000). In terms of specific interpersonal factors, a theory of mind study showed that older people gained better scores than younger people on items requiring the attribution of mental states (Happé, Winner & Brownell, 1998).

One of the reasons why older people are thought to show superior wisdom and interpersonal understanding compared with younger people is that they have greater social knowledge through their wider experience. An important distinction between real-life problem-solving and performance on standardised tests of executive function is the relative contribution of knowledge and experience. Acquired knowledge and experience are likely to contribute to real-life problem-solving rather more than to performance on abstract tasks, since in most abstract tasks all the relevant information is provided, whereas real-life problems are usually open-ended and can often be viewed from a number of perspectives. Unlike executive skills,
disruption to semantic knowledge stores is not associated with alterations in brain function attributable to normal ageing. It has been argued that older adults have intact real-life problem-solving skills and that this is attributable to their extensive life experience (e.g. Phillips & Della Sala, 1998).

Real-life problem-solving has been a focus of research in work with older people, although studies have reported mixed findings, as described in section 5.4. For example, some studies have reported that older people may perform more poorly on real-life-type problem-solving tasks (e.g. Denney & Pearce, 1989; Diehl et al, 1995; Allaire & Marsiske, 1999), while other studies have reported similar levels of performance across the age span (e.g. Blanchard-Fields et al, 1997), or even superior performance in older people (e.g. Cornelius & Caspi, 1987; Watson & Blanchard-Fields, 1998). One explanation for the mixture of findings is the different methodologies employed in the various studies. Marsiske and Willis (1995) conducted a factor analysis of older people’s performance on three different tasks of real-life-type problem-solving, and showed that there were no common factors between them, supporting the position that everyday problem-solving is multidimensional.

The study reported by Marsiske and Willis did not compare the older group with a younger group. However, the three tasks employed in this study had all been used in previous studies examining the effects of age. One of them involved judgement of a range of alternatives for social and non-social problem situations, and found that the older group performed better than the younger group (Cornelius & Caspi, 1987), implying that they are able to select strong courses of action in relation to real-life problems. Another measure involved inferential reasoning using real-life materials and showed that increasing age was related to poorer performance (Diehl et al, 1995); this task may have had greater reliance on executive skills. The third task involved presenting participants with a mixture of social and non-social problems and asking them what they would do if they encountered each problem (Denney & Pearce, 1989). The findings showed that middle-aged participants gained better scores than both older and younger people. However, the scoring system combined
elements of quantity and quality of solutions, making it difficult to determine the source of the differences between the groups. These findings indicate that considering multiple aspects of problem solving is important when investigating age-related effects, although few studies have attempted to achieve this in the same group of participants.

The previous two chapters described the performance of participants with focal lesions, and participants with Tourette's syndrome (TS) on a measure of social problem-solving designed to have greater ecological validity than most abstract executive tests. The findings revealed that both these groups showed difficulties on aspects of the measure relative to matched control groups, including generating fewer ideas, and selecting poorer quality final solutions. Deficits on the Predicaments test were linked to a range of factors including executive skills, decision-making deficits and interpersonal aspects of problem-solving. However, it was also thought that the use of previous relevant knowledge was likely to be important in real-life-type problem-solving, and it was argued that the deficits shown by the TS group may have been attributable to their poorer knowledge base relative to control participants (see section 8.4.5.2). By contrast with participants with TS, healthy older people would be expected to have an extensive knowledge base, and therefore, if experience is important in Predicaments performance, it should have a protective effect for older people.

The current study describes the performance of a group of healthy older people on multiple aspects of real-life-type problem-solving using the shortened version of the Predicaments test. The battery of executive tests described in the previous chapters was also included, and the relationships between performance on these and the Predicaments measures were examined. The older group was compared with a group of healthy younger people, matched for IQ, years of education and sex.
9.1.1 Hypotheses

1) It was hypothesised that the older group would show poorer performance relative to the younger group on all categories of measures included in the executive battery.

2) Predictions about their performance on the Predicaments test were less clear. If executive skills are crucial to performance, the older group should show similar patterns of impairment to the anterior and TS groups in the previous studies. However, if real-world experience is critical, this might be a protective factor and the older group should show intact performance. In addition, the work reviewed above implies that the nature of the measures used in real-life problem-solving may be important, suggesting that older people could show different patterns of performance depending on the type of task in question. Specific predictions about the performance of the older group on the multiple dimensions of the Predicaments test were therefore not made.

9.2 METHOD

9.2.1 Participants and Procedure

Thirty participants (15m, 15f) aged between 60 and 80 (Older group, mean age 68.27, sd 5.33) and thirty participants (13m, 17f) aged between 19 and 37 (Younger group, mean age 25.27, sd 4.92) took part in the study. They were recruited from a healthy volunteer panel of people who had responded to advertisements for help with research. All participants underwent a health-screening interview. To be included, participants had to be fluent in English, and have a verbal IQ score of 85 or above on the NART (Nelson, 1991). Exclusion criteria included significant neurological or psychiatric illness and alcohol or drug dependence. Years of education were slightly higher for the younger group, but this did not reach significance (Older mean 14.03 years, sd 2.51; Younger mean 15.10 years, sd 1.73). NART IQ was slightly higher for the older group, but this did not reach significance (Older mean 114.38, sd 10.99; Younger mean 110.00, sd 8.05). All participants gave written informed consent for the study, and were given breaks between tasks as necessary, to avoid fatigue.
9.2.2 Predicaments test

The shortened version of the Predicaments test was given, as detailed in the previous chapter. This contained eight brief scenarios featuring everyday awkward situations across a range of interpersonal relationships, as listed in Appendix C. Videotaped presentation was intended for all participants in the present study. However, several of the older participants had mild hearing difficulties, and thus the story version was used for them (n=5), and for a similar number of participants in the younger group (n=6). Participants were asked to watch/read each situation, and then to answer a series of questions. The situations were presented in a fixed order.

9.2.2.1 Procedure

The procedure and instructions were the same as those detailed in the previous chapter. Participants were asked to watch each scenario, and then to answer a series of questions.

The Predicaments measures obtained were the same as detailed previously:

1) Number of prompts (out of three) needed to recount the factual details of the awkward situation.
2) Ratings of the degree of awkwardness of the situation, both for the main character, and for themselves if they were in that situation (0-100%). These were combined to give an average score.
3) Total number of solutions generated within a two-minute period. As before, participants were not given any prompts for further information or clarification of their suggested solutions, to ensure that no cues were provided as to the adequacy of their responses.
4) Selection of optimal and personal solutions. These were the responses given when the participants were asked to select the best solution from the perspective of the main character (optimal solution), and then to state what they themselves would do if they were in that situation (personal solution). The results from the two perspectives were combined to give an overall Total Solution Quality score.
6) Their self-ratings of satisfaction (out of 100%) with their optimal and personal solutions. These were combined to give an average score.

7) Their judgement of alternative solutions, where they ranked five different suggestions for what the main character could do in the situation in order from best to worst.

9.2.2.2 Scoring of quality of problem solutions
As before, responses were scored according to the three criteria (see section 7.1.2.2.9) of whether they were judged to show adequate appreciation of the problem (Problem Appreciation), to be socially appropriate (Social Appropriateness), and to provide effective practical means of resolving the problem (Effectiveness). All responses for the study were rated by one rater who was blind as to the identity and group membership of the participants, and by a second rater who was not blind. The two raters agreed for 90.2% of ratings. All differences were resolved by reference to an additional blind rater.

9.2.2.3 Final Solution Quality
The three subscores (Problem Appreciation, Social Appropriateness and Effectiveness) were added together for the two perspectives, optimal and personal. This created a Final Solution Quality score, of a maximum of six points for each item.

9.2.2.4 Solution generation
To assess how efficiently people generated solutions, the number of ideas generated for each problem situation was added (Number of Solutions). Each of these ideas was scored for Problem Appreciation, Social Appropriateness and Effectiveness as described above. These scores were then added together and divided by Number of Solutions, to provide an Average Solution Quality score, i.e. adjusted for the number of solutions given.
9.2.3 Executive Battery

A battery of standardised tests was selected in order to assess aspects of executive function. This consisted of the same measures as those used in the previous studies, including (i) deductive reasoning: Raven's Advanced Progressive Matrices, Set I (Raven, 1976), (ii) attention and set-shifting: Trail Making Test (Reitan, 1958), Rule Shift Cards (BADS, Wilson et al, 1996), cancellation tasks (Star and Letter tasks from the Behavioural Inattention Test, Wilson et al, 1987); (iii) inhibition and strategy generation: Hayling test (Burgess & Shallice, 1996); Letter fluency (Thurstone & Thurstone, 1962); (iv) multitasking: Six Elements Test (BADS, Wilson et al, 1996), (v) strategic encoding/retrieval: Story Recall (Adult Memory and Information Processing Battery, Coughlan & Hollows, 1985). In addition, participants filled out the Dysexecutive Questionnaire (DEX) from the BADS (Wilson et al, 1996), and they were also asked to obtain a rating from a relative or friend who knew them well. This questionnaire was intended to give some information about dysexecutive behaviours in everyday life.

9.3 RESULTS

9.3.1 Statistical analysis

In order to examine the appropriateness of parametric tests, the variables of interest were initially examined for outliers and skewness following the method described in section 7.1.3.1. Logarithmic transformations were performed on the Trail Making variables, and negative reciprocal transformations were performed on the Cancellation and timed Hayling variables. Other variables that did not meet assumptions of normality did not require multivariate analyses, and were therefore analysed non-parametrically using Mann Whitney U tests. This applied to Hayling error scores, Raven's matrices, Six Elements Test and DEX other-ratings. All other variables were analysed parametrically, using t-tests or ANOVA as detailed below. A 5% significance level was adopted throughout. There were occasional missing data points on some tests for individuals as a result of administrative errors; numbers for each group are shown in the Tables if these fall below maximum.
9.3.2 Predicaments test

Mean scores, standard deviations and results of significance tests for scores on the Predicaments test are shown in Table 9.1.

Table 9.1  Mean scores and standard deviations for the Predicaments test: older and younger groups

<table>
<thead>
<tr>
<th></th>
<th>Older group Mean (SD)</th>
<th>Younger group Mean (SD)</th>
<th>Test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of Prompts</td>
<td>0.47 (0.37)</td>
<td>0.25 (0.23)</td>
<td>t=2.72</td>
<td>.009*</td>
</tr>
<tr>
<td>Average Awkwardness Ratings 100%</td>
<td>59.26 (13.01)</td>
<td>58.60 (11.77)</td>
<td>t=0.21</td>
<td>.838</td>
</tr>
<tr>
<td>Solution Generation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Solutions</td>
<td>24.13 (9.22)</td>
<td>34.43 (10.43)</td>
<td>t=4.05</td>
<td>.0001**</td>
</tr>
<tr>
<td>Average Solution Quality</td>
<td>2.06 (0.29)</td>
<td>1.84 (0.28)</td>
<td>t=2.88</td>
<td>.006**</td>
</tr>
<tr>
<td>Solution Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final (Optimal plus Personal)</td>
<td>39.43 (4.73)</td>
<td>38.60 (4.90)</td>
<td>t=0.67</td>
<td>.506</td>
</tr>
<tr>
<td>Final Problem Appreciation</td>
<td>14.80 (1.30)</td>
<td>14.83 (1.37)</td>
<td>t=0.10</td>
<td>.923</td>
</tr>
<tr>
<td>Final Social Appropriateness</td>
<td>12.50 (2.01)</td>
<td>11.67 (1.99)</td>
<td>t=1.61</td>
<td>.112</td>
</tr>
<tr>
<td>Final Effectiveness</td>
<td>12.13 (2.45)</td>
<td>12.10 (2.56)</td>
<td>t=0.05</td>
<td>.959</td>
</tr>
<tr>
<td>Average Satisfaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratings/100%</td>
<td>85.52 (9.63)</td>
<td>77.31 (11.87)</td>
<td>t=2.94</td>
<td>.005**</td>
</tr>
<tr>
<td>Judgement of Alternatives1</td>
<td>125.45 (7.65)</td>
<td>127.67 (7.95)</td>
<td>t=1.09</td>
<td>.280</td>
</tr>
</tbody>
</table>

* p<.05  **p<.01  1N=29 Older, 30 Younger

9.3.2.1 Factual account of the Predicaments

A t-test using separate variance estimates showed that the older participants were prompted slightly more often than the younger participants (t=2.72, df=47.84, p=.009), although examination of the mean scores showed that the number of
prompts needed in order to recount the factual details of the situations was low for both groups.

9.3.2.2 Awkwardness ratings
A t-test on the average awkwardness ratings showed that the two groups did not differ significantly (t=0.21, df=58, p=.838).

9.3.2.3 Solution generation
A t-test showed that the older group generated significantly fewer ideas than the younger group (t=4.05, df=58, p=.0001), as illustrated in Figure 9.1.

Figure 9.1 Mean scores for Number of Solutions for the younger and older groups
A t-test showed that the Average Solution Quality of the ideas generated by the Older group was significantly higher than those generated by the Younger group (t=2.88, df=58, p=.006); these results are shown in figure 9.2.

9.3.2.4 Selection of final solutions
For each situation, participants were asked to select an optimal solution from the perspective of the main character, and then to give their own personal solution. These were rated on Problem Appreciation, Social Appropriateness and Effectiveness, and then these scores were added together to give a Final Solution Quality score out of 6 for each scenario. A t-test showed that the older and younger groups did not differ on this measure (t=0.67, df=58, p=.506); mean scores are shown in Figure 9.3. Comparison of the individual subscales using an adjusted significance level (.05/3=.017) showed that the older and younger groups did not differ on any of the measures: Problem Appreciation (t=0.10, df=58, p=.923), Social Appropriateness (t=1.61, df=58, p=.112), Effectiveness (t=0.05, df=58, p=.959); these results are shown in Figure 9.4.
Figure 9.2 Mean scores for Average Solution Quality for the younger and older groups
Figure 9.3  Mean scores for Final Solution Quality for the younger and older groups
9.3.2.5 Satisfaction ratings
A t-test comparing the average satisfaction ratings for the two groups showed that the older group were significantly more satisfied with their answers than the younger group (t=2.94, df=58, p=.005).

9.3.2.6 Judgement of alternative solutions
In order to examine whether participants showed any difficulties in judging the adequacy of solutions even when they were not required to generate them, participants’ rankings of 5 alternative solutions for each problem situation were examined. T-test comparison of the groups showed no significant differences in Judgement of Alternatives scores (t=1.09, df=57, p=.280).

9.3.2.7 Video versus story presentation
As mentioned above, the intention was to present the task on video for all participants. However, hearing difficulties in five of the older participants meant that
video presentation was not appropriate, and story versions were given to these, and to six younger participants. T-test comparisons of video versus story presentation in the younger group revealed that the two subgroups differed only on the number of prompts received. Those in the story group received fewer prompts than those in the video group, but even in the latter, the number of prompts was extremely small (mean=0.31, sd=0.22). Comparisons in the older group revealed that those who received story presentation produced significantly fewer solutions than those who received video presentation. However, comparison of the ages of the older subgroups showed that those who received the story version of the measure were also significantly older than those who received the video version, and age appeared to affect the number of solutions generated, as shown by the significant difference on this measure between the older and younger groups.

9.3.2.8 Correlations between Predicaments measures

Pearson product moment correlations were calculated between the Predicaments measures for the two groups. All correlations that were significant (p<.05) are reported below. The correlations were in the expected direction, i.e. poorer performance on one task was associated with poorer performance on the other, unless otherwise indicated. For both groups, Number of Solutions correlated with Average Solution Quality, such that higher numbers of ideas were associated with lower average quality of those ideas (older group: r=-.59, p=.001; younger group: r=-.63, p=.0001). For the older group, number of prompts correlated significantly with Final Solution Quality (r=-.38, p=.040), and Number of Solutions correlated with Judgement of Alternatives scores (r=.66, p=.0001). For the younger group, Average Solution Quality correlated significantly with Final Solution Quality (r=.51, p=.004). Table 9.2 shows the correlations for the main Predicaments measures of interest.
Table 9.2  Intercorrelations between Predicaments measures for the older and younger groups.

<table>
<thead>
<tr>
<th></th>
<th>Number of Solutions</th>
<th>Average Solution Quality</th>
<th>Final Solution Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Older Group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Solution</td>
<td>r=-.59</td>
<td>p=.001*</td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final</td>
<td>r=.13</td>
<td>r=.32</td>
<td></td>
</tr>
<tr>
<td>Solution Quality</td>
<td>p=.491</td>
<td>p=.088</td>
<td></td>
</tr>
<tr>
<td>Judgement of</td>
<td>r=.66</td>
<td>r=-.28</td>
<td>r=.31</td>
</tr>
<tr>
<td>Alternatives</td>
<td>p=.0001*</td>
<td>p=.135</td>
<td>p=.100</td>
</tr>
</tbody>
</table>

| **Younger Group**    |                     |                          |                        |
| Average Solution     | r=-.63              | p=.0001*                 |                        |
| Quality              |                     |                          |                        |
| Final                | r=.12               | r=.51                    |                        |
| Solution Quality     | p=.520              | p=.004*                  |                        |
| Judgement of         | r=.19               | r=.23                    | r=.35                  |
| Alternatives         | p=.307              | p=.221                   | p=.059                 |

* p<.01

9.3.3 Executive Battery

Mean scores, standard deviations and significance tests for the groups are shown in Table 9.3.

Mean scores for both groups were compared to age norms for the test, where available (Trail-making, WCST, Stroop, Raven’s Matrices, Story Recall). These showed that both groups scored within +/- 1SD of the mean score on all tests, in line with expectations for healthy normal participants of these age groups. For the comparisons below, raw scores were used, making no adjustment for age, since this was the issue under consideration.
For tests involving two parts (Cancellation time, Trail Making, Hayling time, Story Recall), ANOVA was used, with one between-groups factor (group: older or younger) and one within-groups factor (task: part 1 or 2). T-tests were used for all other parametric analyses; Hayling error scores, Raven’s matrices and Six Elements Test scores were analysed non-parametrically using Mann Whitney U tests.

On the attention and set-shifting variables the older group was significantly slower than the younger group on the Cancellation tests (F=24.70, df=1,58, p=.0001) and the Trail Making Test (F=59.20, df=1,58, p=.0001). Group by task interactions were not significant for the Trail Making Test (F=0.03, df=1,58, p=.862), suggesting that the older group was slowed to a comparable extent on both parts of the task. There was a significant group by task interaction on the Cancellation tests (F=6.63, df=1,58, p=.013), although post-hoc t-tests using an adjusted significance level (0.05/2=.025) showed that the older group was significantly slower than the younger group on both parts of the task (Star Cancellation: t=4.42, df=58, p=.0001; Letter Cancellation: t=4.53, df=58, p=.0001). The older group also gained significantly poorer scores on the Rule Shift Cards Test (t=2.98, df=58, p=.004).

On the inhibition and strategy generation measures, the older group were significantly slower than the control group on the Hayling test (F=43.84, df=1,57, p=.0001). The group by task interaction was marginally significant (F=3.90, df=1,57, p=.053), and post-hoc t-tests showed that the older group was significantly slower on both parts of the test, but that this was more pronounced for the second, inhibitory part of the test which involved completing sentences with nonsensical words (t=5.64, df=57, p=.0001) than for the first part, which involved straightforward sentence completions (t=3.68, df=37.69, p=.001). The two groups did not differ significantly on error scores on the Hayling Test (z=1.69, p=.091) or Letter Fluency scores (t=1.24, df=58, p=.219).
Table 9.3  Mean scores and standard deviations for the executive battery: older versus younger group.

<table>
<thead>
<tr>
<th></th>
<th>Older group</th>
<th>Younger group</th>
<th>Test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Deductive reasoning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raven's Matrices/12</td>
<td>8.63 (2.47)</td>
<td>10.73 (1.34)</td>
<td>z=3.62</td>
<td>.0001**</td>
</tr>
<tr>
<td><strong>Attention and set-shifting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Star time</td>
<td>44.77 (11.61)</td>
<td>33.60 (10.83)</td>
<td>F=24.70</td>
<td>.0001*</td>
</tr>
<tr>
<td>Letter time</td>
<td>62.73 (14.23)</td>
<td>49.60 (10.55)</td>
<td>F=24.70</td>
<td>.0001*</td>
</tr>
<tr>
<td><strong>Trail Making Test(^1)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>44.13 (15.39)</td>
<td>25.73 (9.19)</td>
<td>F=59.20</td>
<td>.0001**</td>
</tr>
<tr>
<td>Time B</td>
<td>89.77 (36.11)</td>
<td>51.57 (12.56)</td>
<td>F=59.20</td>
<td>.0001**</td>
</tr>
<tr>
<td><strong>Rule Shift Cards</strong></td>
<td>3.03 (0.76)</td>
<td>3.53 (0.51)</td>
<td>t=2.98</td>
<td>.004**</td>
</tr>
<tr>
<td><strong>Inhibition and strategy generation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hayling Test(^1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>25.21 (14.75)</td>
<td>17.03 (2.24)</td>
<td>F=43.84</td>
<td>.0001**</td>
</tr>
<tr>
<td>Time B</td>
<td>60.97 (36.34)</td>
<td>26.93 (13.59)</td>
<td>F=43.84</td>
<td>.0001**</td>
</tr>
<tr>
<td>B Errors</td>
<td>2.86 (2.59)</td>
<td>1.77 (1.89)</td>
<td>z=1.69</td>
<td>.091</td>
</tr>
<tr>
<td><strong>Letter fluency</strong></td>
<td>43.20 (11.33)</td>
<td>47.33 (14.26)</td>
<td>t=1.24</td>
<td>.219</td>
</tr>
<tr>
<td><strong>Multitasking</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Six Elements Test</td>
<td>3.40 (0.81)</td>
<td>3.83 (0.46)</td>
<td>z=2.57</td>
<td>.010*</td>
</tr>
<tr>
<td><strong>Executive memory</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story Recall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>38.17 (10.18)</td>
<td>44.87 (5.44)</td>
<td>F=10.60</td>
<td>.002**</td>
</tr>
<tr>
<td>Delayed</td>
<td>36.43 (9.83)</td>
<td>43.07 (6.01)</td>
<td>F=10.60</td>
<td>.002**</td>
</tr>
<tr>
<td><strong>Dysexecutive behaviours (DEX)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEX</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self rating(^1)</td>
<td>16.90 (8.86)</td>
<td>19.47 (8.99)</td>
<td>t=1.11</td>
<td>.273</td>
</tr>
<tr>
<td>Other rating(^2)</td>
<td>12.86 (10.41)</td>
<td>18.44 (7.68)</td>
<td>z=3.02</td>
<td>.003**</td>
</tr>
</tbody>
</table>

* p<.05  **p<.01  \(^1\)N=29 older, 30 younger  \(^2\)N=28 older, 25 younger
On the measure of multitasking, the Six Elements Test, the older group gained significantly poorer scores than the younger group \((z=2.57, p=.010)\). On the deductive reasoning measure, the Raven's matrices, the older group completed fewer items correctly when raw scores were compared \((z=3.62, p=.0001)\). In general, no age adjustments were used for raw scores in this study, since the effect of age is the issue under consideration. However, since age-corrected scores are provided for Raven's matrices, these were compared. As might be expected for healthy older people, these age-corrected scores did not differ significantly between the groups (Older mean 13.77, sd 2.65; Younger mean 13.37, sd 1.85; \(p=.329\)). On the Story Recall measure, the older group recalled significantly fewer elements of the story than the younger group \((F=10.60, df=1,58, p=.002)\), and there was no significant group by task interaction for immediate versus delayed recall \((F=0.01, df=1,58, p=.946)\).

For the DEX questionnaire, all participants except one in the older group filled out self-ratings, and scores did not differ significantly between the groups \((t=1.11, df=57, p=.273)\). Other-ratings were returned for all except two older and five younger participants. These showed a significant group difference, such that the older participants were judged to show fewer dysexecutive behaviours than the younger group \((z=3.02, p=.003)\).

9.3.4 Analysis of Covariance

Analysis of covariance was also conducted to examine the effects of the executive battery on the Number of Solutions generated, which was the only Predicaments measure on which the older group gained poorer scores than the younger group. This showed that the group difference was no longer significant when the attention and set-shifting measures were used as covariates \((p=.054)\). The difference remained significant when the other measures were used as covariates: inhibition and strategy generation \((p=.007)\), multitasking \((p=.002)\), deductive reasoning \((p=.005)\), and executive memory \((p=.004)\).
9.4. DISCUSSION

9.4.1 Summary of results
The main findings on the Predicaments test showed that the older group generated significantly fewer solutions than the younger group, but that their solutions were of higher average quality. The two groups did not differ in the quality of the solutions they selected as their final options, although the older group rated their satisfaction with their solutions as significantly higher. On the executive battery, the older group gained poorer absolute scores than the younger group on most of the measures administered. The older participants were also rated to show fewer dysexecutive behaviours in their daily lives by their relatives and friends.

9.4.2 Executive battery
The results reported for the executive battery are based on comparisons of raw scores because age was the factor under consideration in the current study. However, many standardised psychometric and neuropsychological measures provide age-scaled normative data, because older people are expected to show poorer absolute performance (e.g. Wechsler Adult Intelligence Scales, Wechsler, 1981, 1997). When age-adjusted scores were examined where available in the current study, the older group were seen to perform at expected levels for healthy older people. Nevertheless, the raw score comparisons showed that the older group gained poorer scores than the younger group on all the measures of attention and set-shifting, multitasking, deductive reasoning, and executive memory. The findings on measures of inhibition and strategy generation were mixed, with impairment seen on the timed aspects of the Hayling test, but not on Hayling error scores or Letter Fluency scores.

The poorer absolute levels of performance seen in the older group on most of the standardised neuropsychological tests involving executive function are in line with other studies of normal ageing (e.g. Axelrod & Henry, 1992; Daigneault et al, 1992). The pattern of findings in the current study on these measures was similar to that seen in people with anterior lesions described above, and more marked than that seen in adults with TS in the previous chapter. This is therefore consistent with theories that argue that the normal ageing process has a detrimental effect on the
frontal lobes (e.g. Jernigan et al, 2001; Raz et al, 1998; Coffey et al, 1992), although additional factors such as cohort differences in education cannot be ruled out in the absence of longitudinal data. The older group did not show deficits on the letter fluency task. However, other studies have also reported intact performance on these types of tasks in older people (e.g. Phillips, 1997). It has been argued that people who regularly do activities such as crossword puzzles may be able to use routine strategies to complete fluency tasks, thus reducing the contribution of executive skills (Phillips, 1997; Bryan & Luszcz, 2000). Therefore, although older people might show deficits in novel problem-solving tasks, consistent with the Shallice and Burgess model of frontal lobe functioning (Shallice & Burgess, 1991, 1996), fluency tasks are not always sensitive to these because experience has reduced the novelty.

9.4.3 Interpretation of reduced solution fluency in older people

On the Predicaments task, the older group produced fewer solutions than the younger group. This finding was also seen in the anterior and TS groups. However, unlike the other two experimental groups, the solutions produced by the older group were of higher average quality than those produced by their matched control group. Viewing their reduced solution fluency as an index of impairment is therefore questionable in the light of their higher solution quality scores for these same solutions. In addition, impoverished solution generation was seen as a potentially important contributor to the poorer Final Solution Quality scores in the anterior and TS groups, and there were significant correlations between Number of Solutions and Final Solution Quality for the anterior group, and between Average Solution Quality and Final Solution Quality for the TS group. By contrast, the older group did not choose poor solutions as their optimal and personal options, nor did they have any significant correlations between Final Solution Quality scores and the solution fluency scores.

Why might the older group have generated fewer solutions than the younger group? Slower speed of production is unlikely to account for the older group’s performance on the solution generation task, since participants in both groups usually ran out of ideas well before the end of the time limit. One possible explanation is that their reduced fluency reflected impaired executive function in terms of poorer strategy
generation. However, this seems an unlikely explanation, since the strategy generation measures were those on which they showed least impairment in the executive battery, and analysis of covariance showed that most of the executive measures did not affect the group difference on this measure. In addition, poorer overall strategic processes cannot explain why the older group generated better quality solutions. The most obvious interpretation of these data is that the older group adopted a qualitatively different procedure to the younger group for generating possible solutions. This might operate by means of a deliberate response bias to report only higher quality solutions arising from greater reluctance than the younger group to give poor responses, although this would run counter to the task instructions to suggest as many ideas as possible, regardless of quality, and there was no evidence in general that either group disregarded the task instructions. Another possibility is that access to stored knowledge or past experience relevant to possible solutions differed between the groups, so that information relating to poorer quality solutions is either not stored or is filtered out at an earlier stage for the older group.

Problem-solving may thus be more automatic for older people due to their enhanced experience. One method by which this might operate is by the activation of 'somatic markers' (Damasio, 1994). These markers are thought bias decision-making automatically by marking possible outcomes as negative or positive based on previous experience. As people get older, the affective information may become more salient, and poor decision-making options may therefore be rejected before being available to consciousness (Peters, Finucane, MacGregor & Slovic, 2000). If decision-making in older adults is weighted more by emotional factors, this may be adaptive in many real-life situations, but could also lead to inappropriate biases in some situations. However, as the authors point out, it is difficult to see how to test such hypotheses directly.

9.4.4 Selection of solutions on the Predicaments task

When Final Solution Quality scores were examined, no significant differences were found between the two groups in the current study. This was true both for the total solution quality scores, and for individual subscales relating to appreciation of the
pertinent interpersonal/practical aspects of the situations, and devising socially appropriate and effective solutions. This was in sharp contrast to the findings seen when the performance of participants with anterior lesions and TS was examined. In the anterior and TS groups, it was postulated that their deficits on these measures might reflect difficulties in using their experience to guide their problem-solving, in terms of selecting appropriate goals, and monitoring the possible consequences of actions. The findings of the current study imply that these processes are intact in older adults, consistent with theories that increased experience can aid everyday problem-solving performance in healthy older people.

The groups did not differ when asked to rank order sets of alternative solutions for each problem. However, given that this was a less sensitive measure in the previous studies, and that the older group did not show the difficulties with the Predicaments test seen in the other experimental groups, this is not surprising. When satisfaction ratings were considered, the older participants rated themselves as slightly more satisfied with their own solutions than did the younger group. This may reflect increased confidence in their own judgement (whether or not this is justified) as a result of greater life experience in older people. It may also be related to the smaller number of higher quality potential solutions generated by this group, leading to lesser uncertainty about their ultimate choices from a smaller pool. From this perspective, their higher satisfaction is justified by a higher level of performance in terms of quality.

9.4.5 The relative contributions of executive skills, interpersonal factors and experience to real-life problem-solving in older people

In the previous chapters, both executive skills and knowledge and experience were thought to contribute to real-life problem-solving. Given that the Predicaments test was more sensitive than the executive battery to the deficits seen in the anterior and TS groups, it might have been expected that the older group would show extensive impairments on the Predicaments test, since they gained poorer scores than the younger group on most of the executive measures. On the other hand, greater life experience in older people may confer an advantage that is evident on real-life-type tasks, but less relevant to more abstract ones. The present findings of similar
everyday problem-solving performance with poorer absolute performance on
abstract executive tests are in line with an explanation in terms of greater life
experience.

The problems presented in the current study all contained interpersonal aspects. There is no clinical evidence of socially inappropriate behaviour in healthy older people. Previous work has also indicated that older people have intact theory of
mind (Happé et al, 1998). In the present study, the findings from the DEX
questionnaire indicated that the older group did not differ from the younger group in
their self-assessment of dysexecutive features in everyday life, and the ratings
provided by relatives/friends suggested that they showed fewer features than the
younger group. This suggests that the decline in executive skills demonstrated on the
neuropsychological tests is not necessarily accompanied by dysexecutive difficulties
in everyday life, and indeed that their behaviour may appear more adaptive than that
of a younger group. Previous authors have observed such apparent discrepancies
between laboratory-assessed cognitive skills and real-life performance (Rabbitt,
1977; Salthouse, 1990a).

How might any advantage of greater life experience operate in compensating for
poorer executive processes in real-life problem-solving by older people? Direct or
indirect exposure to prior situations that are relevant, but by no means identical, to
new ones could influence performance by means of the creation and use of enhanced
knowledge structures. Sinnott (1989) reported differences in styles of decision­
making related to age, such that older adults relied more heavily than younger adults
on top-down processing, with the latter group compensating for their lack of relevant
knowledge structures by collecting more data about the problem. There may be a
complex interaction between knowledge structures and the ways in which
knowledge is stored and accessed. Situations that are solved effectively may lead to
storage of information about successful outcomes, and the discarding of information
that did not lead to successful outcomes. This in turn could facilitate faster access to
relevant effective solutions in future. In addition to stored knowledge, successful
problem-solving is likely to depend upon efficient use of such knowledge in terms of
adequate search and retrieval strategies, selection and integration of relevant
information, and capacity to anticipate the consequences of possible actions to judge the probable outcome. Evidence from the present study that the older group differed from the younger group in generating solutions suggests that this may be an important stage at which real-life knowledge/experience may operate. Further work is needed to investigate whether such influences operate primarily by means of enhanced knowledge structures, higher activation of such knowledge structures in memory stores, or better strategic memory search. Since the older group performed below the level of the younger group in absolute terms on most of the executive tests, it seems improbable that they are characterised by better memory search strategies in general. In practice, there is at present no adequate means of measuring accurately the extent and variety of human knowledge and experience, and thus of relating it directly to problem-solving performance (see Salthouse, 1990b, for a review).

The findings of the current study are consistent with a model of normal ageing proposed by Phillips and Della Sala (1998). They argued that dorsolateral regions of the prefrontal cortex subserve executive skills, while orbitofrontal regions are important in interpersonal problem-solving. They therefore suggested that intact real-life problem solving in the context of impaired executive skills could be explained by differential changes in the dorsolateral frontal areas in normal ageing, compared with orbitofrontal areas. Some support for disruption to lateral areas has been provided by studies showing that dopaminergic systems are affected in normal ageing (Volkow et al., 1998; Backman et al., 2000; Inoue et al., 2001), although this has not always been supported (e.g. Arrantz et al., 1993, Meltzer et al., 1998).

9.4.6 Multiple dimensions of problem-solving
The present findings need to be considered in the context of the varying findings reported in the literature on problem-solving in normal ageing. Previous work has demonstrated the multidimensional nature of problem-solving (see e.g. Marsiske & Willis, 1995; Diehl et al., 1995). Some of the real-life-type tasks used to study problem-solving are heavily reliant on executive processes involved in manipulating information in working memory, and may allow relatively little scope for
knowledge/experience to compensate for impairments in such processes, despite the use of everyday materials.

The type of measures used, in addition to the test materials, may also influence the findings. Denney and Pearce (1989) suggested that reduced quantity rather than quality of performance may differentiate older adults from younger ones. The use of forced-choice alternative answers rather than free generation may also affect the findings. In the present study, the quantity measure of number of possible solutions generated did reveal performance differences, whereas measures assessing the quality of the final solutions selected did not. The present study did not include a middle-aged group, who might have the advantage of greater life experience than the younger group, without significant decline in executive processes noted in the older group. Middle-aged participants might therefore score optimally on the Predicaments test, in line with evidence suggesting a U-curve in performance on problem-solving tasks from other studies (e.g. Denney & Pearce, 1989). Alternatively, Predicaments performance may remain relatively constant over the adult lifespan.

9.4.7 Summary of current study

In summary, the older group in the current study showed impairment in aspects of all the categories of executive tests, as predicted in Hypothesis 1. Hypothesis 2 stated that it was not possible to make a clear prediction about older people’s performance on the Predicaments test. The results showed that the older group generated fewer solutions on this measure, in the context of intact performance on all other aspects of the test. The findings were consistent with the greater life experience of older people being a major factor in maintaining real-life problem-solving performance, mediated by enhanced knowledge structures and/or more efficient access to and use of such knowledge. It is important to note that while clinical assessments of performance based on standardised neuropsychological tests may lead to underestimates of the difficulties shown in real life by people with anterior lesions (Eslinger & Damasio, 1985; Shallice & Burgess, 1991), they may lead to overestimates of everyday difficulties in healthy older people.
9.4.8 Summary of the findings presented to date

The findings presented in the first three chapters have shown that participants with anterior lesions and those with Tourette's syndrome have impairments on a real-life-type problem-solving task. The problems focused on interpersonal issues, and factors that were thought likely to contribute to impairment included executive skills, interpersonal factors and experience. While all of these factors are likely to be relevant in everyday problem-solving the findings presented here have provided evidence about the relative relationships between them. It has been shown that executive skills cannot be the only contributory factor to impairments in real-life problem-solving, since a group of older adults showed poorer performance in all aspects of executive function, but intact performance on most aspects of the Predicaments test. The importance of experience to problem-solving was shown by the relative findings in the TS and older groups. The TS group would be predicted to have the poorest social knowledge/experience, and they showed impaired performance on many aspects of the Predicaments test, in spite of having fewer executive impairments than the other experimental groups. By contrast, the intact performance of the older group in the current study is likely to be attributable to their extensive real life experience. The next study attempts to address the role of specific aspects of interpersonal behaviour in real-life problem-solving, by comparing performance on interpersonal versus non-interpersonal problems.
CHAPTER 10
INTERPERSONAL VERSUS NON-INTERPERSONAL PROBLEM-SOLVING
IN PEOPLE WITH FOCAL ANTERIOR BRAIN LESIONS

10.1 INTRODUCTION

The current study describes an adapted version of the Predicaments test. The aim of the study was to investigate further the contribution of interpersonal factors to real-life-type problem-solving performance. This was achieved by examining the relative performance of a group with structural anterior lesions and a matched control group on two different sorts of problems, those containing practical problems with little interpersonal relevance, and those in which interpersonal issues were central to the problem.

The study described in chapter 7 demonstrated that anterior lesions are associated with deficits in solving interpersonal problems, and a variety of factors was thought to contribute to this. Some of these factors were specific to understanding other people, such as pragmatic language processing, theory of mind, and empathy. Other potential factors were applicable to both interpersonal and non-interpersonal problems, such as executive deficits, and the contribution of previous experience. The non-interpersonal problems presented in the current study are expected to draw on executive processes and previous experience in a similar fashion to interpersonal problems, but the specific interpersonal factors are not expected to be relevant to performance. Thus, comparison of the patterns of performance on the two types of problem enables an assessment of the relative contributions of interpersonal factors to real-life problem-solving.

Inappropriate interpersonal behaviour is often reported to be a consequence of anterior brain lesions (e.g. Prigatano 1991a, 1991b; Bardenhagen et al, 1999; Blair & Cipolotti, 2000). People with frontal lobe dysfunction have been shown to have impairments in interpreting nonverbal cues such as facial expression and tone of voice (Hornak et al,
However, contributions of factors such as these to Predicaments performance in participants with anterior lesions in the first study appeared to be slight, since there were no differences in performance when the problems were presented on video versus when they were given as stories.

However, there are other aspects of interpersonal functioning that might have been relevant to problem-solving performance in the first study. These include theory of mind, empathy, and understanding of pragmatic aspects of language. Theory of mind is the ability to appreciate other people’s mental states. Studies have shown that people with frontal lobe lesions are impaired in this ability (e.g. Channon & Crawford, 2000; Stuss et al, 2001), although there is still debate about lateralisation, and which exact areas within the frontal lobes are critical. Empathy refers to a range of cognitive and emotional processes that are involved in understanding other people, and in sharing experiences with others (Eslinger, 1998). Therefore, by definition, empathy can only be relevant to interpersonal experiences, although it may be related to be more general executive processes such as cognitive flexibility (Grattan & Eslinger, 1989). Empathy has been postulated to be dependent on frontal lobe functioning (Grattan et al, 1994; Farrow et al, 2001), and it has been suggested that there may be fractionation of empathy, with dorsolateral areas mediating cognitive empathy, and orbitofrontal areas mediating emotional empathy (Eslinger, 1998). Evidence has also implicated frontal lobe lesions in impairments in aspects of pragmatic language, such as understanding sarcasm, irony, deceit and humour (e.g. McDonald & Pearce, 1996; Bara, et al, 1997; Shammi & Stuss, 1999).

How might these processes be related to the Predicaments test? All of the situations in the Predicaments test involved an interaction between two or more people, which was related to the awkward situation. Thus, in many of them, understanding why the situation was awkward required the ability to understand the mental state of the main character, and empathise with their situation. Solutions were scored on three dimensions as to whether answers showed appreciation of the pertinent details of the
situation, whether they were interpersonally appropriate, and whether they provided an effective practical means of solving the problem. The anterior participants showed impairment on all three aspects of functioning. Deficits in understanding and relating to other people would make it difficult to appreciate the pertinent aspects of situations associated with interpersonal concerns. Such failures in problem appreciation could also affect participants' selections of effective methods of solving the problems. In addition, inability to understand other people would make it more likely that participants would fail to understand that it was important to take other people's feelings into account in their solutions, leading to solutions that were not interpersonally appropriate.

Another, less specific, source of potential difficulty with interpersonal situations would be if these were more complex than non-interpersonal problems. Thus, when it is necessary to consider more than one person's sensibilities, and what the possible consequences of an action might be for each person, it is possible that the greater number of pertinent factors or their nature makes the situations more difficult to solve. If this is the case, then control participants, in addition to participants with anterior lesions, might be expected to gain poorer scores on the interpersonal scenarios.

The study describes the development of awkward situations in which there was a predominantly practical problem. Each scenario contained only one character, and there were no elements of interpersonal relationships to consider. Performance on these Predicaments was compared with performance on a subset of the original scenarios, in which interpersonal relationships were central to the problem. All situations were presented in story form, to avoid possible confounds of non-verbal cues. Two groups of participants were tested, those with structural anterior lesions, and a matched healthy control group. Following Burgess and Shallice (1996a, 1996b), the anterior participants had a unilateral lesion involving the frontal lobe, and no more than one other lobe.
10.1.1 Hypotheses

1) The main aim of the study was to examine whether there were any differences between the interpersonal and non-interpersonal items. It was anticipated that both groups might find aspects of interpersonal problem-solving more difficult than non-interpersonal problem-solving, although specific predictions were not made with respect to the performance of the control group.

2) It was hypothesised that the anterior group would show impairment relative to the control group on aspects of both interpersonal and non-interpersonal problem-solving.

3) It was predicted that the impairments shown by the anterior group would be more marked on the interpersonal problems than the non-interpersonal problems. This was because analysing and solving the interpersonal problems would be expected to draw on specific processes relevant to interpersonal interactions, in addition to processes such as executive function and use of previous experience, which would be expected to be relevant to both types of stories.

10.2 METHOD

10.2.1 Participants

Thirteen participants (7m, 6f) with unilateral left-sided (n=4) or right-sided (n=9) lesions involving damage to the frontal lobes (anterior group) participated in the study. Aetiology of the lesions included vascular (n=6), head injury (n=5) and tumour (n=2). To be included in the study, participants had to be between 18 and 70 years of age and fluent in English, with a unilateral lesion confined to one or two lobes of at least three months duration. The lesions were classified as medial, lateral or orbital using the criteria described by Damasio and Damasio (1989), and the lesion sites are shown in Table 10.1.
Table 10.1: Lesion sites for the anterior group

<table>
<thead>
<tr>
<th>Participant</th>
<th>Side of lesion</th>
<th>Size and site of lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R</td>
<td>Large orbital, medial and lateral FL</td>
</tr>
<tr>
<td>2</td>
<td>R</td>
<td>Small medial and lateral FL</td>
</tr>
<tr>
<td>3</td>
<td>R</td>
<td>Small medial and large lateral FL</td>
</tr>
<tr>
<td>4</td>
<td>R</td>
<td>Moderate medial and large lateral FL</td>
</tr>
<tr>
<td>5</td>
<td>R</td>
<td>Large medial and lateral FL</td>
</tr>
<tr>
<td>6</td>
<td>R</td>
<td>Small lateral FL</td>
</tr>
<tr>
<td>7</td>
<td>R</td>
<td>Moderate lateral FL</td>
</tr>
<tr>
<td>8</td>
<td>R</td>
<td>Large lateral FL</td>
</tr>
<tr>
<td>9</td>
<td>R</td>
<td>Moderate medial and large lateral FL plus moderate PL</td>
</tr>
<tr>
<td>10</td>
<td>L</td>
<td>Small orbital, and moderate lateral FL</td>
</tr>
<tr>
<td>11</td>
<td>L</td>
<td>Moderate medial and lateral FL</td>
</tr>
<tr>
<td>12</td>
<td>L</td>
<td>Small lateral FL plus moderate TL</td>
</tr>
<tr>
<td>13</td>
<td>L</td>
<td>Moderate lateral FL plus moderate TL</td>
</tr>
</tbody>
</table>

As adequate language processing was essential for the study, participants were excluded if they had expressive or receptive dysphasia. The Test for the Reception of Grammar (TROG; Bishop, 1989) was administered as a screen for this, and participants were included who scored errors on three blocks or fewer, equivalent to adult performance at the 25th percentile or above. Exclusion criteria included other significant physical or psychiatric illness, alcohol or drug dependence, hydrocephalus and dementing conditions. Participants were also excluded if they gained an estimated premorbid verbal IQ score below 85, as measured by the NART-II (Nelson, 1991).

Twenty healthy control participants (11m, 9f) also took part in the study. The two groups did not differ significantly from each other in terms of age (anterior mean 42.49, sd 14.99; control mean 41.35, sd 14.74), years of education (anterior mean 14.38, sd 1.89; control mean 13.70, sd 2.08), NART IQ (anterior mean 111.54, sd 9.21; control mean 112.10, sd 9.73), or TROG scores (anterior mean 78.54, sd 1.39; control mean 79.45, sd 0.69). All participants gave written informed consent for the study, and were given breaks between tasks as necessary, to avoid fatigue.
10.2.2 Experimental measure: Interpersonal and Non-interpersonal Predicaments

The test consisted of eight stories of everyday awkward situations or 'Predicaments'. The aim was to have four stories in which interpersonal issues were central to the problem, and four in which interpersonal issues were not necessarily relevant. The four interpersonal items were chosen from the eight interpersonal Predicaments described in the previous chapters. All of the original Predicaments necessarily involved interpersonal contact as they had videotaped versions containing more than one person. However, the four items that were selected for the present study were chosen because interpersonal issues, involving understanding of others’ perspectives, were central to comprehending and solving the awkward situations in each. The four stories contained problems featuring different types of interpersonal relationships, including friends, neighbours, work colleagues and relatives. An example of a interpersonal Predicament is outlined below.

10.2.2.1 Example of a Interpersonal Predicament: Antibiotics

"Neville has gone to the pub at lunchtime for a drink with some of his friends. They ask him why he is not drinking alcohol, and he replies that he cannot because he is on a course of antibiotics. They tell him that he will have to have a drink when Guy gets back, to celebrate Guy's new job after being unemployed for a year. Guy arrives at the table carrying champagne glasses. He has ordered champagne for all of them. All of Neville's friends try to persuade him that he should drink a glass."

The other three items involved a dispute with some neighbours, an embarrassing situation with an employer at work, and a woman making highly personal comments to a younger relative. The set of 4 ‘interpersonal’ stories is contained in Appendix D.

For the purposes of the current study, four further awkward situations were developed, in which there were no obvious interpersonal concerns. In order to generate the non-interpersonal items, a large number of situations was initially generated on the basis of interviews with a range of people of varying ages, backgrounds and ethnicity, and
these were made into vignettes. These were piloted on a small set of healthy
volunteers, and in the process of doing this, it became apparent that some of them
necessarily involved interpersonal relationships; these items were rejected. The four
items that were chosen all contained only one person. The situations involved an
electrical power cut, a flood, discovering that the house has been burgled, and a
problem with paying a telephone bill. An example is shown below; the full set of non-
interpersonal stories are outlined in Appendix D.

10.2.2.2 Example of a Non-interpersonal Predicament: Burglary
“Christine gets home late after a pleasant evening out at the cinema. When she gets
home, she takes off her coat and shoes, looking forward to having a snack and putting
her feet up before going to bed. However, when she walks into her living room she
discovers that she has been burgled. Her television and video recorder are obviously
missing and her possessions are strewn over the floor; some items are broken. When
she goes into her kitchen she discovers a broken window and more mess.”

Although the original study included both videotaped and story versions, only story
versions were used in the current study. This removed the practical difficulty of
videoing the non-interpersonal scenarios. Although this potentially decreases the
ecological validity of the test, it was thought to be justified since the original analysis
found no differences between the videotaped and story versions. In addition, it was
thought to be inappropriate to include nonverbal cues such as facial expressions and
tone of voice in the non-interpersonal items.

10.2.2.3 Procedure
The stories were presented on paper in a fixed order, alternating the non-interpersonal
and interpersonal items. All participants completed the full set of eight stories. At the
beginning of the task, they were told the following:
"I am going to give you a series of short stories. Each story contains an awkward situation that everyone might encounter in daily life. After you have read the story, I am going to ask you some questions about the situation. Here is a list of the questions I will ask you for each story, so that you can get familiar with them. Some of the questions have a time limit, shown on your sheet. If you do not answer within the limit, I will ask you to give me an answer immediately. When I ask you to tell me what happened in the scene (experimenter points to the relevant place on the question sheet), please make your answer as complete as you can.”

Participants were asked to read each story and turn the page onto a blank sheet of paper to indicate when they had finished. They were then asked a range of questions to examine different aspects of problem-solving. These questions were the same as those used in the Predicaments studies described above (see Appendix B). All responses were recorded on a scoresheet. They were also audiotaped to enable a back-up check to be made if the information on the scoresheets was unclear.

10.2.2.3.1 Factual account of the problem situations
After each story was presented, memory for the characters and overt actions was assessed by asking participants to describe what happened in the story. If they did not recall all the main facts spontaneously, they were prompted to give more information. They were then asked to read the story again if important details had not been mentioned. If the answer remained unsatisfactory after this, a verbal summary of any missing details was provided, giving up to 3 prompts in all to ensure awareness of the factual details of the situation.

10.2.2.3.2 Awkwardness ratings
After describing the situation, participants were asked to rate how awkward it was, both for the main character, and for themselves if they were in the same situation (0-100%). On the first item, the scale was explained to them by informing them that ‘0’ would represent a situation that was not awkward at all, while ‘100’ would mean it
was as awkward as a situation could possibly be. Following the procedure described in previous studies, these ratings were averaged across perspective (main character versus self), in order to create one average rating of awkwardness.

10.2.2.3.3 Solution generation
Solution fluency was assessed by asking participants to generate as many potential solutions as possible (Number of Solutions). They were allowed a maximum of two minutes for this. Participants were not given any prompts for further information or clarification of their suggested solutions, to ensure that no cues were provided as to the adequacy of their responses. When this question was asked for the first story, participants were told the following: “When I say this, it means I want you to give me a range of ideas for what the character could do, not just ideas for what you think they should do.”

10.2.2.3.4 Selection of optimal and personal solutions
After generating possible solutions, participants were asked to select the best solution from the perspective of the main character (Optimal Solution). They were then asked to state what they themselves would do if they were in that situation (Personal Solution), in order to examine to what extent they chose a different course of action from that which they considered to be optimal for the main character.

10.2.3.3.5 Satisfaction ratings
After giving their optimal and personal solutions, participants were asked to rate their degree of satisfaction with each (0-100%). Again, clarification about the scale was provided on the first item to ensure participants understood. They were told that ‘0’ represented not being satisfied at all, while ‘100’ meant that they were as satisfied as they could possibly be. Again, following previous procedures, these ratings were averaged across perspective (optimal and personal) to create one average rating of awkwardness.
10.2.2.4 Scoring

The scoring system for the interpersonal items was the same as that used for these items in the previous studies, as outlined in section 7.1.2.2.9. The development of the scoring system for the non-interpersonal items was modelled on that in the original study. It was developed by the present author and project supervisor, who pooled the data collected during the development of the test and sorted the answer into categories reflecting different types of solutions. These categories were then classified according to two criteria, (a) whether they showed adequate appreciation of the problem, and (b) whether they provided an effective practical means of resolving the problem. The scoring guidelines for the original interpersonal Predicaments had included a third dimension, which was to judge whether the solutions offered were interpersonally appropriate. This dimension was not relevant for the non-interpersonal items, and therefore was not considered for either set in the present study as the purpose was to examine the comparability of the two sets of items. However, it is worth noting that this is a fundamental difference between the two sets of items.

Detailed guidelines were written which described each category and gave sample answers for each. All responses for the study were rated by two raters who were blind as to the identity and group membership of the participants. The two raters agreed for 91.1% of the ratings. All differences were resolved by reference to an additional blind rater. All answers provided in both the Solution Generation phase and Optimal and Personal selection phases were scored according to the two criteria provided below.

10.2.2.4.1 Problem appreciation

The Problem Appreciation measure assessed whether or not the solution demonstrated adequate recognition of the pertinent interpersonal/practical aspects of the problem situation that needed to be taken into account in order for a satisfactory outcome to be possible. For example, in the example scenario above, in which Christine discovers that she has been burgled, the categories could be summarised as follows:
(a) Contact the police
(b) Take steps to ensure her safety (e.g. check if the burglar is still there, or leave the house to avoid risk)
(c) Check if there are any witnesses or identifying clues as to who did it
(d) Take steps to prevent a future incident (e.g. mend the window, door locks, etc)
(e) Clear up the mess
(f) Assess the extent of theft/damage (e.g. for insurance reasons)
(g) Irrelevant or incomplete responses (e.g. cry, don’t touch anything)

Categories a, b, c, d, e, and f in this example were assigned a score of 1 to indicate adequate appreciation of the pertinent issues. By contrast, category g was assigned a score of 0, to indicate poor appreciation of the problem (whether or not the solutions would, in practice, be effective).

10.2.2.4.2 Effectiveness
The categories were also used to classify solutions according to whether or not the manner of dealing with the situation was likely to provide an effective practical means of resolving it (Effectiveness, scored 1 or 0). In the example of the “burglary” predicament shown above, only category (a) was considered to be effective. In practice, participants often gave answers that included a range of separate answers for this Predicament. For example, one participant in the control group said that the best thing the main character could do was “Call the police straight away. Once the police have all the information they need, start clearing up and get the window replaced”. Another said that she herself would “Call the police and ring an emergency repair service and my insurance company”.

10.2.2.4.3 Solution quality
A Solution Quality score was also calculated by adding the two subscores (Problem Appreciation and Effectiveness). These subscores were not necessarily independent, as failure to identify the pertinent aspects of the problem (Problem Appreciation) was automatically scored 0 for Effectiveness, since it was associated with generation of a solution that did not recognise or address the correct problem. A composite score,
Final Solution Quality, was created by adding together the scores of the Optimal and Personal responses, to give a score out of 4 for each item.

**10.2.2.4.4 Solution generation**

To assess how efficiently people generated solutions, the number of ideas generated for each problem situation was added to create a total score (Number of Solutions). Each of these ideas was scored for quality as described above. The Solution Quality scores were added together and divided by Number of Solutions, to provide an Average Solution Quality score, i.e. adjusted for the number of solutions given.

**10.3 RESULTS**

**10.3.1 Statistical analysis**

There are multiple comparisons of interest in the current study including the two groups (anterior and control) and the two types of items (interpersonal and non-interpersonal), plus any interactions between these. In order to examine the appropriateness of parametric tests, the variables of interest were initially inspected for outliers and skewness following the method described above in section 7.1.3.1. Logarithmic transformations were performed on the Number of Prompts and Number of Solutions in order to correct positive skewness. Squared transformations were performed on the ratings of satisfaction, in order to correct negative skewness. Final Solution Quality scores for non-interpersonal scenarios for the control group also failed to meet assumptions of normality. However, it was not possible to correct these using a transformation, as there were ceiling effects, which were too great. Final Solution Quality scores were therefore considered separately for the interpersonal and non-interpersonal items, as described below. All other variables were analysed using ANOVA, with one between-groups factor (group: anterior or control) and one within-groups factor (type of story: interpersonal or non-interpersonal). A 5% significance level was adopted throughout to compare the two groups. There were no missing data points.
10.3.2 Interpersonal and non-interpersonal Predicaments

Means, standard deviations and significance tests are shown in Table 10.2.

Table 10.2: Mean scores and standard deviations for the interpersonal and non-interpersonal Predicaments, for the anterior and control groups

<table>
<thead>
<tr>
<th></th>
<th>Anterior Mean (SD)</th>
<th>Control Mean (SD)</th>
<th>Test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Number of Prompts</strong></td>
<td>gp F=12.43 .001**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-interpersonal</td>
<td>0.81 (0.64)</td>
<td>0.25 (0.41)</td>
<td>type</td>
<td>F=0.63 .433</td>
</tr>
<tr>
<td>Interpersonal</td>
<td>0.54 (0.56)</td>
<td>0.28 (0.34)</td>
<td>gp x type</td>
<td>F=2.56 .120</td>
</tr>
<tr>
<td><strong>Awkwardness Ratings /100%</strong></td>
<td>gp F=0.13 .723</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-interpersonal</td>
<td>74.17 (18.22)</td>
<td>72.34 (12.86)</td>
<td>type</td>
<td>F=6.90 .013*</td>
</tr>
<tr>
<td>Interpersonal</td>
<td>65.67 (16.80)</td>
<td>64.13 (16.79)</td>
<td>gp x type</td>
<td>F=0.01 .964</td>
</tr>
<tr>
<td><strong>Number of Solutions</strong></td>
<td>gp F=10.86 .002**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-interpersonal</td>
<td>14.23 (3.49)</td>
<td>19.40 (5.15)</td>
<td>type</td>
<td>F=31.48 .0001**</td>
</tr>
<tr>
<td>Interpersonal</td>
<td>11.69 (4.42)</td>
<td>16.70 (5.47)</td>
<td>gp x type</td>
<td>F=0.54 .470</td>
</tr>
<tr>
<td><strong>Average Solution Quality</strong></td>
<td>gp F=0.16 .692</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-interpersonal</td>
<td>1.50 (0.20)</td>
<td>1.44 (0.23)</td>
<td>type</td>
<td>F=22.73 .0001**</td>
</tr>
<tr>
<td>Interpersonal</td>
<td>1.17 (0.38)</td>
<td>1.29 (0.22)</td>
<td>gp x type</td>
<td>F=2.92 .097</td>
</tr>
<tr>
<td><strong>Final Solution Quality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-interpersonal</td>
<td>15.54 (0.88)</td>
<td>15.80 (0.52)</td>
<td>z=0.74 .459</td>
<td></td>
</tr>
<tr>
<td>Interpersonal</td>
<td>10.46 (3.57)</td>
<td>12.90 (2.86)</td>
<td>t=2.17 .038*</td>
<td></td>
</tr>
<tr>
<td>Anterior: interpersonal vs non-interpersonal:</td>
<td>z=2.96 .003**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control: interpersonal vs non-interpersonal:</td>
<td>z=3.42 .001**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Satisfaction Ratings /100%</strong></td>
<td>gp F=2.98 .094</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-interpersonal</td>
<td>88.63 (10.32)</td>
<td>87.66 (12.07)</td>
<td>type</td>
<td>F=43.38 .0001**</td>
</tr>
<tr>
<td>Interpersonal</td>
<td>82.10 (12.76)</td>
<td>70.18 (11.35)</td>
<td>gp x type</td>
<td>F=8.62 .006*</td>
</tr>
</tbody>
</table>

gp = group; type = interpersonal or non-interpersonal  
* p<.05  ** p<.01
10.3.2.1 Number of prompts

The mean numbers of prompts needed to recount the factual details of the stories are shown in Figure 10.1. ANOVA on the logarithmically transformed data showed that there was a significant effect of group (F=12.43, df=1,31, p=.001). There was no effect of type (interpersonal versus non-interpersonal) (F=0.63, df=1,31, p=.433), nor a group by type interaction (F=2.56, df=1,31, p=.120). Examination of the mean scores revealed that the main effect of group was due to the anterior participants needing more prompts than the control participants, although the number of prompts needed was low for both groups for both types of scenarios (an average of less than one prompt per item).

Figure 10.1: Mean number of prompts for the non-interpersonal and interpersonal stories for the anterior and control groups
10.3.2.2 Awkwardness ratings

Figure 10.2 shows the average awkwardness ratings for the interpersonal and non-interpersonal scenarios for the two groups. ANOVA showed that there were no main effects of group (F=0.13, df=1,31, p=.723) or significant group by type (interpersonal versus non-interpersonal) interactions (F=0.01, df=1,31, p=.964). However, there was a significant effect of type (F=6.90, df=1,31, p=.013). Examination of the mean scores showed that both groups rated the interpersonal items as less awkward than the non-interpersonal items.

Figure 10.2: Mean awkwardness ratings for the non-interpersonal and interpersonal stories for the anterior and control groups

10.3.2.3 Solution generation

Two measures were used to assess participants’ ability to generate solutions. Firstly, the total Number of Solutions generated was counted (Figure 10.3). ANOVA on the
logarithmically transformed data showed a significant effect of group (F=10.86, df=1,31, p=.002), and examination of the mean scores showed that the anterior group produced smaller numbers of solutions than the control group. There was also a significant effect of type (F=31.48, df=1,31, p=.0001), and the mean scores showed that both groups generated more solutions for the non-interpersonal items compared with the interpersonal items. The group by type interaction was not significant, indicating that the two groups showed a similar pattern of responses (F=0.54, df=1,31, p=.470).

Secondly, the quality of the solutions generated was examined, using the Average Solution Quality score (Figure 10.4). ANOVA showed that there was a main effect of type (F=22.73, df=1,31, p=.0001), but that neither the group difference (F=0.16,
df=1.31, p=.692), nor the group by type interaction (F=2.92, df=1.31, p=.097) reached significance. Examination of the mean scores showed that both groups gained higher average scores for their non-interpersonal solutions compared with their interpersonal solutions.

**Figure 10.4:** Mean Average Solution Quality for the non-interpersonal and interpersonal stories for the anterior and control groups

10.3.2.4 Selection of final solutions

For each problem situation, participants were asked to select an optimal solution from the perspective of the main character, and then to give their own personal solution. These were rated on Problem Appreciation and Effectiveness, and combined to give Final Solution Quality scores of a maximum of four per item. The scores for the interpersonal and non-interpersonal items are shown in Figure 10.5. As described above, there were ceiling effects for the non-interpersonal scores, which meant that a
parametric analysis was not justified. A Mann Whitney U test was therefore performed to compare the two groups, and this showed no significant effect of group ($z=0.74$, $p=.459$). As parametric tests were appropriate for the interpersonal Final Solution Quality scores, a t-test was performed. This showed that the anterior group gained significantly poorer scores than the control group ($t=2.17$, $df=31$, $p=.038$).

![Figure 10.5: Mean Final Solution Quality scores for the non-interpersonal and interpersonal stories for the anterior and control groups](image)

In order to examine the effects of interpersonal versus non-interpersonal items, Wilcoxon Signed Ranks Tests were carried out separately for the two groups. These showed that the scores for the interpersonal and non-interpersonal items were significantly different for both the anterior ($z=2.96$, $p=.003$) and the control groups ($z=3.42$, $p=.001$). Examination of the mean scores showed that both groups tended to
gain higher scores for the non-interpersonal items compared with the interpersonal items.

10.3.2.5 Satisfaction ratings

ANOVA comparing the squared transformations for the mean satisfaction ratings for the two groups showed a marginally significant effect of group (F=2.98, df=1,31, p=.094). Both the effect of type (F=43.38, df=1,31, p=.0001) and the group by type interaction (F=8.62, df=1,31, p=.006) were significant. Examination of the mean scores (Figure 10.6.) showed that there was a tendency for the control group to be less satisfied with their answers than the anterior group, and that both groups rated themselves as more satisfied with their non-interpersonal answers than their interpersonal answers. Post-hoc t-tests using an adjusted significance level (.05/2= p<.025) to examine the cause of the significant interaction, showed that the difference between the groups was not significant for the non-interpersonal satisfaction ratings (t=0.20, df=31, p=.843), but that the anterior group were significantly more satisfied with their interpersonal answers than the control group (t=2.95, df=31, p=.006).

10.3.3 Correlations between interpersonal and non-interpersonal Predicaments measures

Pearson product-moment correlations between the interpersonal and non-interpersonal equivalents of the each measure reported above were computed for each group. These are shown in Table 10.3.

Significant correlations were seen for both groups between the Number of Solutions generated for interpersonal and non-interpersonal items, and for the ratings of satisfaction. These were in the expected direction, such that higher scores/higher ratings on one type of item were associated with higher scores/ratings on the other. There were no other significant relationships between the interpersonal and non-interpersonal equivalents of each measure.
10.3.4 Effects of side of lesion

Analyses were also carried out within the anterior group between the unilateral left-sided (LA, N=4) and right-sided (RA, N=9) participants. ANOVAs were used for the variables that were analysed parametrically, with one between-group factor (side: left or right), and one within-group factor (type of story: interpersonal or non-interpersonal). These showed that there were no interactions between side and type of story, indicating no qualitative difference between the way the two subgroups scored on the interpersonal and non-interpersonal stories. For the Final Solution Quality scores, Wilcoxon Signed Ranks tests were carried out within the left- and right-sided groups. These showed that there was no significant differences between interpersonal and non-interpersonal scores for the left-sided group (z=1.84, p=.066), but there was a significant difference within the right-sided group (z=2.32, p=.021). Examination of
the mean scores for the right-sided group showed that they gained higher scores for the non-interpersonal items (mean 15.56, sd 0.88) than they did for the interpersonal items (mean 11.89, sd 3.14).

Table 10.3: Correlations between interpersonal and non-interpersonal predicaments measures for the anterior and control groups

<table>
<thead>
<tr>
<th></th>
<th>Anterior r</th>
<th>Anterior p</th>
<th>Control r</th>
<th>Control p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Number of Prompts</td>
<td>.55</td>
<td>.054</td>
<td>-.30</td>
<td>.206</td>
</tr>
<tr>
<td>Awkwardness Ratings /100%</td>
<td>.32</td>
<td>.287</td>
<td>.44</td>
<td>.051</td>
</tr>
<tr>
<td>Number of Solutions</td>
<td>.77</td>
<td>.002**</td>
<td>.83</td>
<td>.0001**</td>
</tr>
<tr>
<td>Average Solution Quality</td>
<td>.49</td>
<td>.092</td>
<td>.39</td>
<td>.086</td>
</tr>
<tr>
<td>Final Solution Quality</td>
<td>.03</td>
<td>.936</td>
<td>.28</td>
<td>.235</td>
</tr>
<tr>
<td>Satisfaction Ratings /100%</td>
<td>.60</td>
<td>.029*</td>
<td>.59</td>
<td>.006**</td>
</tr>
</tbody>
</table>

* p<.05 ** p<.01

10.4 DISCUSSION

10.4.1 Summary of results

The findings showed that the anterior group performed more poorly than the control group for number of prompts needed and number of solutions generated, regardless of type of problem (interpersonal or non-interpersonal). However, with respect to final solution quality they differed significantly from the control group only for the interpersonal items; both groups scored close to ceiling on the non-interpersonal items for this measure. In addition, the anterior group was more satisfied than the control group with their answers to the interpersonal scenarios, while the two groups did not differ in satisfaction with the non-interpersonal scenarios. There were significant main
effects of type of problem (interpersonal or non-interpersonal) for most of the Predicaments variables including numbers of solutions generated, average quality of these solutions, quality of final selections, and ratings of awkwardness and satisfaction. Mean scores suggested the interpersonal items to be more difficult than the non-interpersonal items.

10.4.2 Contributions to the differences between the interpersonal and non-interpersonal problems
Both the control group and the anterior group gained higher scores on most measures for the non-interpersonal problems than for the interpersonal problems, suggesting that the former were easier to solve. This effect should not reflect the deliberate adoption of different strategies for the two sets of problems, since the two sets of items were interspersed with each other during presentation, and participants were not alerted to the fact that there may have been differences between them. The non-interpersonal problems were designed to differ from the interpersonal problems primarily in that they should make minimal demands on specific interpersonal skills such as pragmatic comprehension of social interactions, theory of mind and/or empathy. Deficits in these abilities have been reported in people with focal anterior lesions (e.g. Stuss et al, 2001; Channon & Crawford, 2000; Grattan et al, 1994). Although social appropriateness was not assessed for this study, since it was largely irrelevant to scoring the solutions for the non-interpersonal items, the contribution of interpersonal skills to performance on the interpersonal items was intended to be the largest factor distinguishing the two sets of items. It is improbable that the control group had deficits in interpersonal processes such as pragmatic comprehension, theory of mind or empathy. Rather, the interpersonal problems were likely to draw heavily on these interpersonal processes, in addition to other factors including executive and decision-making processes and real-life experience that affected both the interpersonal and non-interpersonal problems. The focus on interpersonal issues meant that these scenarios were likely to have involved more subtle understanding and judgement than the non-interpersonal items, involving greater ambiguity of pragmatic meaning and more nuances relating to
others’ perspectives to take into account. This may have made it easier for participants to understand and solve the problems. The dimension of social appropriateness, although not directly scored in the current study, should nevertheless have affected other scores for the interpersonal items, including problem appreciation and effectiveness, since participants are likely to have considered the interpersonal consequences of their actions when evaluating solutions for the interpersonal items.

It is of course possible that the differences found between the interpersonal and non-interpersonal items may have been peculiar to the items in question, rather than reflecting a universal tendency. One way around this would be to try to refine the measure to produce problem situations that do not have an interpersonal element, but do retain a similar level of complexity and subtlety as the interpersonal items. However, it proved problematic in the design stage to generate a range of items with very limited interpersonal involvement. This may reflect the artificiality of such a procedure, and highlights the importance in everyday life of understanding other peoples’ points of view. It is also possible that there were differences between the interpersonal and non-interpersonal problems in terms of the contribution of experience, in that participants may in general have gained greater personal or vicarious experience of the more practical type of non-interpersonal situations. As discussed above in section 8.1, this hypothesis is difficult to test directly.

Interestingly, despite better performance on the non-interpersonal items, both groups rated these as more awkward than the interpersonal items. This would appear at first sight to be counter-intuitive. However, it may have been due to a fundamental difference of emphasis between the two sets of stories. The interpersonal stories were designed to be awkward in terms of interpersonal relationships. By contrast, the non-interpersonal items were designed to be independent of other people. This may have led the non-interpersonal items to be perceived as more awkward since the responsibility for resolving the problem lies solely with the main character in the story. Alternatively, there may have been differences in the perceived risk in the two types of
scenarios. For example, the non-interpersonal item about a person discovering a leak in their home requires immediate action to avert causing further damage to their property and possessions. In the burglary scenario, some participants mentioned that the main character could be in imminent danger if the burglar was still in her house. Therefore, perceived higher risk could be associated with higher rating of awkwardness.

10.4.3 Contributions to the differences between the anterior and control groups
The groups differed significantly for both the interpersonal and non-interpersonal problems in the number of prompts needed to recount the factual details of the situations. However, this measure appeared to be of limited interest when the actual numbers of prompts needed were considered, since these were relatively small. Of greater interest is the difference between the groups in the number of solutions generated, regardless of problem type. The participants with anterior lesions were found to have generated significantly fewer than the control group on both types of problem, suggesting that similar processes contributed to the generation of solutions. Additional support for this was provided by the strong correlations between solution fluency for the two types of story in both groups. Earlier, in section 7.1.4.4.1, it was speculated that the generation phase of the Predicaments test might be heavily dependent on executive skills including inhibition and strategy generation. This is consistent with other work showing inefficient generation and use of strategies in participants with anterior lesions (Burgess & Shallice 1996; Owen et al, 1990).

For Final Solution Quality scores, the anterior group scored significantly more poorly than the control group on the interpersonal items, as expected on the basis of the results reported in the previous study. However, the two groups did not differ on the non-interpersonal items, and there were ceiling effects for both groups. Thus, the anterior group did not appear to have a deficit in selecting courses of action on the non-interpersonal problems. As discussed above, this is likely to reflect the heavy reliance of the interpersonal problems on skills including pragmatic comprehension,
theory of mind and empathy. For example, one of the interpersonal items involved a woman making a number of personal comments about her niece’s weight, such as suggesting that she join a fitness club. In order to gain a point for appreciating the pertinent aspects of the problem, participants had to show some understanding that this situation would be awkward or embarrassing for the younger woman, which requires an ability to understand the situation from her perspective. All participants in the control group showed this understanding, while three of the thirteen participants in the anterior group did not, and simply gave answers which addressed the question of what the younger woman could do to lose weight. Similarly, to gain a point for effectiveness in this situation, solutions had to provide a means of terminating the awkward conversation about weight without doing anything to exacerbate the situation, such as being rude to the aunt or storming out of the room. Only two of the thirteen participants in the anterior group gained a point for effectiveness in this situation, while the majority of the control group did. Therefore, it seems probable that impairments in these types of processes contributed to the anterior group’s impairments on the interpersonal stories, even without the inclusion of the social appropriateness dimension in the scoring system.

When ratings of satisfaction were considered, both groups rated themselves as more satisfied with their non-interpersonal answers than their interpersonal answers. This was appropriate, given that their non-interpersonal responses tended to be of higher quality. The control participants made a sharper distinction between satisfaction with the two types of items than did the anterior participants. This probably reflects greater awareness of the subtleties to be taken into account when solving the interpersonal problems in the control group. Post-hoc analyses showed that the anterior group were significantly more satisfied with their interpersonal solutions than the control group. Given their poorer scores on interpersonal final solution quality, this may reflect a subtle deficit in awareness, consistent with other findings of reduced awareness of difficulties in participants with anterior lesions (e.g. Stuss, 1991a; 1991b).
10.4.4 Summary

In summary, the findings showed that participants in both groups found most aspects of interpersonal problem-solving more difficult than non-interpersonal problem-solving, as predicted in Hypothesis 1 above. It was thought that non-interpersonal problems made fewer demands on specific interpersonal processes such as pragmatic comprehension, theory of mind and empathic skills, although both sets of problems required executive and decision-making skills and would be influenced by experience. Hypothesis 2 predicted that the anterior group would show deficits in problem-solving compared with the control group, and Hypothesis 3 predicted that these would be more marked on the interpersonal items. These predictions were borne out, as the anterior group generated fewer solutions than the control group to both types of story, while their Final Solution Quality scores were lower only for the interpersonal items. Overall, the findings support the assertion that problems involving interpersonal factors are more complex than those with only non-interpersonal considerations, at least for the items selected here, and that this leads to differential impairment in aspects of decision-making in participants with anterior lesions.
CHAPTER 11
PRIORITISATION AND PLANNING IMPAIRMENTS IN GROUPS WITH FRONTAL LOBE DYSFUNCTION

11.1 RATIONALE FOR THE STUDY

This chapter describes the development of two new measures. The first examines prioritisation of real-life tasks using everyday materials, and participants’ abilities to appreciate the possible consequences of failing to complete everyday tasks. The second examines planning abilities on a longer timeframe, setting goals for a fictional character. The chapter is split into two parts. Part A describes the performance of participants with focal anterior lesions relative to a matched control group. Part B describes the performance of adults with Tourette’s syndrome relative to a control group. The aim of the study was to discover more about prioritisation and planning impairments using real-life-type situations.

11.2 PART A

11.2.1 INTRODUCTION

Participants with lesions involving the frontal lobes showed impairments in aspects of real-life-type problem-solving on the Predicaments test described in study 1. This was demonstrated by their selection of poorer quality solutions than the control group as the best course of action, in spite of generating solutions of similar average quality when asked to think of as many as they could (see sections 7.2.3.2.3 and 7.2.3.2.4). The current study was designed to assess whether decision-making deficits would be seen on other types of real-life measures, employing different methodologies. The measures were based on previous work examining planning processes. In the introduction to the BADS battery (Wilson et al, 1996), it
was argued that most standard tests do not assess participants’ ability to make plans covering long time periods, or prioritise tasks when there is more than one competing alternative. It was stated that these are examples of executive abilities that would be expected to be important in everyday problem-solving. The current study describes the development of two tasks, which aim to measure these abilities using real-life-type materials.

Anterior lesions have also been linked with impairments in planning on standardised abstract measures such as the Tower of Hanoi (Morris et al, 1997) and Tower of London (Carlin et al, 2000), although there is debate about the underlying processes involved (see e.g. Goel et al, 2001; Rowe et al, 2001). Some studies have attempted to develop real-life-type measures of planning (see section 3.1.2.3.1). One study described a financial planning task, in which participants were asked to formulate plans to help a fictional couple achieve various financial goals over time (Goel et al, 1997). Participants with anterior lesions showed impairment in a range of processes, such as structuring the problem, allocating their time, judging when they had achieved their goals, and applying their experience to the task. The authors argued that the task became more difficult for anterior participants the further they had to plan ahead in time. The second task in the current study also involves a vignette of a fictional character. The aim of the task was to assess how effectively participants could make plans over two time periods, 1 year and 5 years. One of the differences between real-life and standardised measures is thought to be the relative amount of structure provided by the task (e.g. Galotti, 1989). In order to address this, participants were asked specifically to make plans about one aspect of the character’s life, although other information was included in the vignette. Therefore, the scoring of the task also assessed how frequently participants addressed other aspects of life in their plans, without being explicitly prompted to do so.
The prioritisation task was similar to planning measures involving multitasking such as the Six Elements Test (Shallice & Burgess, 1991; Wilson et al, 1996), Multiple Errands test (Shallice & Burgess, 1991), and the Greenwich test (Burgess et al, 2000) (see section 3.1.2.3.2). The features these tests share in common are that they all contain multiple items that must be carried out one at a time within a time limit. They also contain rules, for example constraints on the order in which the items can be carried out, and they require participants to monitor their own performance, and decide for themselves when they have achieved their goals (Burgess 2000a; 2000b). The Multiple Errands test was carried out in a real-life setting, and the tasks were everyday tasks, such as buying items from shops. Three patients with frontal lobe lesions showed impairments both in terms of completing fewer tasks, and breaking more rules than control participants did. The Six Elements and Greenwich tests were designed as laboratory analogues of the Multiple Errands test, and patients with frontal lobe lesions have been shown to have qualitative impairments similar to those they showed in the Multiple Errands test (Shallice & Burgess, 1991; Burgess et al, 2000).

In the current study, a measure of prioritisation was developed that was based on the multitasking measures described above, but with some fundamental differences. Similarities between the measures included multiple different types of tasks, a time limit within which it was not possible to complete all of the tasks, and a lack of feedback, such that participants had to decide for themselves when to switch from one task to another. The tasks were also carried out in a laboratory setting. However, unlike the two laboratory tests described above (Six Elements and Greenwich tests), the current tasks were ones which participants might be expected to encounter in daily life, such as paying an electricity bill, writing a shopping list, and watering the plants. All materials were based on real-life examples, and personalised to the participant, in order to increase the ecological validity of the test. The main aim of the test was to assess whether participants with anterior
lesions were able to prioritise tasks appropriately. Therefore, the instructions were to complete the most important tasks within the time limit, rather than to attempt as many as possible. Participants were required to actually carry out the tasks, as there is evidence that people with anterior lesions show impairments when carrying out tasks that could not be detected when they were only asked to describe verbally what they would do (Zalla et al, 2001). In addition, it was speculated in the Predicaments study that one possible reason for decision-making deficits in the anterior participants might be an inability to look ahead to the consequences of their actions (section 7.1.4.4.3). This was addressed in the current study by asking participants afterwards what the possible consequences would be if they failed to complete each task in a real-life situation.

The current study describes the performance of participants with anterior lesions relative to a matched control group on aspects of prioritisation and planning on the real-life-type measures described above. The battery of abstract neuropsychological tests described in previous chapters was also included, and the relationships between performance on these and the prioritising and planning measures were examined.

11.2.1.1 Hypotheses

1) On the prioritisation task, it was hypothesised that the anterior group would prioritise fewer of the most important items relative to controls, and might show difficulties in evaluating the consequences of not performing each item.

2) On the long-term planning test, it was predicted that the anterior group would show impairments in formulating plans in areas that were not explicitly cued, relative to the control group.
3) It was predicted that the anterior group would show impairment on all types of measures within the executive battery, consistent with the findings in study 1.

11.2.2 METHOD

11.2.2.1 Participants
To be included in the study, participants had to be between 18 and 70 years of age, fluent in English, and have a verbal IQ score of 85 or above on the NART-II (Nelson, 1991). Exclusion criteria included significant neurological or psychiatric illness and alcohol or drug dependence. Participants in the anterior group had to have a unilateral lesion confined to one or two lobes of at least three months duration. Additional exclusion criteria for this group included hydrocephalus and dementing conditions and expressive or receptive dysphasia. As part of the assessment for dysphasia, the Test for the Reception of Grammar (TROG; Bishop, 1989) was administered, and participants were only included in the study if they scored within the normal range on this measure as specified above in section 7.1.2.1.

Eighteen participants (9m, 9f) with unilateral lesions involving damage to the frontal lobes participated in the study (anterior group). Eight participants had left-sided lesions and ten had right-sided lesions. All were right-handed except two of the left-sided participants, one of whom was left-handed and one ambidextrous. These participants were believed to have normal speech dominance, since both had speech impairments at the time of injury, which had since resolved. The lesions were of mixed aetiology, including vascular damage (n=9), head injury (n=5) or tumour (n=4). Lesion evidence was based on clinical radiological MRI or CT reports, and lesions were classified as medial, lateral or orbital using the criteria described by Damasio and Damasio (1989); lesion sites are shown in Table 11.1;
information on the exact size and site of lesions was not available for two of the left-sided participants.

<table>
<thead>
<tr>
<th>Table 11.1: Lesion sites and sizes for the anterior participants</th>
</tr>
</thead>
</table>

**Left-sided lesions**

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Small orbital, medial and lateral FL</td>
</tr>
<tr>
<td>2</td>
<td>Small orbital plus moderate lateral FL</td>
</tr>
<tr>
<td>3</td>
<td>Small medial plus moderate lateral FL</td>
</tr>
<tr>
<td>4</td>
<td>Moderate lateral FL plus moderate TL</td>
</tr>
<tr>
<td>5</td>
<td>Small lateral FL plus moderate TL</td>
</tr>
<tr>
<td>6</td>
<td>Moderate medial FL</td>
</tr>
<tr>
<td>7</td>
<td>Exact size and site unknown</td>
</tr>
<tr>
<td>8</td>
<td>Exact size and site unknown</td>
</tr>
</tbody>
</table>

**Right-sided lesions**

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Moderate lateral FL</td>
</tr>
<tr>
<td>2</td>
<td>Small medial plus small lateral FL</td>
</tr>
<tr>
<td>3</td>
<td>Large lateral FL</td>
</tr>
<tr>
<td>4</td>
<td>Large orbital plus medial plus lateral FL</td>
</tr>
<tr>
<td>5</td>
<td>Small medial plus small lateral FL</td>
</tr>
<tr>
<td>6</td>
<td>Small lateral FL</td>
</tr>
<tr>
<td>7</td>
<td>Moderate medial plus moderate lateral FL</td>
</tr>
<tr>
<td>8</td>
<td>Small orbital plus moderate lateral FL</td>
</tr>
<tr>
<td>9</td>
<td>Moderate medial &amp; lateral FL, plus moderate TL</td>
</tr>
<tr>
<td>10</td>
<td>Small medial FL, plus moderate PL</td>
</tr>
</tbody>
</table>

Twenty-three healthy control participants (12m, 11f) also took part in the study (21 right-handed, 2 left-handed). The two groups of participants did not differ significantly in age (anterior group (A) mean 44.00 sd 14.43; control group (C) mean 41.13, sd 14.99), years of education (A mean 14.11, sd 2.37; C mean 13.57, sd 2.15); NART IQ (A mean 111.39, sd 8.38; C mean 111.30, sd 9.65 or TROG score (A mean 78.78, sd 1.31; C mean 79.39, sd 0.84). All participants gave written informed
consent for the study, and were given breaks between tasks as necessary, to avoid fatigue.

11.2.2.2 Experimental measures

11.2.2.2.1 Prioritisation task

This task was designed for the current study. It consisted of 13 items, which were presented in a list (see Appendix E). The tasks were based on a range of everyday activities, including paying bills, making a telephone call to confirm an appointment, composing a shopping list, looking up a telephone number and the details for a television programme, and writing a birthday card. For each item, materials were provided that were relevant to each task, such as the bills (see Appendix F for an example), and blank cheques (see Appendix G). All such materials were based on real-life examples, in order to increase the ecological validity of the task, and they were all personalised to the participant, with their name and address (where relevant).

Since many of the items involved deadlines, these were fixed in advance. Thus, the date on a letter asking participants to confirm a hospital appointment was set at 12 days before testing, and the date it stated for the actual appointment was for 2 days’ time. A red electricity bill was dated 4 days before testing and specified that payment had to be received in 7 days. A car tax reminder was set to run out on the day after testing. A letter asking for a monthly credit card payment was dated 3 days before testing, with 5 days available for payment. A form for compensation following a disrupted rail journey informed participants that claims had to be received within one month of travel in order for them to be processed.

The test was designed with the intention that some of the tasks were more important than other tasks, and they were split into ‘most’ and ‘least’ important
categories. This was based on the magnitude of their possible consequences, and the urgency of the task. Thus, the three tasks with potential legal consequences (paying an electricity bill, monthly credit card payment, and car tax) were in the ‘most’ important set. Also in this set was the confirmation of an unspecified hospital appointment that was due to take place in two day’s time, as it was specified that a failure to confirm would result in the loss of the appointment. The remaining two items both involved organising things for that day. These were included in the most important set, as they needed to be done immediately, or else not at all. The first informed participants that they had a friend coming over for dinner, but no food in the house. However, if they wrote a shopping list, their neighbour would get some shopping for them. The second informed participants that they wanted to see a film that afternoon, which their neighbour would tape for them, if they wrote down the relevant time and channel (a television guide was provided). The other seven items were all judged to have less important consequences, or be less urgent than the six listed above.

11.2.2.1.1 Procedure

Participants were told the following:

“I want you to imagine that it is 9am on Monday morning. You arrived back from a holiday late last night. You have important commitments all day today and a very busy week at work ahead. You have twelve minutes to sort out various things before you leave.”

The experimenter then read through the list of tasks with the participant, and drew their attention to all the relevant materials that were needed to complete each task.

After going through the list, the participant’s attention was drawn to the instructions at the bottom of the page, which said:

“Everything you need to perform these tasks is on the desk in front of you.
There is no way you will be able to complete all of these tasks within the twelve minutes, and therefore you must prioritise the items that you think are most important. You should make sure that you complete the tasks you attempt properly.”

Participants were then asked to summarise the important details of the test. If they did not state that they had to prioritise the most important tasks and try to complete them as thoroughly as possible then they were asked direct questions about these rules as follows.

“Do you understand that you will not be able to complete all the tasks in the time limit and that you must therefore prioritise the most important tasks?”

“Do you understand that when you attempt a task, you must make sure you complete it properly?”

If they responded ‘no’ to either question, or were unsure, the instructions were summarised again, and then they were asked to repeat them again, to ensure they had grasped the point of the task. The instructions were also in front of them throughout the test. When they were ready, a timer was set to twelve minutes and placed in front of them. They were informed that it would count down from twelve minutes, and they could use it to organise their time.

At the end of the task, all participants were asked to write down what they thought the possible consequences of failing to do each task would be. This was intended to examine how realistically they were able to appraise each task.

11.2.2.1.1 Scoring system

A number of measures were created in order to examine differences between the groups. Firstly, there were two time measures. These were Initial Planning time (i.e. the amount of time the participant spent at the beginning of the test before they embarked on any particular task), and Ongoing Planning time (i.e. the amount of the twelve minutes that was spent planning what to do in between tasks). The
number of tasks that they attempted overall was compared, as was the number of most important and least important tasks attempted. Finally, the potential consequences that participants attached to each task were examined.

11.2.2.2 Long-term planning task
The second task involved presenting participants with a hypothetical vignette as outlined below:

"Ms Stevens is a 30 year old single mother of a boy aged 9 years. She lives in a rented 2 bedroom flat and currently works part-time as a secretary during school hours, so that she is able to take her son to school and pick him up. She likes her work colleagues, but does not find the work particularly challenging. She has 5 O'levels, and typing and word-processing certificates. She is currently concerned about her financial situation as her ex-husband has recently died without leaving any money, so that she no longer receives his maintenance payments."

Participants were asked to read the vignette. Below it on the page, they were asked to imagine they were Ms Stevens and plan their working career. Space was provided for them to write down their answers for their plans for the next year and subsequently, their plans for the next five years. They responded to these in their own time. No prompts were given at any point in order to avoid alerting participants as to the adequacy of their answers.

11.2.2.2.1 Scoring system
Answers were scored at all both stages, 1 year and 5 years. At each stage, four aspects of life relevant to the details in the vignette were considered: career (including education if this was to increase job projects), finances, living arrangements and family, and social and leisure time (including references to getting a new partner). All were judged according to two criteria, namely whether there was a goal in that area, and whether there was a realistic mechanism to
achieve that goal. These were added together to create a score out of 2. The answers were scored cumulatively, thus, if a participant listed an aim at one year, but not at five years, this was still scored as an aim for both time points, as it was clear from sample answers that participants’ responses often assumed this was implicit. All answers were scored by two raters, one of whom was blind as to the group identity of each individual, and one of whom was not blind. The raters agreed for 91% of the answers. All disagreements were resolved by discussion.

11.2.2.3 Neuropsychological Battery
A battery of neuropsychological tests was selected to assess aspects of executive function, as outlined in previous chapters. The measures included (i) deductive reasoning: Raven’s Advanced Progressive Matrices, Set I (Raven, 1976), (ii) attention and set-shifting: Trail Making Test (Reitan, 1958), Rule Shift Cards (BADS, Wilson et al, 1996) and Cancellation tasks (Star and Letter Cancellation from the Behavioural Inattention Test, Wilson et al, 1987); (iii) inhibition and strategy generation: Hayling test (Burgess & Shallice, 1996); Letter Fluency (Thurstone & Thurstone, 1962); (iv) multitasking: Six Elements Test (BADS, Wilson et al, 1996), (v) strategic encoding/retrieval: Story Recall (AMIPB, Coughlan & Hollows, 1985). In addition, participants filled out the Dysexecutive Questionnaire (DEX) from the BADS (Wilson et al, 1996), and they were also asked to obtain a rating from a relative or friend who knew them well. This was intended to give some information about dysexecutive behaviours in everyday life.

11.2.3 RESULTS

11.2.3.1 Statistical analysis
The variables of interest were initially examined for outliers and skewness as described in section 7.1.3.1. Logarithmic transformations were performed on the Cancellation variables, and negative reciprocal transformations on the timed
variables from the Hayling Test. The remaining items that did not meet assumptions for normality were analysed non-parametrically. This applied to number of errors on the Hayling test, the Six Elements Test, and the Ravens' matrices. Some aspects of the Prioritisation task were qualitative in nature and, where analyses were performed, these were non-parametric Mann Whitney U tests. All data for the Long-term planning task was analysed non-parametrically using Mann Whitney U tests. A 5% significance level was adopted throughout to compare the groups. There were occasional missing data points on some tests for individuals as a result of administrative errors; numbers for each group are shown in the Tables if these fall below maximum.

11.2.3.2 Prioritisation task

The results for this task are shown in Table 11.2.

Two measures of planning time were examined. The two groups did not differ significantly on either Initial Planning time ($t=0.04, \text{df}=39, p=.966$) nor Ongoing Planning time ($t=1.08, \text{df}=39, p=.288$). Both groups had very large standard deviations on these measures, suggesting that there were large individual differences within each group rather than any consistent patterns of performance between the two groups. The groups did not differ in terms of the overall number of tasks they attempted ($t=0.65, \text{df}=39, p=.519$). However, when these were split into two based on their relative priority, the control group attempted significantly more of the most important tasks than the anterior group ($t=2.06, \text{df}=39, p=.046$), but there was no difference between the groups for the number of least important tasks attempted ($t=0.22, \text{df}=39, p=.825$).
Table 10.2: Mean Scores and Standard Deviations for the Prioritisation task for the anterior and control groups

<table>
<thead>
<tr>
<th></th>
<th>Anterior group</th>
<th>Control group</th>
<th>Test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial planning time (secs)</td>
<td>33.28 (43.17)</td>
<td>33.82 (38.87)</td>
<td>t=0.04</td>
<td>.966</td>
</tr>
<tr>
<td>Ongoing planning time (secs)</td>
<td>132.72 (59.59)</td>
<td>151.00 (49.15)</td>
<td>t=1.08</td>
<td>.288</td>
</tr>
<tr>
<td>Number of tasks attempted</td>
<td>7.50 (1.58)</td>
<td>7.91 (2.29)</td>
<td>t=0.65</td>
<td>.519</td>
</tr>
<tr>
<td>Number of most important tasks attempted (/6)</td>
<td>4.28 (0.96)</td>
<td>4.91 (1.00)</td>
<td>t=2.06</td>
<td>.046*</td>
</tr>
<tr>
<td>Number of least important tasks attempted (/7)</td>
<td>3.22 (1.41)</td>
<td>3.00 (1.71)</td>
<td>t=0.22</td>
<td>.825</td>
</tr>
</tbody>
</table>

* p<.05

11.2.3.2 Qualitative information about consequences

The potential consequences that participants attached to the high priority tasks were examined. As these are primarily qualitative data, they are described below. However, some statistical analysis using Mann Whitney U tests was conducted where numbers were appropriate.

1) This item asked participants to pay an electricity bill. The bill was a red bill, and was labelled ‘final reminder’. All participants except one said that the possible consequence of failing to pay was to have the electricity supply cut off. The one exception was a control participant who argued that in practice, it would be likely that the company would send another letter; two other control participants also specified this in their answers.
Having the electricity supply cut off
Expecting to have more time to pay in practice

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Control group (/23)</th>
<th>Anterior group (/18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Having the electricity supply cut off</td>
<td>22</td>
<td>18</td>
</tr>
<tr>
<td>Expecting to have more time to pay in practice</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

2) This item consisted of a form to fill in to renew their car tax, which was due to run out on the following day. All but one participant recognised that if they neglected to do this item then there would be potential legal consequences (e.g. being stopped by the police and fined), or that they would be unable to use the car until they had rectified the situation, and some of the control participants cited both these consequences. The only exception was a control participant who said that he/she would pay the tax in a week’s time when they got a reminder, although this would actually be too late in practice; this participant did perform the task within their twelve minutes.

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Control group (/23)</th>
<th>Anterior group (/18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legal/police consequences, e.g. a fine</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>Being unable to use the car</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Intending to pay at a future time point</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

3) This item consisted of a letter from a fictional hospital informing participants that they had an appointment in 2 days time. The letter did not specify what the appointment was for, but did ask for a telephone call to confirm attendance, and it stated that if confirmation was not received then the appointment would be offered to somebody else. A range of consequences was offered to this item. Many participants simply made the observation that the appointment would be missed. However, some people made more practical suggestions, such as making a new
appointment. This suggestion was offered by both the control participants who did not do this task within their original 12 minutes, and one of the anterior participants. The other anterior participant who did not attempt this task within the twelve minutes did not offer a practical solution but simply stated that they would miss the appointment. Three of the anterior participants made irrelevant or impossible suggestions. For example, one of them argued that the hospital would telephone again, although there was no indication in the information given that the hospital had ever telephoned them, and the letter stated clearly that failure to confirm would result in the loss of the appointment. A statistical analysis was performed to compare the group on the number of participants who made a practical suggestion (either making an alternative appointment or telephoning the following day). This was not significant ($z=1.02, p=.306$).

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Control group</th>
<th>Anterior group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(23)</td>
<td>(18)</td>
</tr>
<tr>
<td>Miss the appointment</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Make an alternative appointment</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Attend at the suggested time and hope to be seen</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Telephone to confirm tomorrow</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Irrelevant/impossible suggestions</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

4) This item consisted of a credit card statement asking for a monthly payment. The most common consequence cited in both groups was the likelihood of being charged additional interest. Another popular answer with anterior participants was the possibility of losing the credit card. As there was a range of magnitude of the consequences presented to this item, a statistical analysis was conducted, splitting the answers in mild (paying more interest and expecting to have more time to pay) and severe (all other responses listed below). A Mann Whitney U test examining
whether the anterior group were giving more extreme answers than the control group approached significance ($z=1.87$, $p=.062$)

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Control group (123)</th>
<th>Anterior group (118)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pay more interest</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>Expect to have more time to pay</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Endanger credit rating</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Lose the credit card</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Future financial difficulties</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Visit from debt collectors</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

5) This item informed participants that they had no food in the house, and that they had invited a friend around for dinner that night. The task was to write a shopping list for their neighbour in order to have food for later. The consequence that was offered most frequently was to state that there would be no food with which to feed the friend. However, many participants spontaneously offered a practical solution such as taking the friend out for a meal, or getting a takeaway. Of the participants who did not offer practical suggestions, 3/8 controls made reference to the interpersonal consequences, e.g. the potential embarrassment, or the rudeness of not providing a meal, or the risk of making the friend unhappy, while none of the anterior participants mentioned interpersonal consequences. A statistical analysis was done to compare the numbers of practical solutions (eating out or getting takeaway) with the other suggestions. As it was specified that there was no time during the day, going shopping later in the day was judged to be an inadequate solution to this problem. A Mann Whitney U test approached significance ($z=1.67$, $p=.095$).
6) This item informed participants that there was a film on television that day that they wanted to see. It stated that their neighbour would be prepared to tape it for them, but that they had to check what time and channel it was on. They were provided with a copy of the Radio Times to enable them to do this. The most commonly reported consequence was simply to miss the film, with some participants expressing that this would make them angry or irritated. The second most common response was to specify that nothing important would happen, e.g. “you would miss it, but it’s just a film!”, or “I would not worry about it”. Some people gave the practical solution that they would hire the film on video. Although this was true of more control than anterior participants, a Mann Whitney U test was not significant (z=1.07, p=.283).
11.2.3.3 Long-term planning task

The results for this task are presented in table 11.3.

Table 11.3: Means and standard deviations for the long-term planning task: anterior and control groups

<table>
<thead>
<tr>
<th>Category</th>
<th>Anterior Mean (sd)</th>
<th>Control Mean (sd)</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Career</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>1.67 (0.69)</td>
<td>1.65 (0.57)</td>
<td>0.41</td>
<td>.684</td>
</tr>
<tr>
<td>5 years</td>
<td>1.72 (0.67)</td>
<td>1.96 (0.21)</td>
<td>1.35</td>
<td>.176</td>
</tr>
<tr>
<td>Finances</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>1.22 (0.94)</td>
<td>1.83 (0.58)</td>
<td>2.53</td>
<td>.012*</td>
</tr>
<tr>
<td>5 years</td>
<td>1.61 (0.70)</td>
<td>1.91 (0.42)</td>
<td>2.01</td>
<td>.044*</td>
</tr>
<tr>
<td>Living arrangements and family</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>0.11 (0.47)</td>
<td>0.17 (0.58)</td>
<td>0.38</td>
<td>.705</td>
</tr>
<tr>
<td>5 years</td>
<td>0.50 (0.86)</td>
<td>0.91 (1.04)</td>
<td>1.42</td>
<td>.155</td>
</tr>
<tr>
<td>Social and leisure time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>0.11 (0.32)</td>
<td>0.13 (0.34)</td>
<td>0.19</td>
<td>.853</td>
</tr>
<tr>
<td>5 years</td>
<td>0.22 (0.43)</td>
<td>0.30 (0.56)</td>
<td>0.35</td>
<td>.725</td>
</tr>
</tbody>
</table>

* p<.05

As the data for this task could only be scored 0,1 or 2, it was inappropriate to use parametric tests as they clearly could not be normally distributed. It was also inappropriate to use chi-square analyses, since the frequencies in each cell were often small, and, therefore, non-parametric Mann-Whitney U tests were used to examine the data for significance.

Breaking the task down into the 4 categories, there were no significant differences between the groups on the first category which included work and study plans (1 year: z=0.41, p=.684; 5 years: z=1.35, p=.176). This question was asked directly at the beginning, and it is perhaps unsurprising that there were ceiling effects,
particularly for the control group. On the second category, finances, the two groups differed, with significantly poorer scores for the anterior group both at one year ($z=2.53$, $p=.012$), and five years ($z=2.01$, $p=.044$). The two groups did not differ in terms of their plans for living arrangements or social and leisure time ($p>.05$).

11.2.3.4 Executive battery

Mean scores, standard deviations and significance tests for the groups are shown in Table 11.4.

On the attention and set-shifting tasks, the differences between the groups approached significance for the Cancellation tasks ($F=3.74$, $df=1,39$, $p=.060$), although there was no group by task interaction ($F=0.29$, $df=1,39$, $p=.593$). A similar pattern was seen on the Trail Making test where the main effect of group approached significance ($F=3.54$, $df=1,39$, $p=.067$), although there was no group by task interaction ($F=1.26$, $df=1,39$, $p=.269$). The two groups also did not differ on the Rule Shift Cards test ($t=1.06$, $df=39$, $p=.294$). There were no significant differences on any of the inhibition and strategy generation measures (Hayling time: $F=0.25$, $df=1,39$, $p=.621$; Hayling error scores: $z=0.05$, $p=.957$; Letter Fluency: $t=1.66$, $df=39$, $p=.105$), nor a group by task interaction on the Hayling test ($F=0.16$, $df=1,39$, $p=.690$).

There was no between-group difference on the measure of Multitasking ($z=0.86$, $p=.388$), although the result on the deductive reasoning measure, Raven's Matrices, approached significance ($z=1.88$, $p=.061$). On the measure of executive memory, the anterior group scored significantly more poorly than the control group ($F=6.87$, $df=1,39$, $p=.012$); there was no group by task interaction ($F=0.01$, $df=1,39$, $p=.965$), indicating that this effect applied to both immediate and delayed recall to the same extent.
Table 11.4. Mean scores and standard deviations for the executive battery: anterior participants versus the control group.

<table>
<thead>
<tr>
<th></th>
<th>Anterior group Mean (SD)</th>
<th>Control group Mean (SD)</th>
<th>Test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deductive reasoning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raven’s Matrices</td>
<td>11.44 (2.83)</td>
<td>12.78 (2.86)</td>
<td>t=1.88</td>
<td>.061</td>
</tr>
<tr>
<td><strong>Attention and set-shifting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1T¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Star time</td>
<td>51.33 (30.78)</td>
<td>39.52 (11.48)</td>
<td>F=3.74</td>
<td>.060</td>
</tr>
<tr>
<td>Letter time</td>
<td>79.17 (34.14)</td>
<td>59.74 (12.08)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trail Making Test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>40.33 (21.63)</td>
<td>29.39 (10.31)</td>
<td>F=3.54</td>
<td>.067</td>
</tr>
<tr>
<td>Time B</td>
<td>90.44 (54.04)</td>
<td>69.65 (22.64)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rule Shift Cards</strong></td>
<td>3.22 (0.94)</td>
<td>3.48 (0.59)</td>
<td>t=1.06</td>
<td>.294</td>
</tr>
<tr>
<td><strong>Inhibition and strategy generation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hayling Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>20.33 (10.92)</td>
<td>20.48 (5.83)</td>
<td>F=0.25</td>
<td>.621</td>
</tr>
<tr>
<td>Time B</td>
<td>50.72 (44.51)</td>
<td>50.00 (56.07)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B Errors</td>
<td>4.06 (5.38)</td>
<td>2.91 (3.29)</td>
<td>z=0.05</td>
<td>.957</td>
</tr>
<tr>
<td><strong>Letter fluency</strong></td>
<td>38.33 (17.33)</td>
<td>46.00 (12.21)</td>
<td>t=1.66</td>
<td>.105</td>
</tr>
<tr>
<td><strong>Multitasking</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Six Elements Test</td>
<td>3.50 (0.86)</td>
<td>3.70 (0.70)</td>
<td>z=0.86</td>
<td>.388</td>
</tr>
<tr>
<td><strong>Executive memory</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story Recall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>36.56 (9.53)</td>
<td>42.70 (5.10)</td>
<td>F=6.87</td>
<td>.012*</td>
</tr>
<tr>
<td>Delayed</td>
<td>34.00 (10.04)</td>
<td>40.09 (5.80)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dysexecutive behaviours (DEX)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self rating</td>
<td>16.83 (8.16)</td>
<td>21.70 (7.62)</td>
<td>t=1.97</td>
<td>.057</td>
</tr>
<tr>
<td>Other rating¹</td>
<td>12.53 (7.67)</td>
<td>18.55 (9.30)</td>
<td>t=2.12</td>
<td>.041*</td>
</tr>
</tbody>
</table>

* p<.05  ¹N=17 anterior, 23 control  ²N=17 anterior, 20 control
On the DEX questionnaire, the result approached significance for self-ratings ($t=1.97$, $df=39$, $p=.057$), and was significant for other-ratings ($t=2.12$, $df=35$, $p=.041$). Against expectation, the anterior group gained lower scores than the control group, indicating that they were thought to have fewer dysexecutive problems in everyday life as judged by both themselves and someone who knew them well.

11.2.3.4 Site and size of lesion
Owing to the small sample sizes, it was not practical to carry out analyses of the effects of size of lesion. Limited analyses were carried out of the effects of side of lesion for the variables that distinguished the anterior and control participants. However, there were no significant differences between the left- and right-sided participants on any of these measures ($p>.10$), although the small sample size led to limited power.

11.2.3.6 Analysis of covariance with neuropsychological battery
In order to examine the relationships between performance on the new measures, and the neuropsychological tests, the experimental measures that significantly differentiated the groups were each examined using the five sets of standardised measures and the DEX as covariates. The results are shown in Table 11.7.

The results showed that for the number of urgent tasks attempted on the prioritisation task, the group difference was no longer significant when any of the categories of measures were used as covariates ($p>.05$). On the long-term planning task, for financial planning over one year, the group difference remained significant when the measure of deductive reasoning, and the measure of multitasking were used as covariates, but was no longer significant when the other types of executive measures were used as covariates. For financial planning over five years, the group
difference was no longer significant when any of the measures were used as covariates (p>.05).

Table 11.5  Analyses of covariance between the Predicaments measures and executive battery

<table>
<thead>
<tr>
<th>Significance of group difference</th>
<th>Number of urgent tasks</th>
<th>Finances 1 year</th>
<th>Finances 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without covariates</td>
<td>p</td>
<td>p</td>
<td>p</td>
</tr>
<tr>
<td></td>
<td>.046</td>
<td>.012</td>
<td>.044</td>
</tr>
<tr>
<td>With executive measures used as covariates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deductive reasoning</td>
<td>.104</td>
<td>.011*</td>
<td>.130</td>
</tr>
<tr>
<td>Attention and set-shifting</td>
<td>.082</td>
<td>.057</td>
<td>.350</td>
</tr>
<tr>
<td>Inhibition and strategy generation</td>
<td>.084</td>
<td>.060</td>
<td>.358</td>
</tr>
<tr>
<td>Multitasking</td>
<td>.071</td>
<td>.020*</td>
<td>.136</td>
</tr>
<tr>
<td>Executive memory</td>
<td>.211</td>
<td>.077</td>
<td>.538</td>
</tr>
<tr>
<td>DEX</td>
<td>.119</td>
<td>.124</td>
<td>.425</td>
</tr>
</tbody>
</table>

* P<.05
11.2.4 DISCUSSION

11.2.4.1 Summary of results
On the prioritisation task, the anterior group attempted fewer of the most important tasks than the control group. When asked about the consequences of failing to do the tasks, they were able to give adequate answers, but there was a tendency for them to produce fewer spontaneous practical solutions than the control group to deal with these consequences. On the long-term planning task, the anterior group was less likely than the control group to generate plans relating to aspects of the vignette that were not directly specified in the question. When the executive battery was examined, the anterior group scored more poorly than the control group on only one measure, Story Recall, although the difference on deductive reasoning and on aspects of attention and set-shifting approached significance.

11.2.4.2 Executive battery
The general lack of significant findings on the executive battery is somewhat surprising given that everybody in the anterior group had a known lesion of the frontal lobes, although previous work has shown that patients with prefrontal lesions do not always show deficits on standardised tests (e.g. Shallice & Burgess, 1991). The results on the executive tests are in contrast to those reported in the earlier chapter that also examined performance of a group with anterior lesions (see section 7.2.3.7). Inspection of the mean scores on the tests that these studies have in common shows that this is mostly attributable to the anterior group in the current study performing at a higher level than the group in the previous study, although there are some tasks in which the current control group also gained lower scores than the earlier control group. Some of the tasks in the present study, such as the Cancellation tasks, Trail Making test and Ravens' Matrices, may have reached significance if a larger sample had been tested. However, most of the tests were not
close to significance, and are therefore likely to reflect a genuine lack of difference between the groups.

11.2.4.3 The experimental tasks

Before considering the findings in detail, limitations of the two tasks should be acknowledged. For example, in the prioritisation task there is certain amount of subjectivity in evaluating which tasks are the most important. Making more marked distinctions between the most and least urgent tasks may have avoided this, although this may have reduced the sensitivity of the test by making it too easy. Using more marked distinctions in the judgement of alternatives measure of the Predicaments test described earlier appeared to suffer from this difficulty, since it was not a sensitive measure in evaluating the performance of either the anterior or TS participants (see sections 7.2.3.2.6 and 8.3.2.6). There was also the question of whether making the task more obvious would have decreased the ecological validity, as these decisions are not always straightforward in real life.

Several methods were used to enhance the ecological validity of the prioritisation task. Firstly, it was based on activities that people commonly encounter in daily life, and the materials were either real (such as a telephone, plants) or based on real examples (such as the electricity bill, credit card statement, and so on). Secondly, participants were asked to perform the actual tasks to the best of their ability, rather than merely to rank-order a hypothetical list. Thirdly, they were not given any prompts during the time limit, regardless of the quality of their performance. However, there were constraints on the extent to which it resembled a real-life situation. For instance, having limited time to decide between a range of reasonably urgent tasks with no time available in the remainder of the day may be a reflection of busy working lives for some people, but not others. In addition, all the equipment needed to perform the tasks was at hand, whereas in real life, people would have to provide the materials such as envelopes and batteries.
Ability to generate alternative, practical suggestions to deal with the consequences of failing to complete each task was not examined explicitly in this study. On the one hand, this had the advantage of exploring the extent to which this came to mind spontaneously, without the provision of structured cues. On the other hand, systematic study might have revealed further deficits in the anterior participants in generating such alternatives, even when they were explicitly cued. Realistic, practical alternatives would potentially reduce the adverse consequences of not completing some of the tasks. For example, the purpose of writing the shopping list was to provide a friend with a meal that evening. The adverse consequences of failing to do this would be to upset or annoy the friend, but some participants recognised that this could be averted by practical alternatives such as buying a takeaway meal, or taking the friend out to a restaurant. It is therefore possible that more of the anterior participants would have been able to think of such ideas, had they been asked. However, it is also likely that more of the control participants would also have been able to achieve this.

On the long-term planning task, it was decided to have a simple scoring system based on presence or absence of a goal and a method of attaining it. There was no attempt to score these answers for quality. It is therefore possible that there were additional differences between the groups that were not picked up by this method of scoring. However, grading the quality of participants’ answers would have been extremely problematic given the limited amount of information available in the vignette. Many of the real-life-type measures that have developed for use with frontal lobe patients are either lengthy to administer (e.g. the Multiple Errands test, Shallice and Burgess, 1991), or have complex scoring systems (e.g. the Financial Planning test, Goel et al, 1997). While this means that these tasks may better approximate real life, it also limits their potential wider use, e.g. in the clinical setting.
11.2.4.3.1 Contributions to impairments on the prioritisation task

On the prioritisation task, as predicted, participants in the anterior group were less likely to perform the most important tasks than those in the control group. Burgess (2000a) argued that investigating multitasking is important because it is central to many everyday situations. Previous studies looking at multitasking measures have argued that there is evidence for the involvement of three separable functions, retrospective memory, prospective memory and planning (Burgess et al, 2000). However, as discussed above, such studies did not use real-world materials, and thus did not consider the extent to which priorities relating to the relative importance of different tasks might in themselves influence performance. The current measure was designed to specifically examine this, and the results demonstrated that anterior lesions were associated with difficulties in prioritising everyday tasks within a limited time period.

As described above, the anterior group in the current study demonstrated surprisingly good performance on the standard abstract measures of executive function. However, the analyses of covariance showed that the group difference on the prioritisation measure was no longer significant when any of the neuropsychological measures were used as covariates, indicating that executive processes were likely to be centrally involved in their difficulties.

One possible key factor contributing to poor selection of courses of action by the anterior group might be an inability to evaluate the possible consequences of their actions adequately, in order to guide their decisions as to which tasks to prioritise. There was tentative evidence that the anterior participants were more limited in their appraisals of the consequences of their actions, in that they had a reduced tendency to generate alternative solutions spontaneously for some of the items. However, they generally showed awareness of the consequences of failing to complete the tasks. For example, all participants within the anterior group realised
that failing to pay an electricity bill could lead to the supply being cut off. It is possible that they were able to think about the consequences of each item when asked specifically about them, but that they were less likely to do this spontaneously when in a time-pressured situation. Participants were not given explicit information about which tasks were considered to be the most important, and therefore had to apply their wider knowledge in order to determine this in deciding which tasks to complete. In study 1 (section 7.1.4.4.1) it was speculated that problem-solving impairments in generating solutions in participants with anterior lesions might be related to their failure to generate, or make use of, appropriate performance strategies in searching for relevant past experience and integrating this effectively with the demands of the current problem situation. It is possible that the current task was sensitive to a similar deficit, and that knowledge was only accessed adequately when participants were explicitly directed to do this. This is consistent with previous work indicating that anterior lesions are associated with deficits in generating and applying strategies (e.g. Burgess & Shallice, 1996; Owen et al, 1990).

In studies 1 and 4, specific interpersonal processes such as pragmatic language abilities, theory of mind and empathy were thought to contribute to the impairments shown by the anterior group on the Predicaments test. These factors would appear to be less relevant to the prioritisation task. Most of the important tasks, such as paying bills and recording a film, did not have any clear interpersonal consequences, and it is therefore likely that interpersonal factors played only a small role in the deficits shown by the anterior group. Nevertheless, evaluation of the possible consequences of failing to complete some of the tests may have required consideration of other people’s feelings. For example, one of the most important items was to write a shopping list, in order to provide dinner for a friend. If a participant did not appreciate that it was important to keep arrangements made with friends, and that otherwise the friend might be upset, then they might not
perceive the task to be important. There was tentative evidence for this, in that some of the control group referred to interpersonal consequences for this measure, while none of the anterior group did. However, the numbers involved were too small to draw any more than a speculative conclusion.

In Study 1, it was speculated that emotional processes could potentially have contributed to the deficits shown by the anterior group (see section 7.1.4.4.4). Could similar processes apply to the prioritisation task in the current study? Emotional contributions to decision-making have primarily been studied using gambling tasks (e.g. Bechara et al, 1994; Rogers et al, 1999). Such studies indicate that patients with bilateral ventromedial lesions are impaired at decision-making based on relative rewards and punishments. In particular, they fail to learn to avoid cards with long-terms penalties/punishments, if these cards provide immediate rewards. There is still speculation about the processes contributing to gambling performance (e.g. Bechara et al, 2000). Some authors have suggested that impulsivity may be relevant (e.g. Rahman et al, 2001). Impulsivity is a multi-dimensional concept, but includes failure to persist with tasks, and a tendency to make decisions too quickly. It has been linked with inhibitory processes – i.e. failing to inhibit an attempt to gain an immediate reward, when a delayed reward would actually be of greater benefit. Alternatively, it has been suggested that patients with ventromedial lesions may have impaired perception of risks (e.g. Rogers et al, 1999), and cannot adjust their behaviour appropriately as the level of risk changes. Although none of the participants in the current study had bilateral lesions, it is possible that emotional factors could have contributed to their pattern of performance, in addition to cognitive processes, although no direct evidence was available to evaluate this. When the processes that are relevant to gambling tasks have been elucidated further, this may provide a fruitful avenue of further research into the contributory factors to selection of courses of action in tasks such as those in the current studies.
11.2.4.3 Contributions to impairment on the planning task
The main finding of interest on the long-term planning task was that participants with anterior lesions were significantly less likely than the control group to make plans that encompassed aspects of functioning that were not explicitly cued by the question. What could account for these deficits? It was speculated above that the anterior group might not have accessed information about the possible consequences of actions spontaneously on the prioritisation task. This was potentially linked to a failure to generate and apply strategic processes to long-term knowledge. A similar process could apply to their deficits on the current task. Thus, most of the control group recognised that when making plans for the career of somebody with financial difficulties, it was important also to consider the impact of these plans on their finances. This suggests they were thinking more about the real-world consequences than the participants with anterior lesions, or perhaps that their superior interpersonal skills helped them to see a more complete picture when they put themselves in the position of the fictional main character. However, it is of note that neither group tended to generate plans spontaneously for the other aspects of information included in the vignette, such as family and living arrangements.

As for the prioritisation task, the analyses of covariance showed that the group difference on the planning measure at five years (but not necessarily at one year) was no longer significant when any of the neuropsychological measures were used as covariates, indicating that executive processes potentially contributed to their difficulties. This is consistent with the suggestion outlined above, that the participants with anterior lesions were less effective at applying strategic processes to their long-term knowledge stores. Emotional considerations may also potentially influence planning on a task of this nature, but this is difficult to assess directly.
11.2.4.5 Summary

The findings demonstrated that the impairments in selecting appropriate courses of action seen in Study 1 also apply to other types of real-life-type measures. Participants with anterior lesions demonstrated impairment in prioritising real-life tasks, as predicted in Hypothesis 1. There was some evidence to link this to restricted appreciation of the negative consequences of not carrying out each item, but this was not clear-cut. They also showed impairment in making plans when these were not directly cued, as predicted in Hypothesis 2. Hypothesis 3 predicted that the anterior group would show impairment on the range of measures within the neuropsychological battery. This prediction was not borne out by the evidence, as the anterior group were only impaired on the Story Recall test. It was argued that the participants in the current study are likely to be relatively high-functioning. Given the relatively intact performance of the anterior group on the standardised executive measures, it is noteworthy that both the new tasks detected impairments in the anterior group relative to the control group. Thus, this study provides another example of ‘real-life-type’ measures being more sensitive to the subtle impairments seen in a high-functioning group than standardised executive measures, in common with previous studies (e.g. Shallice & Burgess, 1991; Bechara et al, 1994).
11.3 PART B

11.3.1 INTRODUCTION

Participants with TS showed impairments in aspects of real-life-type decision-making on the Predicaments test described in Study 2. The pattern of deficits they showed was the same as that seen in participants with anterior lesions in Study 1, in that they generated fewer solutions, and selected poorer quality ideas as their final options. Like the anterior group, they generated solutions of similar average quality to their control group, implying that they may have had specific deficits in selecting strong courses of action (see sections 8.3.2.3 and 8.3.2.4). The current study examines whether a group with TS would continue to show deficits similar to those seen in participants with anterior lesions, when selection of courses of action was examined using the new measures of prioritisation and planning described above.

People with TS are thought to show some deficits in executive skills, as outlined in section 4.2.3, although these are generally thought to be milder than those seen in people with structural anterior lesions. The findings from the current studies indicated that the TS group in study 2 showed impairment in aspects of attention and set-shifting, inhibition and strategy generation, and executive memory, although this only applied to a subset of the measures. In addition, it was suggested in section 4.1 that having a developmental disorder would have effects on the development of real-world knowledge throughout the age-span. The results of studies 2 and 3 indicated that experience was likely to have been a contributory factor to the performance of the TS group, as they showed deficits on the Predicaments test, in spite of showing fewer executive impairments than older people.
11.3.1.1 Hypotheses

1) On the prioritisation task, it was hypothesised that the TS group would prioritise fewer of the most important tasks relative to control participants, and might show difficulties in evaluating the consequences of not performing each item.

2) On the long-term planning test, it was predicted that the TS group would show impairment in formulating plans in areas that were not explicitly cued, relative to the control group.

3) It was predicted that the TS group would show impairment on some measures of attention and set-shifting, inhibition and strategy generation and executive memory within the executive battery, consistent with the findings in Study 2.

11.3.2 METHOD

11.3.2.1 Participants

Eleven participants (10m, 1f) who met DSM-IVTR criteria (American Psychiatric Association, 2000) for Tourette Syndrome and no other disorder took part in the study. In order to establish the diagnosis and rule out any comorbid disorders such as ADHD and OCD, participants were assessed using the National Hospital Interview Schedule for Gilles de la Tourette Syndrome (Robertson & Eapen, 1996) by a psychiatrist specialising in the field. Those who met DSM-IVTR criteria for ADHD, OCD or any other comorbid psychiatric disorder (e.g. psychosis) were excluded from the study, as were those with any history of neurological disorder (e.g. head injury). To be included in the study, participants had to be between 18 and 70 years of age, fluent in English, and have a verbal IQ score of 85 or above on the NART-II (Nelson, 1991).
Nine participants were right-handed, one was left-handed, and one was ambidextrous. This group was considered separately from the anterior group described previously because the two groups were not matched for age, sex, years of education, or NART IQ scores. The TS group was therefore compared with a subgroup of the control participants described above, that was more closely matched to them (control group: n=18, 11m, 7f). T-tests showed that these two groups did not differ significantly in age (TS mean 35.09 sd 12.65; control mean 37.78 sd 14.28), years of education (TS mean 13.00 sd 2.24; control mean 13.17 sd 2.09); or NART IQ (TS mean 105.36 sd 10.03; control mean 109.17 sd 9.70). All participants gave written informed consent for the study, and were given breaks between tasks as necessary, to avoid fatigue.

11.3.2.2 Measures
The new real-life-type measures described in section 11.2.2.2 were administered to the TS group in the same manner as outlined above. In addition, the executive battery described in section 11.2.2.3 was also administered.

11.3.3 RESULTS
As above, the variables of interest were initially examined for outliers and skewness, for both the TS and control groups. Time taken on the Hayling test was positively skewed for both groups, and these data were therefore transformed using negative reciprocal transformations. The other variables that did not meet assumptions of normality were the Six Elements Test, and error scores on the Hayling Test, which were analysed non-parametrically. The other tests in the executive battery were analysed using t-tests, or ANOVA for those with more than one task. The experimental measures were analysed using t-tests or Mann Whitney U tests, as described below. There were occasional missing data points on some tests for individuals as a result of administrative errors; numbers for each group are
shown in the Tables if these fall below maximum. A 5% significance level was adopted throughout, to examine any differences between the two groups.

11.3.3.1 Experimental measures

11.3.3.1.1 Prioritisation task
Mean scores, standard deviations and significance tests are shown in Table 11.6.

<table>
<thead>
<tr>
<th></th>
<th>TS group</th>
<th>Control group</th>
<th>Test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial planning time (secs)</td>
<td>43.82 (43.17)</td>
<td>37.22 (41.37)</td>
<td>t=0.41</td>
<td>.685</td>
</tr>
<tr>
<td>Ongoing planning time (secs)</td>
<td>151.94 (52.38)</td>
<td>138.82 (60.32)</td>
<td>t=0.62</td>
<td>.541</td>
</tr>
<tr>
<td>Number of tasks attempted</td>
<td>6.73 (2.41)</td>
<td>7.61 (2.33)</td>
<td>t=0.98</td>
<td>.337</td>
</tr>
<tr>
<td>Number of most important tasks attempted (/6)</td>
<td>4.27 (1.01)</td>
<td>4.89 (0.96)</td>
<td>t=1.64</td>
<td>.112</td>
</tr>
<tr>
<td>Number of least important tasks attempted (/7)</td>
<td>2.45 (1.69)</td>
<td>2.72 (1.74)</td>
<td>t=0.41</td>
<td>.688</td>
</tr>
</tbody>
</table>

The two groups did not differ significantly on either Initial Planning time (t=0.41, df=27, p=.685) nor Ongoing Planning time (t=0.62, df=27, p=.541). The groups also did not differ in terms of the overall number of tasks they attempted (t=0.98, df=27, p=.337). In contrast to the anterior group, there was no difference between the TS group and their control group on either the number of most urgent tasks (t=1.64, df=27, p=.112) nor the number of least important tasks attempted (t=0.41, df=27, p=.688).
11.3.3.1.1 Qualitative information about consequences

The potential consequences that participants attached to the most important tasks were examined. As these are primarily qualitative data, they are described below. However, some statistical analysis using Mann Whitney U tests was conducted where numbers were appropriate.

1) This item asked participants to pay a red electricity bill. The TS participants all recognised that failure to pay could result in the supply being cut off.

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Control group (/18)</th>
<th>TS group (/11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Having the electricity supply cut off</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>Expecting to have more time to pay in practice</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

2) This item consisted of a form to fill in to renew their car tax. The TS group recognised that if they did not renew their car tax then there would be potential legal consequences (e.g. being stopped by the police and fined), or that they would be unable to use the car until they had rectified the situation.

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Control group (/18)</th>
<th>TS group (/11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legal/police consequences, e.g. a fine</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Being unable to use the car</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Intending to pay at a future time point</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

3) This item consisted of a letter from a fictional hospital informing them that they had an appointment in 2 days time. Most of the TS participants gave similar answers to the control group to this item. The one exception was a participant who
said that the hospital would telephone him/her to ask for confirmation although this was contrary to the information in the letter and was not suggested by any other participant.

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Control group /18</th>
<th>TS group /11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miss the appointment</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Make an alternative appointment</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Attend at the suggested time and hope to be seen</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Telephone to confirm tomorrow</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Irrelevant/impossible suggestions</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

4) This item consisted of a credit card statement asking for the monthly payment. The TS participants showed an even split between three answers on this item, paying more interest, expecting to have more time to pay, and losing the credit card. One TS participant argued that debt collectors might come round. A Mann Whitney U test, comparing the groups on their numbers of mild (paying more interest and expecting to have more time to pay) and severe answers (all other responses listed below), was not significant (z=1.18, p=.237).
5) This item informed participants that they had no food in the house, and that they had invited a friend around for dinner that night. The task was to write a shopping list for their neighbour in order to have food for later. In contrast to the control group, no participant in the TS group offered a viable practical solution to this problem. The difference between the control and TS groups was significant \((z=2.55, p=.011)\).

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Control group (18)</th>
<th>TS group (11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pay more interest</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Expect to have more time to pay</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Endanger credit rating</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Lose the credit card</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Future financial difficulties</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Visit from debt collectors</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

6) This item informed participants that there was a film on television that day that they wanted to see. It stated that their neighbour would be prepared to tape it for them, but that they had to check what time and channel it was on. They were provided with a copy of the Radio Times to enable them to do this. The pattern of
results for the TS group was similar to that of the control group on this item. One participant offered the practical solution of hiring the film on video, but most simply acknowledged that they would miss the film.

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Control group (/18)</th>
<th>TS group (/11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miss the film</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Nothing important</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Rent the film on video</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

### 11.3.3.1.2 Long-term planning task

The results for the Long-term planning task are presented in table 11.7. Non-parametric Mann-Whitney U tests were used to examine the data for significance, as described above in section 11.2.3.3.

<table>
<thead>
<tr>
<th></th>
<th>TS Mean</th>
<th>sd</th>
<th>Control Mean</th>
<th>sd</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Career</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>1.27</td>
<td>0.65</td>
<td>1.56</td>
<td>0.62</td>
<td>1.24</td>
<td>.216</td>
</tr>
<tr>
<td>5 years</td>
<td>1.73</td>
<td>0.47</td>
<td>1.94</td>
<td>0.24</td>
<td>1.62</td>
<td>.106</td>
</tr>
<tr>
<td>Finances</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>0.82</td>
<td>0.87</td>
<td>1.89</td>
<td>0.47</td>
<td>3.59</td>
<td>.0001**</td>
</tr>
<tr>
<td>5 years</td>
<td>1.36</td>
<td>0.81</td>
<td>1.89</td>
<td>0.47</td>
<td>2.42</td>
<td>.016*</td>
</tr>
<tr>
<td>Living arrangements and family</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>0.18</td>
<td>0.40</td>
<td>0.11</td>
<td>0.47</td>
<td>0.98</td>
<td>.328</td>
</tr>
<tr>
<td>5 years</td>
<td>0.27</td>
<td>0.47</td>
<td>0.89</td>
<td>1.08</td>
<td>1.52</td>
<td>.128</td>
</tr>
<tr>
<td>Social and leisure time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>0.00</td>
<td>0.00</td>
<td>0.11</td>
<td>0.32</td>
<td>1.13</td>
<td>.260</td>
</tr>
<tr>
<td>5 years</td>
<td>0.09</td>
<td>0.30</td>
<td>0.22</td>
<td>0.43</td>
<td>0.89</td>
<td>.372</td>
</tr>
</tbody>
</table>

* p<.05  **p<.01
There were no significant differences between the groups on the first category which included work and study plans (1 year: z=1.24, p=.216; 5 years: z=1.62, p=.106). On the second category, finances, the two groups differed, with significantly poorer scores for the TS group both at one year (z=3.59, p=.0001), and five years (z=2.42, p=.016). The two groups did not differ in terms of their plans for living arrangements or social and leisure time (p>.05).

11.3.3.1.3 Executive battery
Mean scores, standard deviations and significance tests for the executive battery as shown in Table 11.8.

On the measures of attention and set-shifting, both the effect of group (F=3.50, df=1,25, p=.073), and the group by task interaction (F=3.24, df=1,25, p=.084) approached significance on the Cancellation tasks. Post-hoc t-tests using an adjusted significance level (.05/2=.025) showed that the two groups differed significantly on Star time (t=2.75, df=25, p=.011), with the TS group being slower than the control group. The two groups did not differ on Letter time (t=0.86, df=25, p=.398). On the Trail Making test there was no effect of group (F=0.66, df=1,26, p=.426), nor a group by task interaction (F=0.40, df=1,26, p=.541). A t-test using separate variance estimates showed that the two groups also did not differ significantly on the Rule Shift Cards test (t=0.70, df=8.79, p=.502).
Table 11.8. Mean scores and standard deviations for the executive battery: TS participants versus the control group.

<table>
<thead>
<tr>
<th>Test Description</th>
<th>TS group Mean (SD)</th>
<th>Control group Mean (SD)</th>
<th>Test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deductive reasoning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raven’s Matrices(^2)</td>
<td>11.80 (3.01)</td>
<td>12.39 (3.07)</td>
<td>t=0.49</td>
<td>.629</td>
</tr>
<tr>
<td><strong>Attention and set-shifting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIT(^1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Star time</td>
<td>52.22 (13.79)</td>
<td>38.50 (11.41)</td>
<td>F=3.50</td>
<td>.073</td>
</tr>
<tr>
<td>Letter time</td>
<td>64.11 (20.05)</td>
<td>58.83 (11.98)</td>
<td>F=0.66</td>
<td>.426</td>
</tr>
<tr>
<td><strong>Trail Making Test(^2)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>24.36 (9.12)</td>
<td>27.50 (10.05)</td>
<td>F=0.66</td>
<td>.456</td>
</tr>
<tr>
<td>Time B</td>
<td>60.20 (28.54)</td>
<td>68.06 (24.02)</td>
<td>F=0.66</td>
<td>.426</td>
</tr>
<tr>
<td><strong>Rule Shift Cards(^3)</strong></td>
<td>3.25 (1.16)</td>
<td>3.56 (0.62)</td>
<td>t=0.70</td>
<td>.502</td>
</tr>
<tr>
<td><strong>Inhibition and strategy generation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hayling Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time A</td>
<td>24.82 (18.00)</td>
<td>20.33 (6.20)</td>
<td>F=0.57</td>
<td>.456</td>
</tr>
<tr>
<td>Time B</td>
<td>39.00 (20.33)</td>
<td>54.22 (62.37)</td>
<td>z=1.27</td>
<td>.203</td>
</tr>
<tr>
<td>B Errors</td>
<td>2.45 (2.58)</td>
<td>2.72 (3.04)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Letter fluency</strong></td>
<td>36.36 (11.27)</td>
<td>46.39 (12.97)</td>
<td>t=2.12</td>
<td>.044*</td>
</tr>
<tr>
<td><strong>Multitasking</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Six Elements Test(^1)</td>
<td>4.00 (0.00)</td>
<td>3.72 (0.76)</td>
<td>z=0.25</td>
<td>.801</td>
</tr>
<tr>
<td><strong>Executive memory</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story Recall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>38.55 (10.36)</td>
<td>43.22 (5.13)</td>
<td>F=4.31</td>
<td>.047*</td>
</tr>
<tr>
<td>Delayed</td>
<td>33.45 (14.60)</td>
<td>41.11 (5.42)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dysexecutive behaviours (DEX)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self rating</td>
<td>19.36 (9.62)</td>
<td>20.67 (7.72)</td>
<td>t=0.40</td>
<td>.691</td>
</tr>
<tr>
<td>Other rating(^4)</td>
<td>22.86 (11.75)</td>
<td>18.53 (10.08)</td>
<td>t=0.91</td>
<td>.371</td>
</tr>
</tbody>
</table>

* p<.05  \(^1\)N=9 TS, 18 control  \(^2\)N=10 TS, 18 control  \(^3\)N=8 TS, 18 control  \(^4\)N=7 TS, 17 control
On the measures of inhibition and strategy generation, the groups did not differ significantly on the timed parts of the Hayling test \((F=0.57, \text{df}=1,27, p=.456)\), and there was no group by task interaction \((F=0.10, \text{df}=1,27, p=.754)\). In addition, the groups did not differ on Hayling error scores \((z=1.27, p=.203)\), although the TS group did generate significantly fewer words than the control group on the Letter Fluency test \((t=2.12, \text{df}=27, p=.044)\).

The groups did not differ on the measure of deductive reasoning, the Raven's matrices \((t=0.49, \text{df}=26, p=.629)\), nor on the measure of multitasking, the Six Elements test \((z=0.25, p=.801)\). On the executive memory test, Story recall, there was a main effect of group \((F=4.31, \text{df}=1,27, p=.047)\), but the group by task interaction was not significant \((F=0.91, \text{df}=1,27, p=.349)\). The mean scores showed that the TS group recalled less of the story than the control group, but the lack of interaction indicates that this was of a comparable degree for both parts of the test (immediate and delayed recall).

11.2.3.6 Analysis of covariance with executive battery

In order to examine the relationships between performance on the new measures, and executive function, the experimental measures that significantly differentiated the groups on the long-term planning test were examined using the five sets of executive measures and the DEX as covariates. The results are shown in Table 11.9.
Table 11.9  Analyses of covariance between the Predicaments measures and executive battery

<table>
<thead>
<tr>
<th>Executive measures</th>
<th>Finances 1 year</th>
<th>Finances 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deductive reasoning</td>
<td>p=.0001*</td>
<td>p=.029*</td>
</tr>
<tr>
<td>Attention and set-shifting</td>
<td>p=.0001**</td>
<td>p=.064</td>
</tr>
<tr>
<td>Inhibition and strategy generation</td>
<td>p=.0001**</td>
<td>p=.014*</td>
</tr>
<tr>
<td>Multitasking</td>
<td>p=.0001*</td>
<td>p=.088</td>
</tr>
<tr>
<td>Executive memory</td>
<td>p=.002**</td>
<td>p=.193</td>
</tr>
<tr>
<td>DEX</td>
<td>p=.001**</td>
<td>p=.396</td>
</tr>
</tbody>
</table>

* p<.05

For financial planning over one year, the group difference remained significant when any of the executive measures, or the DEX, were used as covariates. For financial planning over five years, the group difference remained significant when the measures of deductive reasoning (p=.029), and inhibition and strategy generation (p=.014) were used as covariates, but was no longer significant when the other types of executive measures were used as covariates.

11.3.4 DISCUSSION

11.3.4.1 Summary of results

On the prioritisation task, the TS group did not differ from the control group in terms of the number of the most important items they attempted. However, when asked about the consequences of failing to do the items, although they were able to give adequate answers, there was a tendency for them to produce fewer
spontaneous practical solutions than the control group to deal with these consequences. On the long-term planning task, the TS group showed a pattern of performance similar to that seen in participants with anterior lesions, in that they were less likely than the control group to generate plans relating to aspects of the vignette that were not directly cued. When the executive battery was examined, the TS group scored more poorly than the control group on some aspects of attention and set-shifting, inhibition and strategy generation and executive memory.

11.3.4.2 Executive battery

The results on the executive battery can be compared with those seen in study 2 (section 8.3.3). In both studies, the TS group showed impairment only on the Star Cancellation task from the attention and set-shifting measures. On the inhibition and strategy generation measures, the TS group showed a more narrow range of impairments in the current study, in that the only significant result was seen on the Letter Fluency test. The result on this measure approached significance in the previous study, while both time and error scores on the Hayling test were previously significant. In both studies, the TS group did not differ from the control group on the measures of deductive reasoning and multitasking, but they did show poorer performance than a control group on a test of executive memory. The results of the current study provide further evidence that uncomplicated TS is associated with deficits in some aspects of executive function. The measures on which they showed impairment are all thought to involve inhibitory processes to some extent, and the findings are therefore consistent with other work indicating that TS might reflect a failure of inhibition (Leckman et al, 1991).

11.3.4.3 Prioritisation task

In contrast to the anterior group described above, there were no differences between the TS group and the control group in terms of their ability to prioritise the most important tasks. It was speculated above in section 11.3.4.3 that deficits in
executive function contributed to the difficulties shown by the anterior group on this measure. One possible explanation for the intact performance of the TS group is that their relatively subtle deficits on aspects of executive function were not large enough to influence their performance on prioritising. However, this is unlikely to be the entire explanation, given that the anterior group described above also showed relatively intact performance on the executive battery. It was also speculated above that other factors might have contributed to the anterior groups' poorer prioritisation performance, including deficits in aspects of interpersonal and emotional processing. Impairments in processes such as these may be less relevant to the TS group. For example, it has been suggested that processing of interpersonal factors, such as theory of mind, is intact in TS (Baron-Cohen et al, 1997). In addition, deficits in emotional processing have been linked particularly to orbital and medial areas of the frontal lobes (e.g. Damasio et al, 1990), and TS has been linked particularly with disruption to lateral cortical areas (see section 4.2.1).

In study 2, the other major contributory factor to the deficits shown by the TS group was thought to be disrupted social knowledge/experience. Each of the component tasks in the present study was selected to be familiar, everyday ones that were not in themselves likely to present any difficulties to participants if they were simply asked to perform them individually. They were likely to be considerably more familiar to participants than the interpersonal everyday awkward situations in study 2, and thus to be influenced rather less by any differences in previous experience. Support for this was provided by examination of the possible consequences cited by the TS group, in that they generally showed realistic appraisals of these.

Although the TS group showed realistic appraisals of the consequences of failing to perform the important items, there was tentative evidence that they were more limited in their appraisals of the consequences of their actions, like the anterior
group described above, in that they had a reduced tendency to generate alternative solutions spontaneously for some of the items. This might reflect a subtle deficit in generating and applying strategic processes to long-term knowledge, consistent with some impairments in inhibition and strategy generation measures in this group.

11.3.4.4 Long-term planning test
The TS group showed similar impairments to the anterior group described above on the long-term planning task, in that they were significantly less likely than the control group to make plans that encompassed aspects of functioning that were not explicitly cued by the question. In the anterior group, this deficit was also linked with failure to generate and apply strategic process to long-term knowledge, and this seems to be a likely explanation of the impairments seen in the TS group in the current study. However, unlike the anterior group, when analyses of covariance were examined, group differences at one year remained significant in the current study when any of the standardised measures were used as covariates. In study 2, it was suggested that a developmental disorder might have effects on the development of real-world knowledge throughout the age span. It is possible that subtle differences in real-world experience contributed to the TS group being less likely than the control group to integrate information from different aspects of life when this was not directly cued.

11.3.4.5 Summary
In summary, the findings showed that participants with TS did not show impairment in prioritising real-life tasks, contrary to the prediction in Hypothesis 1. However, they did show evidence of restricted appreciation of the negative consequences of not carrying out each item. They also showed impairment in making plans when these were not directly cued, as predicted in Hypothesis 2. Hypothesis 3 predicted that the TS group would show impairment on aspects of
attention and set-shifting, inhibition and strategy generation, and executive memory form the executive battery. The results showed that this was the case, as they were impaired relative to the control group on Star Cancellation time from the attention and set-shifting measures, Letter Fluency scores from the inhibition and strategy generation measures, and the Story Recall measures. The findings demonstrated that participants with TS might have some difficulties in evaluating the consequences of courses of action, but this did not lead to poorer prioritisation relative to a control group.
CHAPTER 12
GENERAL DISCUSSION

12.1 SUMMARY OF FINDINGS

The results of the five experimental studies that have been presented are summarised in Table 12.1.

Table 12.1 Summary of deficits seen in the experimental groups on the new measures of real-life-type problem-solving

<table>
<thead>
<tr>
<th>Task</th>
<th>Anterior Group</th>
<th>TS Group</th>
<th>Older Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpersonal Predicaments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Prompts</td>
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**Key**
- 'X' experimental group gained significantly poorer scores
- '=' no difference between the groups
- '+' experimental group gained significantly higher scores
- Blank cells measure not administered to this group
Study 1 described the development of the Predicaments test, which was designed to assess multiple dimensions of interpersonal problem-solving using everyday awkward situations. The findings showed that participants with adult-acquired structural brain lesions were impaired in aspects of real-life-type problem-solving performance. As expected, impairments were more extensive in participants with lesions involving the frontal lobes than in those with posterior lesions, and the left-sided participants in the anterior group showed the most marked deficits. The second part of study 1 described the development of a shorter, more-user friendly, version of the Predicaments test, which was more sensitive than the original to the deficits shown by participants with anterior lesions. It was hypothesised that a range of factors potentially contributed to the impairments shown by the anterior group, including inadequate application of previous experience to guide problem-solving, poorer executive skills, difficulties with decision-making, and poorer comprehension and judgement of interpersonal issues. The subsequent studies were designed to investigate further the role of these factors in everyday problem-solving. In each one, either the selection of participants or the types of measures was manipulated in some way, in order to achieve this.

Studies 2 and 3 examined the contributions of executive skills and previous experience to real-life-type problem-solving. This was achieved by using the same shortened Predicaments test described in the second part of Study 1, but using different groups of participants, in order to manipulate the contributions of experience and executive function. Adults with Tourette’s Syndrome (TS) would be expected to have fewer executive deficits than participants with anterior lesions, in the context of also having slightly reduced real-world knowledge as a result of the primary and secondary effects of developmental disorder. By contrast, healthy older people would be expected to show greater difficulty on a broader range of executive measures, but to have more comprehensive real-life experience than participants with TS or anterior lesions. The results showed that the older group did perform more poorly on a wider range of executive measures relative to their control group than did the TS group, consistent with expectations. On the Predicaments test, both groups generated fewer initial solutions than their control
groups, but in the case of the older group, this was mitigated by the generation of higher-quality solutions, and similar performance to the control group in the quality of their final solutions. In the case of the TS group, they showed poorer performance both in the quality of their final solutions. The evidence suggests that life experience can counteract the adverse effects of executive deficits in everyday problem-solving.

Study 4 focused on the contribution of specific interpersonal factors to problem-solving. In order to investigate this, the Predicaments measure was manipulated, in order to create new problems with little interpersonal relevance. The purpose was to allow a comparison of performance on problems with relatively few interpersonal concerns, with those in which interpersonal issues were central to the problem. Participants with anterior lesions were compared with a matched control group. The results showed that the anterior group was impaired on the number of solutions generated on both types of measure. When selection of final solutions was examined, the anterior group was impaired on those with interpersonal content, but not those that were relatively independent of interpersonal concerns (which showed ceiling effects for both groups). This study suggests that interpersonal skills such as pragmatic comprehension, theory of mind and empathy are potentially important contributors to the difficulties shown by patients with frontal lobe lesions in everyday life.

In study 5, everyday decision-making was examined further by developing new measures looking at prioritisation and planning abilities. The prioritisation measure focused on decision-making when asked to choose amongst a set of items to perform, without the need for participants to generate these themselves. Unlike previous studies, the items used were real-life activities that differed in their possible consequences if not carried out. Those with anterior lesions showed impairment in their ability to prioritise when asked to carry out the tasks they considered to be the most important. They also showed evidence of reduced ability to consider the consequences of their actions, both on this task and when asked to make a life plan for a fictional character. When a group of participants with TS was assessed on the same tasks, they showed impairment on the life planning test.
similar to that seen in the participants with anterior lesions. They also showed some
evidence of limited thinking about the consequences of the prioritisation task, but
did not show any impairments in their ability to prioritise. Overall, study 5
confirmed that frontal lobe dysfunction is associated with impairments in a range of
real-life-type situations.

12.2 CONTRIBUTIONS TO REAL-LIFE PROBLEM-SOLVING
PERFORMANCE

As described above, the overall aim in the current studies was to investigate the
relative contributions of experience, executive function, and interpersonal factors to
real-life problem-solving performance. The implications of the current findings for
these functions are described below. Obviously, the processes are not completely
independent, since, for example, deficits in strategic executive processes could
affect the retrieval of relevant information from long-term knowledge stores.
Nevertheless, the current findings are consistent with each of these factors making
independent contributions to everyday problem-solving.

12.2.1 The role of executive processes in real-life problem-solving

Clinically, tests of executive function are often administered with the intention of
providing information about a person’s real-life difficulties with problem-solving.
However, as detailed in section 2.2, previous work has demonstrated that patients
with frontal lobe lesions can show intact performance on abstract measures of
executive function, whilst showing impairments in real-life problem-solving
situations (e.g. Eslinger & Damasio, 1985; Shallice & Burgess, 1991; Goldstein et
al, 1993). The findings presented in the current study provide further evidence that
measures designed to have greater ecological validity can be more sensitive to the
impairments seen in participants with anterior lesions. For example, in Study 1, the
anterior group did not differ from a posterior group on any measures within the
executive battery, but they showed more marked deficits on the Predicaments test
on both generation and selection of solutions. In Study 5, the anterior group
showed relatively intact performance on the executive battery, in spite of showing
deficits on some aspects of the new measures.
The aspect of real-life-type problem solving that was most strongly related to the standardised executive tests in the current studies was the generation of solutions in the Predicaments test. As postulated in section 7.1.4.4.2, the processes that might be involved in this include initiation of strategies in order to search long-term knowledge stores for relevant information to the problem. In participants with anterior lesions, and older adults, the measures that were most strongly related to the numbers of solutions generated were those of attention and set-shifting and inhibition and strategy generation. The shared demands and close relationships between performance on these tasks indicate that it might be expected that they would share a neurological basis. Executive processes, including those listed above, are thought to be highly reliant on lateral areas of prefrontal cortex (e.g. Duncan & Owen, 2000; Stuss et al, 2001). All the patients with anterior lesions in Study 1 had lesions involving lateral areas. Normal ageing has also been linked with differential effects in dorsolateral areas relative to orbitofrontal areas (Phillips & Della Sala, 1999). However, the evidence is less clear-cut in this group, as numbers of solutions generated was the only aspect of problem-solving on which they scored below the younger participants. As discussed above, this may reflect poorer executive skills, or may simply reflect a different strategy for solution generation, reflecting the higher quality of solutions that come to mind for this group.

By contrast, selection of final solutions was less strongly related to executive processes. Participants with TS, but not healthy older people, showed impairment in this aspect of functioning in spite of the TS group showing impairment on fewer of the executive measures. The Predicaments task did not examine to what extent participants considered the consequences of their chosen courses of action in selecting final solutions. Ability to look ahead to the outcomes of possible actions is likely to be a critical factor in successful problem-solving performance, and deficiencies in this domain may be sufficient to account for poor selection of solutions on each of the tasks studied. This issue was investigated further in Study 5 by examining planning performance in two new measures, one of which assessed immediate prioritisation of competing items, and the other of which assessed life
planning over a longer time period. Both these tasks and the Predicaments test potentially involve evaluating a range of options in order to select the best course of action, although in the Predicaments and life planning test, these options are generated by the participant, whereas in the prioritisation test, they are provided. The findings from Study 5 showed that in both tasks, those with anterior lesions and those with TS showed a reduced tendency to consider the consequences of their actions. In the prioritisation task, which examined this most closely, they were able to spell out potential negative consequences, but did not tend to seek compensatory strategies to minimalise these in the same way as the control group.

In spite of ability to perceive the negative consequences, the anterior group performed fewer of the important items in the prioritisation task than the control group. What other factors might have contributed to this? This task shared common features with tests designed to study multitasking, i.e. carrying out a range of tasks in limited time. A recent study examining localisation within multitasking suggested that there are three distinct processes involved, planning, retrospective memory, and prospective memory (Burgess et al, 2000). Planning was linked with right dorsolateral areas, consistent with the executive literature discussed above. Retrospective memory was linked with anterior cingulate areas, and prospective memory with left medial frontal areas. The prospective memory component is the ‘intentionality’ component that is thought to be relevant in delayed intentions, and impairments in this are demonstrated by factors such as rule breaks, and the number of tasks attempted. Support for these regions in prospective memory has been provided by an imaging study (Burgess et al, 2001). Prospective memory failure may have contributed to poorer prioritisation in the anterior group in the present study. Another potential contributory factor is the influence of emotional processes on decision-making; these are considered below.

12.2.2 The role of specific interpersonal processes in real-life problem-solving
The relevance of specific interpersonal factors in real-life problem-solving was demonstrated in Study 4, which showed that anterior participants showed fewer deficits when interpersonal concerns were removed from the Predicaments problems.
Frontal lobe lesions have been associated with deficits in interpersonal factors in terms of impaired theory of mind, empathy, pragmatic language and processing of nonverbal cues (e.g. Rowe et al, 2001, Grattan et al, 1994; McDonald & Pearce, 1994; Hornak et al, 1996). Study 1 demonstrated that the contribution of nonverbal cues, such as interpretation of face and voice expressions, was likely to be small, given that there was no difference in performance between video and story presentation. Study 4 enabled further consideration of other interpersonal processes, and showed that factors such as these are important in real-life problem-solving, but did not enable the relative contributions of each one to be established. One possible way in which the current studies could have been improved may have been to address this by including individual measures of these processes in order to covary them out of Predicaments performance, in a similar fashion to that done with the standardised neuropsychological measures. However, the choices of which measures to use would have been difficult to make. For example, there is debate about whether theory of mind is a unitary concept. One study of patients with anterior lesions showed that there may be differences in performance depending on the measure used (Stuss et al, 2001). In addition, different theory of mind tasks have implicated different brain areas (Baron-Cohen et al, 1994; Fletcher et al, 1995; Goel et al, 1995; Baron-Cohen et al, 1999).

Empathy is also thought to be a non-unitary concept, in that distinctions have been made between cognitive and emotional empathy, and these have been linked with different areas of frontal cortex (Eslinger, 1998). The concept of cognitive empathy has been compared to theory of mind, although little has been done to consider the similarities and differences when examining the various measures used to tap these processes. With respect to pragmatic processing of non-literal language, a wide range of tasks has been used, including understanding sarcasm, irony and humour. It has been argued that theory of mind represents a particular subset of non-literal language processes, requiring particular emphasis on the comprehension of others’ perspectives. Although pragmatic language processing was originally thought to rely on the right hemisphere, the involvement of the frontal lobes is increasingly recognised (e.g. Brownell et al, 1990; McDonald & Pearce, 1996; Winner et al,
1998). It is surprising how few studies have attempted to address the question of whether these various interpersonal processes are distinct and dissociable from each other. Further work is needed to address these issues, before a more detailed analysis is made of their contributions to real-life problem-solving in measures such as the Predicaments test.

These issues are important to address for clinical reasons. This is illustrated by the problem appreciation measure of the Predicaments test. As described previously, failure to appreciate the pertinent aspects of the problem can lead to the wrong problem altogether being addressed. This has serious implications for everyday life. Even if the individual is able to reason effectively about the consequences of actions, and understand that it is important to take other people’s feelings into account, this will be to no avail if they are addressing the wrong issues. This can be extended more widely. For example, pragmatic language is essential to everyday communication. An inability to understand when a statement is not meant to be taken literally, such as sarcasm, irony and jokes, would cause severe disadvantages in daily life.

12.2.3 The role of experience in real-life problem-solving

The relative contribution of previous experience is one of the major differences between real-life problem solving and abstract laboratory tests (Galotti, 1989). There are two main ways in which experience may be affected directly. The first of these involves normal knowledge acquisition, with later disruption of knowledge as a result of brain injury/illness. For example, damage to long-term memory stores could result in relevant memory traces being lost. However, this was an unlikely source of difficulty for any of the groups considered in the current studies, since long-term stores are not generally thought to be localised in the frontal lobes (e.g. Poldrack & Gabrieli, 1997; Buckner & Wheeler, 2001). Another possible direct effect on experience is limited or absent acquisition of knowledge as a result of failure to encounter the relevant problem-solving situations, or enhanced experience as a result of increased exposure. In the current study, it was argued that participants with TS, adult-acquired lesions, and older people, would have different amounts of real-world experience upon which to draw, although these effects might
be relatively subtle. The finding that participants with TS showed greater impairment on the Predicaments test than the older group, in the context of less marked executive deficits, supports the theory that experience is important in real-life problem-solving.

As discussed above, the possession of relevant stored knowledge is not in itself sufficient, since it is also necessary to access and apply that knowledge appropriately to the task in hand. While long-term stores themselves are not thought to be localised in the frontal lobes, retrieval strategies are thought to depend on lateral areas of the frontal lobes (e.g. Buckner & Wheeler, 2001), and there is general agreement that memory deficits seen in patients with anterior lesions are likely to be attributable to executive deficits (e.g. Shimamura et al., 1991; Della Rochetta & Milner 1993; Mayes & Daum, 1997). However, as described above, healthy older people in Study 3 showed poorer performance than younger people on all types of executive measures, including executive memory. They nevertheless showed minimal deficits in problem-solving. How might enhanced knowledge in older people compensate for deficits in executive function? One question is the ready availability of stored knowledge. It may well be that relevant memories are more plentiful and/or more easily accessed for older people in real-life problem-solving situations, thereby reducing the executive load. Within the Shallice and Burgess model of frontal lobe functioning (e.g. Shallice & Burgess 1993, 1996), there is a crucial distinction between routine and novel problem-solving, such that the frontal lobes are thought to be necessary only in the latter. Thus, greater life experience in older people may result in substantially more exposure to a wide variety of problem situations, both directly and indirectly, and also exposure to a variety of means of solving problems. Successful problem solutions may therefore be accessed relatively automatically, rather than requiring strategic retrieval. In support of this, the older group generated fewer solutions than younger group, suggesting executive impairment, but their ideas were of higher quality, implying that they only access relatively good solutions.
12.3 CLINICAL RELEVANCE

As outlined in section 1, one important application of measures such as those in the present study is to provide methods of assessing the difficulties patients have in their everyday lives within a laboratory setting. The current findings indicate that measures such as those presented here do provide more sensitive tools to achieve this than many abstract tasks. When such measures are actually developed as clinical tests, e.g. the BADS (Wilson et al, 1996), then they enable a quicker and more practical method than observation to be used in order to detect difficulties. Structured tests are also more objective than observation, as normative data are generally collected from a representative range of the normal population, in order that any individual’s performance can be placed in a relevant context.

Assessment of difficulties is necessarily the first step in ascertaining goals for rehabilitation. Nevertheless, there is then the question of how this leads on to rehabilitative strategies for aspects of functioning such as those described above. There is a variety of methods of achieving rehabilitation, including compensatory strategies, improving learning of new skills, and capitalising on the brain’s ability to recover (Wilson, 1998). The appropriateness of each technique to the function in question is likely to depend on the extent of the behavioural, cognitive and emotional consequences of the deficits, and the site and size of the injury. Deficits resulting from frontal lobe lesions are thought to be particularly difficult to treat (e.g. Wilson, 1998). However, compensatory strategies have been shown to be effective in one case (Evans, Emslie & Wilson, 1998), as has ‘goal management training’ which teaches patients a set of steps aimed at helping them to develop, follow through and monitor, appropriate goals. This has been shown to be beneficial in a real-life planning situation (Levine, Robertson, Clare, Carter, Hong, Wilson, et al, 2000). Other studies looking at patients with severe dysexecutive and memory impairments have also shown that behavioural techniques can increase self-monitoring of behaviour (Alderman, Fry & Youngson, 1995). There may therefore be some scope for offering strategies to patients with real-life problem-solving deficits.
The findings of subtle indications of reduced awareness in participants in the
current studies are also potentially of clinical relevance. This is because reduced
awareness of deficits means that patients’ self-reports that they have no difficulties
in real-life problem solving may not be reliable. This in turn could lead, in a
clinical setting, to a failure to offer appropriate treatment. For instance, the TS
participants in Study 2 did not differ from control participants in their ratings of
everyday difficulties on the DEX, while their relatives and friends reported them to
show a more substantial range of problems in daily life.

One further point on the clinical relevance of the studies presented here is that they
suggest that caution should be used in interpreting the results of standardised
assessments with older people. As shown in Study 3, this group was deficient in
comparison with younger people on abstract executive measures (although they
performed normally for their age group), in the context of intact everyday problem-
solving performance. It is therefore possible that while standardised assessments
may sometimes underestimate the everyday difficulties of people with structural
frontal lesions, they may overestimate the difficulties shown by older people in
their daily lives.

12.4 LIMITATIONS OF THE CURRENT STUDIES, AND IMPLICATIONS
FOR FUTURE WORK

12.4.1 Localisation
As described above, the various factors considered to be important in real-life
problem-solving, are, to some extent, thought to be localised in different areas of
the brain. The current studies focused on the performance of participants with
acquired anterior lesions. However, the small sample sizes did not permit detailed
investigation of the role of different brain regions, beyond the observation that left-
sided lesions were associated with greater impairments on the Predicaments test
than right-sided lesions. Other studies, such as decision-making studies using
gambling tasks (e.g. Bechara et al, 1994) have included participants with bilateral
lesions, and it is possible that a greater range of deficits would have been seen in
the current studies had a group with bilateral lesions been included. However, the
use of participants with acquired structural lesions to investigate these processes is
limited by the small numbers of suitable patients, and the obvious heterogeneity of
lesion sites caused by events such as head injuries and strokes. In addition, the
behavioural effects caused by acquired lesions may differ depending on the
aetiology. Thus, although more information about the localisation of real-life
problem-solving deficits may have been provided by testing larger samples,
including a bilateral group, methodological and interpretation difficulties would
have remained. Indeed, determining localisation of function within the frontal lobes
is likely to remain a difficult task when looking solely at patients with acquired
lesions.

This has been acknowledged to be a problem in the area, and the focus of work
directed towards localisation has shifted towards functional imaging of healthy
participants. Studies looking at structured laboratory tasks have indicated that
different areas of frontal cortex are associated with different processes. For
instance, dorsolateral prefrontal cortex has been associated with the executive
components of working memory (e.g. Petrides, 1996; Owen, Herrod, Menon,
Clark, Downey, Carpenter et al, 1999), whereas decision-making has been linked to
the orbitofrontal regions (Rogers et al, 1999). Therefore, there is increasing
evidence for fractionation within the frontal lobes. However, there are still
relatively few studies evaluating the brain areas involved in tasks with greater
ecological validity. Therefore, one possible area of future work would be to use
tasks such as those described in the current studies in functional imaging
paradigms, although the relative complexity of the different contributory
components would make the subtraction methodology difficult to implement.

12.4.2 Reliability and validity of the measures
The measures presented in the current studies were designed specifically for these
studies. This means their psychometric properties remain largely unknown. The
current measures therefore would not be appropriate for use in clinical practice,
without considerable further development. When clinical tests are made available
for use, it is important that their reliability and validity has been explored.
Reliability refers to the consistency of a test. One aspect of this is the extent to which different raters are consistent in their judgements of the same data. Inter-rater reliability in the current studies was found to be adequate, since it ranged between 87-91%. Another aspect of reliability is the extent to which a test gives similar results for the same individual with repeated administrations (test-retest reliability), which was not assessed in the current studies. However, it has been noted that test-retest reliability poses something of a problem for executive tests. In the BADS manual, Wilson and colleagues (1996) state that one of the key concepts of the dysexecutive syndrome is novelty. Hence, on repeated testing, one might not expect a participant to gain an identical score to that achieved on the first occasion, because the novelty of the task is reduced. Consistent with this, they found that there was a tendency for scores to improve slightly on the BADS measures with repeated testing.

If measures such as those in the current studies were applied in a clinical setting, it would be important to know that they enabled valid predictions to be made about real-life functioning. The tasks all had face validity, in that they were open-ended, with no absolute no right or wrong answers, and gave little feedback about performance. In addition, the Predicaments situations were all based on real-life problems encountered in daily life. In the prioritisation test, participants were asked to actually carry out the tasks, using everyday materials, in order to more closely approximate real-life conditions. The long-term planning test involved decisions about common aspects of life including career, finances, family and living situation. However, face validity is not adequate alone to judge that the tasks provide valid information about real-life problem-solving. The DEX was intended to provide a measure of concurrent validity. Subscales of the DEX questionnaire could also have been examined, since these may have had different relationships to the various experimental measures. Previous work (Burgess et al, 1998) has indicated that a factor analysis of the DEX demonstrates that there are five different factors within it, including inhibition, intentionality, executive memory, and positive and negative affect. An analysis of the subscales of the DEX was not undertaken in the current study, due to the lack of group differences on this measure between anterior and control participants. However, as noted above, these
ratings probably did not give a full picture of any deficits shown in real life by the participants in the current study, since the raters were sometimes thought to underrate their difficulties, and deficits were relatively mild for some of the participants. In the BADS manual (Wilson et al., 1996) the authors comment that independent raters for the DEX should be chosen carefully in the clinical context, and that people vary in their ability and experience in making objective observations of another person’s behaviour. Future work could examine validity issues more closely, either by using the DEX with different raters, or by interviewing patients and their relatives. Of course, the best way to evaluate real-life validity would be to observe the way people deal with such problems in their daily lives. However, there are obviously practical limitations to doing this, which is why most studies prefer to use a measure that has already been standardised.

Another issue in relation to the validity of the current tasks is the non-unitary nature of problem-solving. It is possible that the measures chosen were not fully representative of the range of problem-solving components that contribute to real-life performance. The difficulty is how to gauge this, in order to address it more adequately. The tasks in the current studies were based on everyday activities, and the dimensions addressed in the Predicaments test were based on previous work indicating that there are potentially separate processes in problem-solving (D’Zurilla & Goldfried, 1971). In support of this, the present results showed that some of these dimensions appear to be relatively independent of each other in some groups. For example, although the number of solutions generated in the Predicament test was related to the quality of the final solutions selected in those with anterior lesions, these were not related in healthy older people, who performed more poorly than the younger group on the former, but not the latter. However, there may be other aspects of problem-solving that were not addressed adequately. This is considered further below.

12.4.3 How might factors contributing to problem-solving performance be investigated further?

One of the postulated sources of difference between the groups was their use of problem-solving strategies, linked to dorsolateral executive skills. Previous work
has reported that patients with frontal lobe lesions are less likely than control participants to use strategies spontaneously (Burgess & Shallice, 1996; Owen et al, 1990). Thus, an option for future work might be to use specific cues on the Predicaments task, and see if this affects performance. For example, some participants in the control group stated that when they were asked to generate as many ideas as they could, they tried to think of the best and worst thing they could do in that situation, and then generate some intermediate options. This could be offered as a strategy to patient groups to see if it affected their ability to generate solutions, and, in turn, their ability to select strong options for their courses of action.

A similar approach might be used with regard to selection of courses of action, either when selecting final solutions on the Predicaments task, or when choosing between items in the prioritisation task. One possible strategy would be to ask participants to list the likely consequences of each of their solutions, and then to decide which one was likely to be the best. The effect of providing participants with strategies has been investigated in depression (Channon & Green, 1999), although the study showed that while this increased the use of strategies, it did not improve the overall performance levels of the depressed participants. The authors suggested that the effectiveness of providing strategies depended upon the extent to which these were readily adopted by participants, and the amount of practice needed to make effective use of such strategies rather than their habitual methods of approaching problems.

With respect to the role of knowledge/experience, determining the contribution of this to problem-solving is a difficult area to assess. As explained previously (see section 8.1), there is no reliable method of quantifying experience, and any method would be post-hoc and difficult to validate. The current studies used groups of participants with differing levels of experience to achieve this. Another option would have been to ask participants directly whether or not they had personal experience of each one, or how familiar each awkward situation was to them. It was noted informally during testing that participants often remarked that they had been in similar situations to some of the scenarios presented in the studies. Future
studies could examine whether there was any correlation between self-rated experience and problem-solving performance.

With regard to specific interpersonal processes, although Study 4 demonstrated that they contributed to real-life-type problem-solving performance, it was not possible to distinguish with the present materials between the relative contributions of pragmatic language, theory of mind and empathy, all of which have been linked with frontal lobe dysfunction. As stated above, in section 12.2.3, it would be possible to include individual measures of these factors, and examine which of these are most related to performance on the experimental measures. However, this requires further work on the processes themselves before they are applied to the current measures.

Increasingly, it has been argued that emotional factors influence decision-making (e.g. Bechara et al, 2000; Peters et al, 2000). This theory is based on studies using gambling tasks in which participants with ventromedial lesions fail to learn to avoid cards with high long-term penalties if they provide immediate rewards. A study examining the functional imaging of gambling (Rogers et al, 1999) showed both medial and orbitofrontal areas to be associated with this task in situations in which the least likely choice carries the largest rewards. Poorer gambling in patients with ventromedial lesions has been linked with impaired perception of risk (Rogers et al, 1999; Rahman et al, 2001), such that these patients tend not to take risks, even in favourable circumstances, unlike control participants. Could deficient risk-taking account for the impairments seen in anterior participants in the current studies? It is possible that in the prioritisation task, the anterior group were less likely to prioritise tasks with greater negative consequences, despite appreciation of what these consequences were. However, this would imply taking greater risks, whereas the patients in the Rogers et al study took fewer risks. Greater risk taking has been reported in patients with fronto-temporal dementia, and has been associated with reduced awareness (Rahman et al, 1999). Further investigation of the role of risk-taking would require adaptation of the studies in order to deliberately vary the potential risks, and the magnitude of favourable consequences.
In summary, the studies presented here have described the development of new tasks designed to approximate real-life problems. The findings showed that participants with anterior lesions and Tourette's Syndrome had deficits relative to control groups on these measures, and these tended to be more marked than their impairments on standard neuropsychological measures. Executive function, specific interpersonal factors, experience and possible emotional contributions to decision-making were all thought to be potentially relevant to performance. Further work may shed further light on the relative roles of these different factors, and the localisation of deficits in different dimensions of real-life problem-solving.
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APPENDIX A: STORY VERSIONS OF THE PREDICAMENTS ITEMS

Set A

Practice:
Tina and Wendy are talking over coffee. Tina is telling Wendy about how dreadful her driving lesson was. During the lesson, Tina mounted the pavement while reversing round a corner. Later on, she nearly drove through a red light, because she was concentrating so hard on the road, she did not notice it. Wendy says that she is sure Tina’s mistakes were due to nerves. Tina replies that her driving instructor also says it was nerves, but that her test is tomorrow. Wendy says that she is sure it cannot have been that bad. However, Tina is sure she is going to fail, and does not want to take the test.

1) Miss Mills is at home when a man knocks on her door. He introduces himself, and explains that he is a Crime Prevention officer and that there have been a number of burglaries in the area, including Mrs Brown at number 52. He says that he has been sent from the Crime Prevention office to check whether residents have enough security in their homes. When he asks whether Miss Mills has security measures such as door and window locks, she replies that she has some. He then asks if he could come in and inspect them to ensure that they meet British Safety standards and that they have been fitted correctly.

2) Stuart is working in his office when Nick comes over to him. Nick apologises for bothering him and asks whether Stuart can do him a favour and lend him £200 until the middle of the month. Stuart points out that they only got paid yesterday. Nick explains that he has been paying off an overdraft and he needs to borrow money for his rent. However, he would only need it until the middle of the month because that is when his wife gets paid. He acknowledges that there were problems when he borrowed money from Stuart last year, but says it will not happen again. He says he will pay it all back when his wife is paid and suggests that they can take Stuart out for a meal then to say thank you.

3) Bill and John are having a coffee break at work, when John asks Bill how his meeting with their boss Henry went. Bill is exasperated, and says that ever since Henry joined them things have been awful. He explains that Henry asked him to calculate some statistics for their meeting. Bill does not like figures, but worked very hard to get them ready. However, when he took them to Henry, Henry had forgotten asking for them. Bill describes Henry as incompetent and is going on to what other people think of him when he notices that Henry has walked in and is listening to their conversation. He coughs to warn John, but John does not notice and says that the statistics were Henry’s silly idea in the first place. He then notices Henry.

4) Mrs Davies is in the house when a man knocks on the door. He says good morning and explains that he has been doing some work on a roof over the road from her, and noticed that she needs some work done on her roof tiles rather urgently. She says that she has not had any leaks so far, but he replies that she is likely to have trouble later in the year unless she has some work done now. She explains that she does not know much about roofs, and he tells her that he and his colleague could do the job for her
that afternoon. He estimates that it will cost around £100, but she will have to give
him £50 now in order for him to go and buy the necessary materials.

5) Miss Rutherford has gone to a shop to purchase a computer and the salesman
recommends one in particular, which is very light to carry, and suitable for all her
needs. She says that it is exactly what she is looking for and that she will take it. At the
till, she hands the salesman her credit card, which he runs through the machine.
However, he then tells her that there is a problem and that the card has not been
authorised.

6) Anne is in her office when Tony comes in. She asks how he is, and he says he is okay,
but tired. She agrees that he looks tired, and asks what is the matter. He has new
neighbours who moved into the flat above his a couple of weeks ago. They are nice
people, but they own dogs and keep them in their kitchen at night, which is directly
above Tony's bedroom. All night, and every night since they moved in, the dogs jump
around and bark. He finds it impossible to get to sleep. He says he has had a word
with the neighbours, and although they were very reasonable, they said they had
nowhere else to put the dogs, as it is a block of flats.

7) George is reading when Richard comes into his office. Richard asks George if he is
going to the Liverpool match tomorrow. George explains that he wanted to, but that
the tickets sold out two weeks ago, and he could not get one. Richard tells George that
he had arranged to go with a friend who has let him down, and that he has a spare
ticket if George is interested. George says, enthusiastically, that he is, but then
remembers that he has promised to help Pete, a mutual friend, move house, and that
Pete needs to use his van.

8) Hilda and Dennis, a middle-aged couple, are packed and ready to leave their hotel, but
they cannot find Hilda’s purse or their chequebooks. The purse contained their money
and credit cards. They are checking all their bags, but Hilda is sure that all the items
were in her handbag. They try to remember when they last paid for something, and
recall the cup of coffee they had earlier. Hilda put the bag down next to her after
paying and Dennis says that the items must have been stolen then. Hilda asks how
they are going to pay to get home and Dennis points out that they cannot pay the hotel
either - they have no cards, cash or chequebook.

Set B

Practice:
Louisa and her friend are walking back to Louisa’s car after a meeting. Louisa’s friend
has to use crutches at the moment, and she thanks Louisa for driving her to the
meeting, as she could not have made it otherwise. When they reach the car, Louisa
reaches in her pocket for her keys, but they are not there. She searches her bag, and her
friend points out that the meter is ticking away, but the keys are not in her bag either.
She appears to have lost them.

1) Miss Adams is in the house when a man knocks on the door. He says good morning
and explains that he is from the gasboard and has come to check her house for leaks.
She asks why he thinks there might be a leak, and he says that a number of problems
have been reported in her area. Miss Adams tells him that none of her neighbours have
said anything to her, and he tells her that it is better to be on the safe side. She says that she has not smelt any gas, but he replies that you cannot always smell it, although it can still be very dangerous. He asks if he could come in and check.

2) Neville has gone to the pub at lunchtime for a drink with some of his friends. They ask him why he is not drinking alcohol, and he replies that he cannot because he is on a course of antibiotics. They tell him that he will have to have a drink when Guy gets back, to celebrate Guy's new job after being unemployed for a year. Guy arrives at the table carrying champagne glasses. He has ordered champagne for all of them. All of Neville's friends try to persuade him that he should drink a glass.

3) Ms Wood is working in her office when there is a knock at the door. When she sees that it is an employee, Tony, she tells him to come in and sit down. She asks what he anted to see her about and he says, hesitantly, that it is a little awkward, but he wants to talk about the new employee, George. He feels that George is not pulling his weight. Ms Wood is surprised, because she has been getting on well with George. She asks Tony to explain what he means. Tony replies that George works hard when Ms Wood is around, but when she is not there he does not seem to pull his weight at all. Ms Wood again shows surprise – Tony has been working there a long time, and she trusts his judgement, but she repeats that she has been getting on very well with George. Tony has presented her with a problem.

4) Daniel is having a drink in a pub when a man asks if he can join him. After a brief discussion about the weather, the man asks what Daniel does. Daniel explains that he is a breakfast chef, and has just finished his shift. The man says that he is in the wholesale business and has just bought some bankrupt stock. He tells Daniel that it consists of some video recorders, which he does not usually deal in. He asks Daniel if he owns a video recorder, to which Daniel says no. The man says they could both do each other a favour, as he could let Daniel have one for £150.

5) It is Clare’s birthday, and she has taken some of her friends out to a restaurant to celebrate. While the food is arriving, her friends thank her for buying the meal, and drink a birthday toast to her. However, when one of them, Sally, starts eating her food, she grimaces and whispers to one of the others that she cannot eat it.

6) Rita and John are gardening. Rita calls John over to look at some forget-me-nots, and mentions that the lawn needs cutting. John replies that he knows, and that he wants to cut it, but he cannot, because they do not have a lawnmower at the moment. Rita remembers that their neighbour Derek has borrowed the lawnmower and still has not returned it. As she says to John, they have asked for it back twice already, and now it is getting embarrassing.

7) Rachel lives in the USA, but has come to stay in England with her aunt, who is pleased to see her. They are sitting drinking tea and eating biscuits, when her aunt starts making comments about Rachel's weight, saying that Rachel has put on weight since they last saw each other, and that she looks like her mother did at her age. She asks if Rachel has thought of joining a fitness club, and, when she says no, suggests that she join one while she is in England. Her aunt goes on to say that American boys like "chubby, nicely-rounded girls".
8) Judy is reading a magazine during her coffee break when Sue joins her. Sue appears to be slightly down and Judy asks her what is wrong. She tells Judy that she took out a car loan with her bank some months ago, because she needed a car to get to work, but she has not met any of the repayments for months. That morning she received a nasty letter from the bank, and now she doesn’t know what to do.
APPENDIX B: Questions asked for each Predicament

- What happened in the situation?

- How awkward a situation is it for (main character) out of 100%?

- How awkward a situation would it be if you were in (main character’s) position out of 100%?

- What could (main character) do in this situation? Suggest as many ideas as you can [2 mins]

- What is the best thing (main character) could do? [1 minute]

- How satisfied are you with your solution out of 100%?

- How many people out of 100 would be satisfied with your solution?

- If you were in (main character’s) situation, what would you do? [1 minute]

- How satisfied are you with your solution out of 100%?

- How many people out of 100 would be satisfied with your solution?
APPENDIX C: STORY VERSIONS OF THE EIGHT PREDICAMENTS

1) Rita and John are gardening. Rita calls John over to look at some forget-me-nots, and mentions that the lawn needs cutting. John replies that he knows, and that he wants to cut it, but he cannot, because they do not have a lawnmower at the moment. Rita remembers that their neighbour Derek has borrowed the lawnmower and still has not returned it. As she says to John, they have asked for it back twice already, and now it is getting embarrassing.

2) Daniel is having a drink in a pub when a man asks if he can join him. After a brief discussion about the weather, the man asks what Daniel does. Daniel explains that he is a breakfast chef, and has just finished his shift. The man says that he is in the wholesale business and has just bought some bankrupt stock. He tells Daniel that it consists of some video recorders, which he does not usually deal in. He asks Daniel if he owns a video recorder, to which Daniel says no. The man says they could both do each other a favour, as he could let Daniel have one for £150.

3) Bill and John are having a coffee break at work, when John asks Bill how his meeting with their boss Henry went. Bill is exasperated, and says that ever since Henry joined them things have been awful. He explains that Henry asked him to calculate some statistics for their meeting. Bill does not like figures, but worked very hard to get them ready. However, when he took them to Henry, Henry had forgotten asking for them. Bill describes Henry as incompetent and is going on to what other people think of him when he notices that Henry has walked in and is listening to their conversation. He coughs to warn John, but John does not notice and says that the statistics were Henry's silly idea in the first place. He then notices Henry.

4) Anne is in her office when Tony comes in. She asks how he is, and he says he is okay, but tired. She agrees that he looks tired, and asks what is the matter. He has new neighbours who moved into the flat above his a couple of weeks ago. They are nice people, but they own dogs and keep them in their kitchen at night, which is directly above Tony's bedroom. All night, and every night since they moved in, the dogs jump around and bark. He finds it impossible to get to sleep. He says he has had a word with the neighbours, and although they were very reasonable, they said they had nowhere else to put the dogs as it is a block of flats.

5) Rachel lives in the USA, but has come to stay in England with her aunt, who is pleased to see her. They are sitting drinking tea and eating biscuits, when her aunt starts making comments about Rachel's weight, saying that Rachel has put on weight since they last saw each other, and that she looks like her mother did at her age. She asks if Rachel has thought of joining a fitness club, and, when she says no, suggests that she join one while she is in England. Her aunt goes on to say that American boys like "chubby, nicely-rounded girls".
6) Mrs Davies is in the house when a man knocks on the door. He says good morning and explains that he has been doing some work on a roof over the road from her, and noticed that she needs some work done on her roof tiles rather urgently. She says that she has not had any leaks so far, but he replies that she is likely to have trouble later in the year unless she has some work done now. She explains that she does not know much about roofs, and he tells her that he and his colleague could do the job for her that afternoon. He estimates that it will cost around £100, but she will have to give him £50 now in order for him to go and buy the necessary materials.

7) Neville has gone to the pub at lunchtime for a drink with some of his friends. They ask him why he is not drinking alcohol, and he replies that he cannot because he is on a course of antibiotics. They tell him that he will have to have a drink when Guy gets back, to celebrate Guy's new job after being unemployed for a year. Guy arrives at the table carrying champagne glasses. He has ordered champagne for all of them. All of Neville's friends try to persuade him that he should drink a glass.

8) Hilda and Dennis, a middle-aged couple, are packed and ready to leave their hotel, but they cannot find Hilda's purse or their chequebooks. The purse contained their money and credit cards. They are checking all their bags, but Hilda is sure that all the items were in her handbag. They try to remember when they last paid for something, and recall the cup of coffee they had earlier. Hilda put the bag down next to her after paying and Dennis says that the items must have been stolen then. Hilda asks how they are going to pay to get home and Dennis points out that they cannot pay the hotel either - they have no cards, cash or chequebook.
Appendix D: Interpersonal and non-interpersonal Predicaments

Interpersonal Predicaments

1) Neville has gone to the pub at lunchtime for a drink with some of his friends. They ask him why he is not drinking alcohol, and he replies that he cannot because he is on a course of antibiotics. They tell him that he will have to have a drink when Guy gets back, to celebrate Guy's new job after being unemployed for a year. Guy arrives at the table carrying champagne glasses. He has ordered champagne for all of them. All of Neville's friends try to persuade him that he should drink a glass.

2) Bill and John are having a coffee break at work, when John asks Bill how his meeting with their boss Henry went. Bill is exasperated, and says that ever since Henry joined them things have been awful. He explains that Henry asked him to calculate some statistics for their meeting. Bill does not like figures, but worked very hard to get them ready. However, when he took them to Henry, Henry had forgotten asking for them. Bill describes Henry as incompetent and is going on to what other people think of him when he notices that Henry has walked in and is listening to their conversation. He coughs to warn John, but John does not notice and says that the statistics were Henry's silly idea in the first place. He then notices Henry.

3) Anne is in her office when Tony comes in. She asks how he is, and he says he is okay, but tired. She agrees that he looks tired, and asks what is the matter. He has new neighbours who moved into the flat above his a couple of weeks ago. They are nice people, but they own dogs and keep them in their kitchen at night, which is directly above Tony's bedroom. All night, and every night since they moved in, the dogs jump around and bark. He finds it impossible to get to sleep. He says he has had a word with the neighbours, and although they were very reasonable, they said they had nowhere else to put the dogs as it is a block of flats.

4) Rachel lives in the USA, but has come to stay in England with her aunt, who is pleased to see her. They are sitting drinking tea and eating biscuits, when her aunt starts making comments about Rachel's weight, saying that Rachel has put on weight since they last saw each other, and that she looks like her mother did at her age. She asks if Rachel has thought of joining a fitness club, and, when she says no, suggests that she join one while she is in England. Her aunt goes on to say that American boys like "chubby, nicely-rounded girls".

Non-interpersonal Predicaments

1) Elizabeth has recently moved into her new house. This evening, she is glad to be home as there is a severe storm. On the news she noticed a warning about severe weather conditions with risks of falling trees and major power cuts in areas around the country. Elizabeth is intending to settle down in front of the television to watch her favourite programme, "EastEnders". Yesterday's episode was particularly gripping, and she is keen to know what happens next. She gets a shepherd's pie out of the freezer and puts it in the microwave in time for the start. Then the lights suddenly go out and the microwave and television go off - there is obviously a power cut.
2) After a long day at work James is relieved to arrive home. He lives in a detached house with a small garden, which he only finished redecorating a few months ago. He has stripped and painted several rooms, and put new carpeting on all the ground floor. However, when he opens the front door he is taken aback to find that there is water all over the hallway. He goes into the kitchen and finds that water is pouring through the ceiling and down the walls.

3) Christine gets home late after a pleasant evening out at the cinema. When she gets home, she takes off her coat and shoes, looking forward to having a snack and putting her feet up before going to bed. However, when she walks into her living room she discovers that she has been burgled. Her television and video recorder are obviously missing and her possessions are strewn over the floor; some items are broken. When she goes into her kitchen she discovers a broken window and more mess.

4) Simon is always keen to pay his household bills on time. Three months ago he paid a telephone bill. However, since then, he has received a letter from the telephone company claiming that he has not paid. Simon wrote back to explain that there must have been a mistake, but has now received a letter from a debt collection agency acting on behalf of the telephone company. This letter makes no reference to Simon’s letter, but says that his credit rating may be affected and he may have to go to court if the bill remains unpaid.
APPENDIX E: Prioritisation test

I want you to imagine that it is 9am on Monday morning. You arrived back from a holiday late last night. You have important commitments all day today and a very busy week at work ahead. You have twelve minutes to sort out various things before you leave.

They are the following:

1) You have a letter asking you to confirm an appointment.

2) The battery in your alarm clock has run out.

3) Your partner has left you a note explaining that there’s a problem with the car radio (it is an Audi car), and asking you to find a phone number.

4) You have a bank statement which you have not yet checked.

5) You recently took a rail journey. You caught the 10.30 train which was one and a half hours late arriving at your destination due to a defective train in front. You have been informed that you are entitled to compensation, but have not yet filled in the form.

6) The plants need watering.

7) You have a form to fill in to renew your car tax.

8) You have no food in the house, and a friend is coming round tonight. Your neighbour has said she will get your shopping for you if you write her a list and put it through her letter box. (You can settle the bill later)

9) An electricity bill has not yet been paid.

10) You are keen to meet up soon with your friends, John and Frances Jones, who sent you a book for your birthday while you were on holiday. They are not on the telephone.

11) You would like to see a film, ‘Out of the Clouds’. You think your neighbour might tape it for you but you cannot remember what time or channel it is on.

12) You have a credit card statement, which asks for your next payment.

13) You missed your neighbour’s birthday while you were away. You have a card but have not yet written it.

Everything you need to perform these tasks is on the desk in front of you.

There is no way you will be able to complete all of these tasks within the twelve minutes, and therefore you must prioritise the items which you think are most important. You should make sure that you complete the tasks you attempt properly.
APPENDIX F: EXAMPLE OF A BILL FROM THE PRIORITISATION TASK
Electricity Bill

BRITISH ELECTRICITY

Name of participant
Address
Address
Address
Address

PLEASE IGNORE THIS LETTER IF YOU HAVE ALREADY PAID YOUR BILL.

FINAL NOTICE

Our records indicate that you have not paid your outstanding electricity bill.

If you have not paid within 7 days, we may cut off your supply. If we do this, you will have to pay extra to have it re-connected. Please contact us on the above number if you have any difficulty paying this bill.

Payment Slip

<table>
<thead>
<tr>
<th>CUSTOMER REFERENCE NUMBER</th>
<th>AMOUNT DUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>333 857 1284</td>
<td>£ 39.85</td>
</tr>
</tbody>
</table>

Signature ____________________________ Date ____________
Cash ____________ Cheques ____________
Total ____________

Please do not write or mark below this line or fold this payment slip

QTF48960302-58” +958305730209493 SSE93950–333*
APPENDIX G: EXAMPLE OF A BLANK CHEQUE FROM THE PRIORITISATION TASK

<table>
<thead>
<tr>
<th>DATE</th>
<th>PAYEE</th>
<th>PRIOR BALANCE</th>
<th>AMOUNT</th>
</tr>
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<tbody>
<tr>
<td>100208</td>
<td>12 Bookstreet Ave, LONDON K2P 1SR</td>
<td>£</td>
<td>£</td>
</tr>
</tbody>
</table>

100208* - 531202* - *8773105

Name of participant