Facilitating word retrieval in people with aphasia: an exploration of the relationship between language and neuropsychological processing

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Declaration

I, Jennifer Grassly confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signed:______________________________

Acknowledgements

‘Speak your truth quietly and clearly; and listen to others...’

Desiderata, Max Ehrmann, 1927

My Great Uncle Bill provided my first experience of meeting someone with aphasia. Our previous get-togethers were characterised by his taking centre stage and sharing anecdotes about adventures to countries far and wide, or escapades experienced as one of the first members of the Youth Hostel Association. But after his stroke our meetings were different, he was no longer able to regale us with his tales, but instead sat quietly, frustrated. His frustration was one that I have since listened to many others share: frustration at being unable to get the words out.

My subsequent interest in anomia therapy research was supported early on in my clinical career by my manager, Jenny Sugden, and my colleague, Ali Greenwood. With their encouragement I was able to participate in a collaborative research project early in my career, and subsequently apply for post-graduate research.

Wendy Best has been huge source of support, encouragement, enthusiasm and knowledge throughout my involvement in the collaborative research project, and for the duration of my PhD. I am very thankful to her for this and for her friendship. Caroline Newton has shown endless patience with my questions and has provided invaluable feedback for numerous drafts. Her constant encouragement and positivity has been a source of strength and I am very grateful to her for all her support.

The participants in the study were, without fail, happy partners in the research sessions. I am humbled by their faith in me to produce something of value from their hours of dedicated input and will be forever grateful for their huge contribution to this thesis.

The process of submitting a PhD thesis is not one that can be confined to set hours. The submission of this thesis has been achieved with the constant support, encouragement, child care and sustenance provided by my family and friends, especially my Mum and Dad.

Finally, I would like to thank Kyle, Isabella, Max and Millie. Max and Millie have been the perfect walking companions when I’ve needed some thinking time. Isabella, who joined us mid-way through this journey, has been a great source of inspiration, fun and grounding. Without Kyle, I would not be able to submit this thesis. His constant positive energy, love, support, encouragement and patience is not done justice in the words on these pages.

Abstract

Background: The challenge of understanding word retrieval is one that has long been the subject of investigation in aphasia therapy research, and has been confounded by the finding that people with similar patterns of language impairment can respond in different ways to the same therapy approach. Consideration has now turned to factors other than just language processes when planning intervention, including extra-linguistic cognitive processes, and the provision, and type, of feedback given.

Aims: To investigate the language and neuropsychological processing abilities of people with aphasia, and to examine how these abilities relate to response to facilitation and feedback.

Methods & Procedures: Eight adults with aphasia, aged between 25 and 81, participated in a case series design. A novel battery of language and neuropsychological assessments was administered. Five facilitation studies were carried out, in which the effect on word retrieval at a later point in time was investigated for different linguistic cues and use of feedback.

Outcomes & Results: The differences in participants' profiles enabled significant theoretically-motivated correlations to be identified between several aspects of processing within the areas under investigation: language, facilitation, neuropsychology and feedback.

Conclusions & Implications: Assessments of memory and attention show potential for use within a wider battery administered by clinicians. Measures of executive function were less straightforward, due in part to its multifaceted nature; assessments of this domain should therefore be considered on an individual basis with regards to the underlying processes measured. Language skills alone are not able to predict response to facilitation. Facilitation was found to be a robust and valid tool and it is suggested that it may be used as a reliable probe tool to identify appropriate therapy techniques. Clinician-delivered feedback can improve word retrieval for responses that were initially incorrect; promoting self-feedback following correct responses can result in superior delayed naming.

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1: Introduction

Luria (1973, page 15) 'Progress must be based on real facts, on the achievement of real knowledge....such progress will naturally require time, and the ultimate goal will be reached by stages, each one making its own contribution to the solution'.

For clinicians working with people with aphasia, one of the most important roles early in the therapy process is collaborating with clients to make decisions about the goals of therapy. From clinical experience, the goal that is most commonly identified by clients is to improve word finding ability. This is reflected by Nickels (2002, page 4) who commented that 'part of the approach to understanding the impact of aphasia on an individual's life is understanding word retrieval'.

The challenge of understanding word retrieval is one that has long been the subject of investigation in the aphasia therapy research literature. There is a large body of research promoting different therapies for particular patterns of language impairment, but people with similar patterns of language impairment can respond in different ways to the same therapy technique. This has led authors to suggest that clinicians need to consider factors other than just language processes when planning intervention. Martin and Reilly (2012, page 254) summarised the current position: 'research addressing the relations between language and other cognitive processes is integral for advancing our understanding of the dynamic nature of language impairment in aphasia and also for directly informing its treatment'.

The desire to contribute to our understanding of language impairment in aphasia led to the research reported in this thesis. Two pieces of knowledge were of particular interest: effective use of language relies on both content and processes, language representations form the content, but support processes are not necessarily linguistically based; and the clinical and empirical finding that people with aphasia frequently present with co-morbid impairments to extra-linguistic cognitive processes (Martin and Reilly, 2012).

In addition to these extra-linguistic cognitive processes, another variable which may influence response to therapy is the provision, and type, of feedback given. Within the field of speech and language therapy, clinician-client interactions have been found to be heavily influenced by feedback, both in monitoring performance and modifying therapy (Simmons-Mackie, Damico and Damico, 1999). However, to date there are relatively few examples of studies which have examined or manipulated feedback.

The method of facilitation has been used as a means to measure the impact of manipulating aspects of therapy. Facilitation was described by Howard, Paterson, Franklin, Orchard-Lisle, and Morton (1985a) as a tool to investigate the effects of different tasks on word retrieval at a later point in time. Best, Herbert, Hickin, Osbourne and Howard (2002) reported that facilitation is useful, not only in improving long term word retrieval, but also as a simple probe tool to predict optimal therapy approaches. The relatively quick administration of facilitation enables investigation of the effect of a number of different types of cues on word retrieval at a delay, and variations in response can be analysed alongside underlying language and neuropsychological processing.

Therefore, the aims of the thesis are as follows:

- To identify a group of neuropsychological assessments, from a larger battery, that can be administered to people with aphasia, without language impairment confounding the interpretation of results
- To establish whether people with aphasia show similar patterns of neuropsychological processing, for example is executive function universally affected in people with aphasia cf Helm-Estabrooks (2002)?
- To investigate the relationship between underlying language and neuropsychological processing and response to facilitation
- To investigate the effectiveness of different cues on naming at a delay following facilitation
- To establish the reliability of facilitation as a probe tool
- To manipulate feedback and analyse its effect on delayed word retrieval.

The first part of the thesis contains a review of the literature in three key areas: facilitation and cueing therapy for word finding difficulties; feedback in aphasia therapy and neuropsychological assessment and therapy for people with aphasia. Based on the outcomes of the literature reviews, the methodology adopted in the current thesis is outlined.

Eight participants with aphasia are described, along with a detailed account of their language and neuropsychological processing as measured by the battery of assessments compiled for this thesis. Specific relationships between language processing, neuropsychological processing, facilitation and feedback are analysed and discussed with reference to implications for clinical practice.

2: Background

2.1: Cueing Therapy for Word Finding Difficulties

2.1.1: Introduction

2.1.1.i: Cognitive Neuropsychology

Cognitive neuropsychology first emerged as a discipline in the 1970s (Whitworth, Webster and Howard, 2005). Good cognitive neuropsychology has been described as paying 'real attention to providing accounts that address how individual people with brain lesions behave...' (Whitworth et al, 2005, page 3).

Within this discipline Patterson and Shewell (1987) proposed a model of language processing, which was an adaptation of an earlier logogen model. Whilst this model is underspecified with regard to the processing that occurs within the boxes, it provides a helpful framework within which to consider language processing and a level of description that can guide both assessment and analysis of performance. Figure 1 shows a model based on Patterson and Shewell (1987), taken from Nickels (2000).

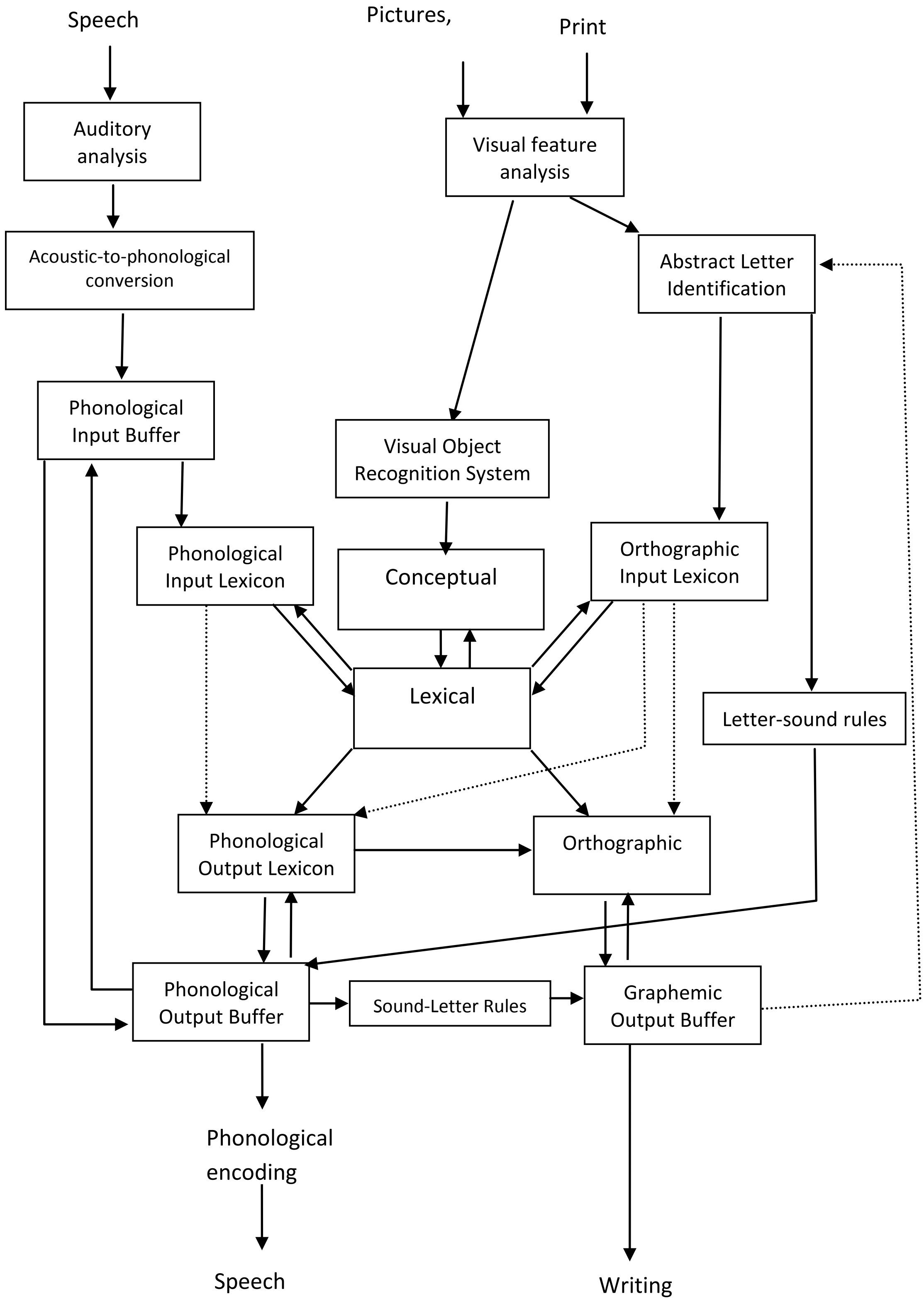
Whilst it is not within the scope of this thesis to discuss alternate hypotheses to this basic framework, it is acknowledged that there is an ongoing debate around the existence of the connections between certain aspects of processing, the use, and quantity, of bi-directional arrows to represent two way processing and the terminology used. However, this basic model is considered to provide sufficient information upon which to base thinking about language processing within both aphasia and normal language processing.

Patterns of spoken word processing, from semantics to phonological output, have been described in more detail by many authors (for example, Foygel and Dell, 2000; Levelt, Roelofs and Meyer, 1999; Rapp and Goldrick, 2000). The aim of these authors has been to provide more detailed accounts of the representations and processes involved in the task of spoken word production.

In 1985, Ellis reviewed the cognitive neuropsychological approach to spoken word production using a two-stage framework with three major representational components: the conceptual semantic system; the speech output lexicon; and the phoneme level. These concepts represent the process of translation from the concept through to a set of phonemes, via mediation of the lexical form. This basic two-stage model is still the foundation of most research and practice in spoken word production. However, features including the basic architecture, the internal organisation of the spoken lexicon and activation dynamics are still debated. Whilst these are not considered in detail here, it is worth noting the progress that has been made since Ellis' basic two-stage framework.

With regards to the basic architecture, it is now widely considered to be the case that word meanings and word forms have distinct representations, as it has been demonstrated that people with aphasia can make semantic errors in naming, but have intact comprehension and make no semantic errors in written naming (for example Nickels, 1992; Miceli and Capasso, 1997). This is reflected in Figure 1, with a separate representation for lexical semantics and phonological output lexicon.

Figure 1: A sketch of the cognitive processes involved in the comprehension and production of single words (from Nickels, 2000).



With regards to activation dynamics, the role of feedback and cascading activation has been examined, with two distinct positions: the discrete view as supported by Levelt et al. (1999) and the interactive view as supported by Dell, Schwartz, Martin, Saffron and Gagnon (1997). The discrete view proposes that all processing occurs in a feed forward direction only, with processing at any one stage only occurring once one item has been selected at the previous stage and its' activation sent on. Competing lexical units are not allowed to pass on their activation to subsequent levels. By contrast, the interactive view proposes a forward and backward flow of activation, with competitors allowed to pass on their activation. Processing at all levels continues until the most active phoneme units have been selected.

In 2000, Rapp and Goldrick carried out a series of computer simulation studies in which they modelled architectures ranging from highly discrete to highly interactive. Of all the architectures, they found their 'Restricted Interactivity Account' (RIA) was best able to account for critical patterns of data from both people with aphasia and people with no language impairment. The RIA allows both feedback and cascading activation, but feedback is limited from the phonological to the lexical level, with no such feedback occurring from the lexical level back up to lexical semantics. The RIA account is represented in Figure 1, with single directional arrows showing activation in a feed forward direction only from lexical semantics to the phonological output lexicon, but bidirectional arrows showing both feed forward and feedback activation that can occur between the phonological output lexicon and the phonological output buffer.

The representations and processes outlined in Figure 1 are referred to throughout this thesis for analysis of individuals' assessment data and response to intervention.

2.1.1.ii: Therapy for impaired spoken word production

As Best, Howard, Bruce and Gatehouse (1997, page 106) noted, 'treatments can broadly be divided into those focusing on meaning and others focusing on form'. For many years 'meaning' (semantic) tasks were thought to be more effective than 'form' (phonological) tasks in improving word retrieval. However, since the 1990s phonological tasks have been widely argued to be the most appropriate therapy for impairments in retrieval of (or damage to) the phonological form from the phonological output lexicon (e.g. Hillis and Caramazza, 1994; Miceli, Amitrano, Capasso and Caramazza, 1996; Nettleton and Lesser, 1991). The body of research devoted to word retrieval impairments is vast and in 2002 Nickels carried out a comprehensive review of the literature devoted to treatment, summarising papers published between 1980 and 2002. Nickels' review presents single case studies and covers both semantic and phonological approaches to therapy. Themes in the literature were identified, including the differences in approach (strategic and facilitative/repair), the contrast between semantic and phonological tasks in therapy, generalisation, and the relationship between impairment, therapy task and outcome. Nickels concluded that effectiveness of therapy for word retrieval and production disorders has been clearly demonstrated though we are still unable to predict which therapy will work for which impairment.

The following is a review only of those studies which have focused on form, primarily in phonological form, but with some consideration to studies using the orthographic form where appropriate. The review aims to summarise the research studies that have used cueing techniques to improve word retrieval. Primarily phonological cueing studies are reviewed, but semantic and orthographic cueing studies are discussed if there is overlap or correlation to phonological cueing. As this is now an extensive area of research, the review is necessarily restricted. Papers are only considered if they have single word spoken naming as the primary task, or outcome measure; have a design that allows comparison between treated and untreated items; and have a single clearly defined treatment task (cf. Nickels, 2002). The first group of studies reported here focus on facilitation, in which a cue is delivered only once, and its effect is examined in another task at a later point. The review then considers therapy studies, in which cues are generally applied several times over days, weeks or months. General themes can be seen to emerge within this set of studies including: phonological versus semantic cues, orthographic versus phonological cueing, the application of errorless learning techniques, carry over to connected speech and factors that predict response to therapy. Whilst there is overlap within each of these fields, where possible the review considers papers within these broad themes.

2.1.2: Facilitation

Howard, Paterson, Franklin, Orchard-Lisle, and Morton (1985a) conducted what has become an influential study of four facilitation trials, using different tasks to determine which improved word retrieval at a later point in time. Howard et al. studied the differences between semantic (spoken and written word to picture matching and judgements) and phonological tasks (repetition, rhyme judgements, cueing with a word that rhymes). Results indicated that both tasks had positive effects on immediate naming, but the effect of the phonological tasks did not last beyond a few minutes. In contrast the effects of the semantic tasks were found to last at least 24 hours, and were therefore recommended as the preferred therapy approach.

However, a similar study carried out by Barry and McHattie (1991) found not only significant facilitation of naming 20 minutes later from single applications of tasks requiring semantic processing, but also a small, significant effect from phonological (repetition) tasks. This finding has been criticised however by Best, Herbert, Hickin, Osbourne and Howard (2002) since analysis of the procedure revealed that semantic judgements were presented in mixed blocks with repetition, which may have led to interacting effects.

Best, Herbert, Hickin, Osbourne and Howard (2002) carried out a facilitation study to identify whether depth of processing can account for differences in effectiveness of facilitation with phonological and semantic tasks. They set out to replicate the findings of Howard *et al.* (1985a) in showing that phonological facilitation tasks produce short term effects only, while comparing this with the effect of offering a *choice* of phonological cue. Using a case series design with 11 participants with aphasia, Best et al. found that in using repetition, CV cues and rhyme (VC) cues, a positive effect on immediate naming was elicited as predicted, but in contrast to Howard et al. they also found a significant effect on naming at a delay of at least 10 minutes. Furthermore, Best *et al.* (2002) reported improved word retrieval for both a single phonological cue *and* a choice of cues. In hypothesising why differences were found between their findings and those of Howard *et al.* (1985a), Best et al. suggested that the presence of a picture supports semantic processing to a greater degree than repetition of the word form in isolation. They then extended the facilitation study with a therapy study employing phonological and orthographic cueing, discussed in more detail later. One particularly encouraging finding was that facilitation may be useful not only in improving long-term word retrieval, but also as a simple probe tool to predict which clients may benefit from a similar cueing approach to therapy.

Subsequently, Crofts, Nickels, Makin, Taylor and Moses (2004) have tried to isolate the interacting influences by comparing the effects of semantic tasks without the word form, with phonological tasks, both within and across individuals. Ten participants took part, all of whom produced semantic errors, with the majority also producing phonological errors. Stimuli were three sets of 30 items matched for frequency and length. One set was facilitated using a phonological task (repetition in the presence of a picture), a second set was facilitated with a semantic task (feature verification without the word form), and the third set was un-facilitated control items. Items were presented for immediate naming and again for naming after a delay of 10 minutes. For the group as a whole both semantic and phonological facilitation tasks significantly improved delayed naming. On an individual level the majority of participants showed a numerical benefit for the phonological condition over the control condition, but only one reached significance. Only one participant showed a significant benefit from semantic facilitation. Hence the outcomes mirror those of Best *et al.*(2002) with both finding that semantic and phonological tasks used in facilitation can produce benefits on subsequent naming, even when the word form is not provided.

In an examination of phonological and orthographic cueing, Lorenz and Nickels (2007) carried out a facilitation study with three people with chronic aphasia, in which participants were given either the initial letter or the initial phoneme of the target word. In a change of design to other facilitation studies, the immediate and delayed effects were assessed over six facilitation sessions. Stimuli were controlled for regularity of orthographic-phonologic conversion (OPC) of the target's initial letter, so that items were either regular (e.g. DOLL), ambiguous (e.g. KING) or irregular (e.g. KNIFE). All three participants underwent a battery of assessments in order to determine language processing abilities in detail, with particular attention to auditory discrimination of single phonemes and words (repetition of words and non-words), visual processing (reading words and non-words), semantic processing and naming of pictures. All participants were found to have a mild impairment of semantic processing, with anomia likely to be resulting from a primarily post semantic deficit in accessing lexical entries for production. Results indicated that two of the participants benefited from the initial letter but showed no effects of the initial phoneme on spoken naming accuracy. Uncued control pictures remained stable for both of these participants. The other participant, MCB, benefited from both letter and phoneme cues, though the benefit of phoneme cues was not transparent during the initial sessions. In contrast to the other participants, MCB was found not to show an imageability effect in word repetition and it was hypothesised that phonological cues may have been effective for this participant by a direct lexical route from phonological input to phonological output, rather than via the lexical-semantic route. Furthermore, it was found that regularity of OPC did not influence effectiveness of initial letter cues. The authors conclude that initial letter cues are effective in treating word retrieval problems and that they may be beneficial even in participants who are unable to benefit from phoneme cues. In relating facilitation response to underlying impairment, Lorenz and Nickels hypothesise various mechanisms as being responsible for benefit of initial letter cues. As all the participants showed some impairment in sounding out single letters and reading non-words, Lorenz and Nickels hypothesised that a lexical mechanism may account for their findings in addition to a previously hypothesised sub-lexical semantic mechanism (Best et al., 2002).

To date the results from facilitation studies have been mixed. The reason for these differing outcomes may relate to the differences in the study designs and the types of phonological cues utilised. The design employed by Best et al., may have encouraged a lexical processing route to be used due to the provision of a picture along with the phonological form. Other studies may have promoted a sub-lexical processing route through the lack of pictorial support (Howard et al., 1985a) and minimal phonological information (Lorenz and Nickels, 2007).

Facilitation studies are not yet robust enough in their methodology to produce reliable outcomes enabling predictions about which pattern of underlying impairment will respond to which type of cue. However, they have proved beneficial to word retrieval, both at the time of application and at a delay, and as a potential probe tool to help identify appropriate therapy approaches for people with word finding difficulties.

2.1.3: Cueing therapy studies

The use of cues as a therapy technique for people with aphasia has long been the subject of investigation (see Berman and Peele, 1967; Marshall, 1976; Webb and Love, 1977). The type, hierarchy and intensity of delivery of cues have all been manipulated in different studies leading to equivocal results, as detailed below.

Linebaugh, Shisler and Lehner (2005) reviewed their earlier work (Linebaugh, Shisler and Lehner, 1977) in which they designed a study to develop a new treatment approach in which cues of increasing power were presented sequentially, contingent upon participant responses. Working with five participants with aphasia a mixed semantic-phonological cueing hierarchy was applied, with 10 levels, in which increasingly powerful cues were provided until the correct response was elicited. Upon elicitation of the correct response the hierarchy was reversed, under the hypothesis that repeated elicitation of the correct response with less powerful cues would optimally stimulate the processes underlying word retrieval. If an error was made on reversal of the cueing hierarchy, the hierarchy was once again reversed providing increasingly powerful cues until the correct response was elicited, at which point the hierarchy was again reversed. In order to differentiate the task from repetition, participants were encouraged not to respond until the complete cue had been provided at each level of the hierarchy. Levels 1 to 6 of the cueing hierarchy were all semantic in nature, with phonological cues being introduced in sentence completion tasks for levels 7 to 9, and the final level being repetition of the target word. Treatment stimuli were 10 words, 5 high frequency and 5 low frequency. A further set of 20 words (10 high frequency and 10 low frequency) were presented every 5 sessions with a one way cueing hierarchy to assess for generalisation. Treatment was terminated when a predetermined criterion was met, which was achieved by each participant in 15-25 sessions.

Results show improvement on naming performance of the treated stimuli for four of the five participants. Three of these participants also showed improved naming of words tested for generalisation, with two of these three showing greater improvement on the generalisation word list than on the treated stimuli. The authors report anecdotally that some participants were observed to 'self-cue' using one of the levels of the cueing hierarchy.

Linebaugh et al. (2005) acknowledge significant design flaws in their study. Of note, the authors make reference to their use of a one-way cueing hierarchy, which is likely to have affected naming performance of the 'untreated' items. As two of the participants showed greater improvement on the generalisation items than on treated items, it may be that the one way cueing hierarchy is more effective for some people. Additionally such small numbers of treatment stimuli, which lack statistical analysis, limit the scope of the conclusions. However this paper provided some early evidence of the beneficial effects of cues on naming performance for people with aphasia.

Thompson, Kearns and Edmonds (1981) published a single case study examining the effects of a cueing hierarchy on acquisition, generalisation and maintenance of naming behaviour in a 64 year old patient with anomic aphasia, 4 years post onset. Stimuli were 40 pictures of monosyllabic and bisyllabic nouns matched for frequency, and divided into 4 word lists of 10 words each. Baseline naming assessment was carried out four times prior to therapy. Therapy continued for a maximum of twenty sessions or until a 90% success criterion had been met. The cueing hierarchy used combined semantic and phonological cues, and consisted of:

1. a sentence completion cue
2. a sentence completion cue plus a phonetic cue
3. a sentence completion cue plus a verbal model.

The first cue in the hierarchy was provided alongside presentation of the visual stimulus. The participant was then given 10 seconds in which to respond, if a correct response was not elicited then the next cue in the hierarchy was given, and this was repeated until the final cue had been given. The participant attended therapy 2-3 times per week until a 90% criterion had been reached or until twenty treatment sessions had been completed.

Analysis of the results revealed a positive effect of cueing on acquisition of words, but no generalisation to either semantically related or unrelated words. However, naming performance on trained words was found to be maintained at a level superior to baseline throughout the maintenance period.

While this paper suggests the use of cueing hierarchies was effective for this individual with aphasia, we are unable to draw any firm conclusions about phonological therapy due to the small number of therapy items, the lack of statistical analysis, and the inability to identify whether the effect came from the semantic or phonological cues.

Following their facilitation study, Howard et al. (1985b) studied the effects of using the same facilitation tasks as therapy, by exposing participants to a single technique applied repeatedly over a period of time. Twelve people with aphasia participated, all at least six months post onset, all able to repeat single words and all with specific word-finding problems. Items were selected for treatment on the basis of being difficult to name for each individual, the criteria for which was failure to name on at least one of the two pre-test naming exposures. The test stimuli were assigned to one of five conditions: semantic therapy, semantic naming control, phonological therapy, phonological control and baseline control. Half the participants received semantic therapy first (spoken word to picture matching, written word to picture matching, answering yes/no questions) and the other half phonological therapy first (repetition without a picture, spoken word production with picture and aid of phonemic cue, rhyming judgement). Results of therapy were assessed using a pre-test before the start of each therapy session, and post-tests on the complete set of pictures at one week and six weeks after the end of each type of therapy.

In contrast to their facilitation study the daily pre-test showed a significant advantage for treated items over naming controls for both semantic and phonological therapy, and that significant improvement occurred as more treatments were given. At one week post-therapy there remained a significant treatment effect for both semantic and phonologically treated items. In considering generalisation, word retrieval for semantic naming controls was found to be significantly better than for the semantic (unnamed) controls and the phonological named controls. Hence generalisation resulted from semantic therapy to those items that had been named or attempted to name during the semantic therapy, but no similar generalisation effect was observed from phonological therapy. However, at six weeks post therapy this difference disappeared and there were no statistically significant differences between the control and treated items. Howard *et al.* suggest that this may be a result of limited therapy intervention.

In a review of this work, Howard (2000) proposed that the critical feature of therapy is that both the semantics and the phonological form of a target word are activated, with simultaneous activation strengthening the mapping between the two. Howard proposed that the differences between the semantic and phonological therapy used in Howard et al. (1985b) may have been overstated as both tasks involved presentation of a picture, giving rise to semantic processing, and the word form, activating phonological processing. The resulting activation of both semantics and phonology may account for the lack of differences seen between the two therapies both during and after therapy.

Using a model driven approach, Raymer, Thompson, Jacobs and Le Grand (1993) designed a multiple baseline study with four participants. The cognitive-neuropsychological model was used to describe each participant's locus of impairment and their corresponding response to treatment. All participants presented with a severe naming impairment, which was hypothesised to arise from lexical-semantic information failing to access phonological representations. Therefore treatment was aimed at improving access from semantics to phonology by targeting the phonological representation. Stimuli consisted of 2 sets of 30 items, each set containing 10 target training words, 10 rhyming words and 10 semantically related words. During treatment participants were required to name a picture and if unable to name the target, a cueing hierarchy was applied as follows: presentation of a word that rhymes with the target, an initial phoneme cue, and an auditory model. The hierarchy was stopped once the correct response had been elicited and the participant was instructed to repeat the word five times. Each target item was treated 2 or 3 times per session and treatment continued until an 80% criterion was reached for 2 consecutive sessions or until 15 training sessions were completed. All four participants' naming improved on treated items, however none of the participants reached criterion within 15 sessions. Two of the four participants appeared to show generalisation through improved oral naming of related word sets.

Whilst this study demonstrates that therapy targeting phonological representations can be effective, the applicability to clinical practice may be limited by the disappointing finding that none of the participants reached criterion within fifteen sessions, despite small treatment sets. However, having some evidence to suggest that oral reading may be predictive of success with this therapy approach is helpful for clinicians to consider when determining the most effective therapy schedule for people with word finding difficulties.

Miceli, Amitrano, Capasso and Caramazza (1996) adopted the same methodological approach in matching therapy to hypothesised loci of impairment. Two therapies for word-finding difficulties were administered to two clients, RBO and GMA, both of whom were hypothesised to have selective damage to the phonological output lexicon. Only therapy for GMA is discussed here as this was the only one to include a cueing approach. Therapy stimuli were a set of words GMA demonstrated comprehension of, but was unable to name. Treatment was given in three sets, each involving hourly sessions over seven days. The three treatments were as follows:

1. reading aloud with the picture present
2. reading aloud without the picture present
3. naming pictures with progressive phonological cues provided if unable to name.

All three treatments resulted in item-specific improvement whilst performance on a fourth set of untreated words remained stable. Miceli et al. found that the first and third treatments in which the picture was present improved naming performance faster, but all three were effective, and maintenance was demonstrated for at least 17 months.

This provides some support for Howard's (2000) hypothesis that for therapy to be most effective, both semantic and phonological representations need to be activated. Provision of a picture along with the phonological form ensures that this occurs. Improvement and maintenance of word retrieval from a relatively short timescale of therapy is an encouraging finding for both clinicians and people with aphasia. However what is not clear from the study is whether the intensity of therapy delivery was a crucial factor in achieving success, and if so whether other modes of therapy delivery, such as computer-delivered or self-delivered, could achieve the same level of improvement.

Whilst Miceli et al.'s findings support the evidence base for phonological cues as an effective therapy for improving spoken word naming, they are not able to compare effectiveness with other therapy approaches. In order to address this issue, Wambaugh et al. examined the relative effects of phonological and semantic cueing treatments over a series of studies.

2.1.3.i: Semantic and Phonological Cueing Techniques

In the first of the series, Wambaugh, Linebaugh, Doyle, Martinez, Kalinyak-Fliszar and Spencer (2001) compared the effects of a semantic cueing treatment (SCT) with a phonologic cueing treatment (PCT). They argued that a cueing hierarchy design was beneficial as they could replicate across treatments the number of steps, the relative difficulty of steps, the opportunity for provision of feedback, the type of feedback provided, and the rate and length of exposure to the stimuli. Each step within the hierarchy aimed at increasing the semantic or phonological activation for SCT and PCT respectively. Wambaugh et al. recruited three people with aphasia, each of whom had a hypothetically different locus of breakdown: predominantly semantic, predominantly phonological and mixed semantic-phonological. Each participant received both treatments in a multiple baseline design. They found all three participants responded positively to both treatments to some degree. However, contrary to predictions that treatment would be most effective when aimed at the level of impairment, they found that the participant with the phonological level deficit appeared to demonstrate preference for SCT as he achieved higher levels of accuracy in fewer treatment sessions. Beyond the general finding that cueing can be beneficial to word retrieval, conclusions are limited by design flaws. Firstly, SCT and PCT could both be argued to actually strengthen the mapping between semantics and phonology (cf. Howard, 2000) as both treatments include a semantic element (a picture) and a lexical response. Secondly, no statistical analysis was carried out, and only a small treatment set was used, making it difficult to exclude the element of chance as accounting for the improvements in naming, and the differences between treatments. Finally, rationale for categorising the participants' locus of impairment were not clearly defined, with the participant assigned as having a phonological deficit also showing evidence of a semantic level impairment.

Having demonstrated some effectiveness of these cueing hierarchies on noun retrieval, Wambaugh, Doyle, Martinez and Kalinyak-Fliszar (2002) compared the effects of SCT with PCT on action naming. It was not assumed that these cueing hierarchies, which had previously been shown to be successful in improving object naming, would have the same effect on action naming. Three people with chronic aphasia took part, all of whom had been involved in the object naming treatment. Test stimuli were three sets of twelve items each for the first two participants (1 and 2), and three sets of six items each for the third participant (3). Two of the sets were used for treatment with the remaining set used for evaluation of generalisation. Cueing treatments were different for each participant with participant 1 receiving SCT, participant 2 PCT and participant 3 both PCT and SCT. The application of the cueing hierarchy proceeded in the same way as for Wambaugh *et al.* (2001) with provision of cues being response contingent, cues increasing in strength at each stage of the hierarchy and provided in reverse order upon elicitation of the correct response. Treatment was carried out 2-3 times per week, and ceased when at least 90% of the treatment items were named correctly or when 15 sessions had been conducted for a particular set of items. Results demonstrated improvement for participants 1 and 3 but not for participant 2. Once again conclusions are limited by the small number of treatment items, and lack of statistical analysis. The authors conclude that 'PCT and SCT may have utility in facilitating action naming for some speakers with aphasia, but that the effects of these treatments may vary across grammatical form classes'. However there is not sufficient specificity to make informed projections about who may benefit from each type of therapy. The data suggest that for participant 1, items that were exposed each session but not treated, improved almost as much as treated items, whereas those items unexposed and untreated did not change. While this would suggest a facilitating effect of exposure alone for this participant, this issue is not addressed. Finally, there are no outcomes that relate to functionality, and specifically whether there was any evidence to suggest that treated verbs were subsequently used in conjunction with nouns.

In a follow up study, Wambaugh (2003) used a single case study design with a 44 year old male fifteen months post onset, who received both SCT and PCT at the same time, in an alternating treatment design with multiple baselines. Separate lists of words were assigned to each treatment condition with an additional set of words incorporated to assess generalisation. Each list comprised twelve items. In this study, SCT and PCT began with a pre-stimulation phase in which the participant was asked to point to a picture that corresponded either with a description or a non-word rhyme (used in SCT and PCT respectively), from a choice of the target and three distractor pictures. The cueing treatments were then administered, with both SCT and PCT composed of five cues, each aiming to stimulate increasing levels of activation for the target word. Upon elicitation of the correct response the cues were applied in the reverse order. Treatment was conducted until 100% naming accuracy was achieved on at least two out of three probes, or until twenty treatment sessions were conducted. Treatment was conducted two to three times a week, with probing conducted immediately prior to the start of each treatment session. Follow-up treatment probes were conducted at two- and six-week intervals.

The results showed that both treatments improved naming, however in this study the participant displayed a superior performance for the SCT over the PCT with higher levels of naming accuracy (20% higher) and shorter duration to meet criterion. The difference in naming performance was maintained at six weeks post treatment. The participant's responses to untrained items remained relatively stable indicating no generalisation. While this study demonstrates the importance of using the correct therapy approach to optimally benefit naming for people with aphasia, there is insufficient information to enable predictions to be made about which factors are critical to evaluate when selecting therapy.

One way in which stimuli have often differed between semantic and phonological therapy, is in the use of treating words in categories of related items in semantic tasks. Where studies have looked for generalisation effects from treated stimuli to untreated phonologically related words, none have been found (Howard et al., 1985b; Best et al., 1997). Martin, Fink, Laine and Ayala (2004) aimed to further the understanding of targeting words in related contexts, that is within sets of semantic or phonological relatives, by comparing this to target words in unrelated sets. They hypothesised that items treated in related contexts may show an initial interference for naming resulting from priming of related items, followed by a facilitative effect at a delay, and that this effect would be greatest for participants with impairment in the context being treated. Working with eleven participants with aphasia, Martin et al. found an overall immediate significant decline in naming for those items primed in the semantic context, but no difference for those words treated in a phonological or unrelated context. However, one participant, EL, who had impaired phonological abilities, produced more contextual errors in the phonological context than in the unrelated context, giving some evidence to support the hypothesis that the effect of context is related to the underlying impairment. Results from naming after a short delay demonstrate that all participants showed facilitation in at least one condition, with seven showing facilitation in all conditions. One participant, DB, showed facilitative effects in the phonological condition only. The results therefore point to an immediate interference for naming items treated in a related context, but a facilitative effect at short term follow up, suggesting that targeting related words can be beneficial.

Having observed this effect, Nadine Martin's group carried out a 'modified contextual priming' technique over a longer time period (Renvall, Laine and Martin, 2007). Working with two participants with aphasia, one with a primarily semantic deficit and the other with a primarily phoneme sequencing deficit, Renvall *et al* (2007) carried out contextual priming with additional tasks. In so doing they were able to demonstrate sustained improvement in word retrieval over a longer term.

The results reported by Martin et al. provide some support for the benefit of treating words in related contexts. However, design flaws prevent the assumption that phonological therapy will be more effective if stimuli are treated in phonologically related sets. For example, many treatment sessions were required to treat a comparatively small set of items, the mechanism by which therapy works is unclear (i.e. is the benefit from the repetition priming, the related contexts, the additional tasks or an interaction between these factors?) and the relationship between the underlying impairment and response to therapy is not apparent.

2.1.3.ii: Orthographic and Phonological Cueing Techniques

Within the framework of cognitive neuropsychology, Basso, Marangolo, Piras and Galluzzi (2001) studied the effects of three different approaches to learning new words for spoken output with control participants with no language impairment. The learning methods used were those of repetition, reading aloud, and orthographic cueing. Basso et al. chose orthographic cues over phonological cues for two reasons. Firstly, they did not want potential interference from prosody that may accompany a phonological cue and secondly, since the orthographic cue stays in view the participant has longer to search for the target word. Stimuli were sixty invented words with associated pictures. It was hypothesised that the stimuli simulate participants having complete semantic information but inability to access the phonological representation. Results showed that the orthographic cueing technique required significantly fewer sessions to reach naming criteria than the other two methods. Furthermore, orthographic cueing resulted in significantly more names being recalled at a one week follow-up. Subsequently, the three techniques were applied in a study to improve spoken naming with two participants with aphasia. Results from the control group were replicated, with orthographic cueing proving significantly more efficacious than repetition or reading aloud. Basso *et al.* (2001) hypothesise that the advantageous effect of orthographic cueing is the result of participants having to be actively involved in the learning process. While the locus of the effect of this hypothesised active learning is not specified, previous explanations are referred to, citing either semantic memory or intrinsic characteristics of a generation task as being responsible. The beneficial effect of orthographic cues on spoken word output is clinically useful, but it would have been interesting to be able to compare these effects with phonological cues, and the participants' language profiles.

In 2002, Hickin, Best, Herbert, Howard and Osborne set out to investigate whether the use of phonological and orthographic cues could produce lasting effects following therapy, and whether there was a relationship between response to facilitation and response to therapy. They identified that a potentially important difference between semantic therapy techniques and phonological therapy techniques is the element of choice, in keeping with the work of Basso et al.. In semantic therapy participants are often required to select the target word from a group of spoken or written distractors, whereas phonological cues are typically provided with no active participation required from the person with aphasia. Furthermore, they questioned the limited research investigating the effectiveness of orthographic cues on naming. In order to address these issues, the authors designed a study in which participants were offered a choice of phonological cues and a choice of orthographic cues. Eight people with aphasia were recruited to a case series design study. Five assessment stages were administered, two prior to therapy, one following the first eight week phase of therapy, which focused on single word retrieval, one following the second eight week phase of therapy, which aimed to improve word retrieval in conversation tasks, and the final one, eight weeks following the conclusion of therapy. In the phonological cueing condition participants were presented with pictures to name. If unable to name the item participants were presented with the first phoneme plus schwa of the target item and the first phoneme plus schwa of an unrelated distractor. If they were still unable to name, the first syllable was provided and if that cue also had no effect, the whole word form was provided of both the target word and unrelated distractor. The same procedure was followed for orthographic condition but with cues presented in the orthographic form. The number of distractors was gradually increased across eight therapy sessions until a maximum of three distractors was provided. Following therapy it was found that seven of the eight participants showed significant improvements in naming treated items, with the effects of therapy being cumulative across the sessions. Of those seven participants none showed an advantage for either type of cue. Five of the seven participants showed item-specific effects only. With regard to the relationship between language profile and response to therapy, it was found that ability to retrieve the initial phoneme from reading non-words correlated significantly with overall therapy effect as did reading aloud words. Additionally it was found that for the group there was a significant correlation between response to facilitation and response to therapy, suggesting that facilitation could be a very useful clinical tool to use when assessing appropriateness of different therapy approaches for people with aphasia. However, two participants did not show any benefit from facilitation but did benefit from therapy leading the authors to suggest that people with more severe aphasia may need more than one session to assess the effectiveness of cues.

2.1.3.iii: Relationship to Connected Speech

In a follow-up study Best, Greenwood, Grassly and Hickin (2008) aimed to replicate the results of Hickin et al. in a clinical setting. Given the equivocal results found for orthographic and phonological cues, these were combined and the element of choice was contrasted with single cues. Furthermore, the authors set out to investigate the impact on the participants' views of their aphasia. Eight people with aphasia and their conversation partners participated in the study. All participants showed significant improvement in naming treated items following therapy thereby adding to the evidence base of the significant effects that cues can have on word retrieval for people with aphasia. With regards to participants' views, all participants reported greater ease of participation after therapy as rated by the Communication Disability Profile (Swinburn & Byng, 2006). This finding provides some evidence for anecdotal reports that improvement in impairment measures impacts on real-life communication.

Greenwood, Grassly, Hickin and Best (2010) provide a detailed account of one participant, TE, from the Best et al. (2008) study. It is interesting to include this here as not only did TE demonstrate significant improvements in word retrieval following cueing therapy, but significant improvements were also demonstrated in connected speech and aspects of conversation. For TE improvement in word retrieval was equivocal following a single cue and a choice of cues, but TE stated a preference for the single cue.

This change in conversation was confirmed by Best, Grassly, Greenwood, Herbert, Hickin and Howard (2011) who combined the results across Hickin et al. (2002) and Best et al. (2008) to analyse 13 participants with aphasia. For the group there was a significant change in naming following cueing therapy, and this was true for 11 of the 13 participants. The change was found to be gradual across the eight therapy sessions. With regards to change in conversation Best et al. found no significant change on conversation measures for the group, but found some significant changes for individuals. In particular, a significant, positive relationship was found between change in picture naming and the two variables considered to reflect this change most closely: number of nouns produced in a 5 minute conversation sample and number of nouns produced per substantive turn. It was hypothesised that the mechanism for the observed change was a subtle shift in the ease of lexical access.

This series of studies has provided important evidence to support the use of phonological and orthographic cues as a reliable therapy approach for treating word retrieval. Moreover the work shows that such impairment-based tasks can have an impact on real-life measures of conversation. Depth of processing did not seem to be an advantageous inclusion to cueing therapy with choice of cues producing equivocal results to a single cue, and furthermore phonological cues were as effective as orthographic cues for participants included in the first study.

While the remit of this review is to focus on single word naming therapies, the study by Cameron, Wambaugh, Wright and Nessler (2006) is considered as an exception, as it aimed to use the same approach as previous research by Wambaugh et al. (Wambaugh et al., 2001; Wambaugh, 2003) and extend this to connected speech. In contrast to Best et al. (2008) who treated single words and examined the effect on connected speech and conversastion, Cameron et al. treated 'information units' (an identified word, phrase or acceptable alternative from the story stimulus) with a cueing technique. Five people with aphasia participated in a multiple baseline design, and were described as having anomic aphasia (1), conduction aphasia (2) and Broca's aphasia (2). In order to test their hypothesis that semantic-phonological cueing therapy would have an effect on trained and untrained words produced in discourse tasks, they timed and counted information units in a story retelling task. Treatment was carried out two to three times per week, with sessions lasting up to an hour. Treatment continued until at least 90% of the targeted information units were correctly elicited or until ten trials were completed. Follow-up probes were conducted at three and six weeks post treatment. A cueing hierarchy was used, based on that used in their original study, commencing with minimal semantic information and progressing to semantically loaded sentences with phonological cues and ending with the word form. Provision of cues was response contingent, and following elicitation of the correct response the cueing hierarchy was reversed.

Following therapy, four out of five participants improved at retrieval of targeted information units, however there was negligible generalisation to production of overall information units. The remaining participant demonstrated minimal improvement in production of either targeted or untrained information units. The authors conclude that a combined semantic-phonologic cueing treatment may be effective for increasing production of targeted words at a discourse level for some people with aphasia. Although this study was designed to study the impact of a cueing hierarchy on connected speech, there is no reference to functional carry over. Additionally claims of this task demonstrating improvements at the level of discourse must be made with caution given elicitation of information units was stimulated by pictorial presentation. Given that the scope of the task was limited, with target information units elicited only in response to specific pictures it seems unsurprising that there was no generalisation.

2.1.3.iv: Errorless learning

In a series of studies Fillingham et al. (Fillingham, Sage and Lambon Ralph, 2005a; Fillingham, Sage and Lambon Ralph, 2005b; Fillingham, Sage and Lambon Ralph, 2006) explored a novel approach to treating anomia by employing errorless learning techniques. The principle behind using errorless learning is that errors can be self-reinforcing by strengthening an incorrect association. Therefore using errorless techniques should serve to strengthen correct associations between a target item and its corresponding phonological form. Eleven people with aphasia were recruited with varying degrees of naming severity, but all had the ability to repeat with 70% or above accuracy. Having identified that errorless learning has been demonstrated to be an effective technique for amelioration of word finding difficulties in people with severe memory impairments, Fillingham et al. (2005a) set about to see whether the effects were replicable with people with anomia resulting from aphasia. The errorless therapy condition was designed so that participants were given both the spoken and written name of a target picture and then asked to name the picture. Provision of the target word in dual modalities prior to the participants' attempt at naming aimed at minimising the number of errors produced. In the errorful condition, participants were asked to name a picture. If unable to name, a progressive phonological and orthographic cueing hierarchy was applied until successful naming was achieved. Errorless learning was first administered for five weeks, followed by a week break, after which errorful learning was administered for five weeks. Results showed that no participant performed better with errorless learning than with errorful learning, but four of the participants showed a significant long-term effect only for errorful learning and five showed a significant long-term benefit from both types of therapy. As the overall therapy effect varied across participants, correlations were carried out to identify any factors that may predict response to intervention. None of the language factors were found to correlate with therapy outcome, but evidence was found to suggest that good attention and recall memory skills may be associated with slightly better long-term naming following errorful therapy.

In a follow up study, Fillingham et al. (2005b) considered whether the absence of any difference in naming performance following errorful or errorless learning was due to the difference in feedback provided across the two therapies. It was hypothesised that while errorless learning did not have a feedback component, errorful learning has implicit feedback by the provision of progressive cues following an incorrect naming attempt. Furthermore as participants with better working memory, recall memory and attention tended to respond better to errorful therapy it was suggested that these cognitive factors are essential for providing effective monitoring and responding to feedback to aid learning. Therefore Fillingham et al. removed feedback from therapy to try and reduce the differences between errorful and errorless learning, hypothesising that errorless learning would produce greater benefits to naming than errorful therapy with feedback removed. Employing a multiple baseline, crossover design with seven people with aphasia, they found that no participant showed a significant difference in favour of errorless learning or errorful learning with feedback removed. This occurred even though in the errorless condition participants were only provided with one phoneme and no feedback was given about their response. The authors note that despite using only one phoneme, as therapy progressed this was sufficient to cue the name of the picture. However, the participants did not learn as well as overall in the first study. The removal of feedback did result in participants requesting feedback, particularly in the early sessions, reflecting perhaps expectations of a typical clinician-clinic interaction. All seven participants preferred the errorless learning condition, finding it more rewarding and less frustrating. Furthermore, in the errorless condition provision of the target word for repetition meant that participants were better able to provide their own feedback. In analysing the relationship between response to therapy and underlying language and neuropsychological profiles, previous results were replicated with immediate naming improvements being related to participants' executive skills, regardless of therapy type. Participants who responded better overall had better executive/problem solving skills and monitoring ability. No correlations were found with language skills.

In a final investigation, Fillingham et al. (2006) set out to replicate their previous findings and to examine why the second study had resulted in less successful learning overall. In order to examine further how the therapy might have been working, the number of naming attempts were examined by increasing opportunities to name to the same level as in the first study. Again it was found that participant's naming was similar following both therapy approaches: even when feedback was omitted, errorless and errorful learning produced equivocal results. The cognitive skills of monitoring ability, recall memory, and problem solving were still found to be predictors of therapy outcome, whereas language skills were not. It was found that the number of naming opportunities provided during therapy significantly affected overall naming.

This series of papers suggests that production of errors does not affect people with aphasia during therapy for naming, and furthermore that provision of feedback is not an important factor during naming therapy (see the review of feedback literature in this thesis for further discussion of this latter finding). However, errorful learning with feedback, as provided in the first study (Fillingham et al., 2005a), was not directly comparable to errorful learning without feedback. The former employed an increasing cue hierarchy with implicit feedback given by the provision of the next cue in the hierarchy if an incorrect response had been produced, whereas the latter condition only provided the initial phoneme and grapheme, with no increase in stimulation of the target item. It is not clear from the papers whether there was additional explicit feedback provided in the first study, serving to modify or maintain the target response by providing information about the accuracy of the response, for example use of 'yes' when correct and 'no' when incorrect. Whilst it is clear that this form of feedback was removed from the third study (Fillingham et al., 2006), it is not clear whether this is being contrasted to provision of purely implicit feedback or implicit plus explicit feedback from the first study. Furthermore, the role of other forms of feedback, such as covert feedback provided by facial expression and body language, is not discussed.

Using a similar principle to the errorless learning studies, Abel, Schultz, Radermacher, Willmes and Huber (2005) studied the effects of applying vanishing cues, starting with the strongest cues and continuing in a decreasing strength hierarchy. The hypothesis was that this method of cueing would comply with the errorless learning literature by working as a 'relearning' technique as opposed to cues of increasing strength which work as a 'stimulation' technique. Working with ten participants with aphasia ranging from five to fifty-nine months post onset, Abel et al. embarked on a four week therapy programme, in which sets of twenty-five items were assigned to one of four conditions: control (no training), vanishing cue, increasing cue and both-cue condition. Therapy occurred five times a week, giving a total of twenty therapy sessions, ordered in an alternating treatments design, ten sessions with increasing cues and ten sessions with vanishing cues. In each session ten different items were presented, resulting in each item being presented twice for each cueing method. The treatment methods differed in the order of the cues given but not in the content of the cues. In the vanishing cue condition, cues were presented until the participant made an error, at which point the hierarchy would be applied in the reverse order. The cues were of mixed phonological-semantic content and, starting with the strongest cue, were: repetition of the target word, first syllable, first sound, semantic closure phrase, super-ordinate and unspecific facilitation ('that is a …?').

Analysis of the group performance demonstrated significant improvements for all conditions. However, items treated in the increasing and both-cue condition led to significantly stronger training gains than in the vanishing cue condition. Analysis of single cases showed two participants did not benefit from any cue type. Of the remaining eight participants, five showed a significant training effect, with two demonstrating continual improvement over the duration of the study, and one demonstrating improvement at follow-up only. Of the five with a training effect, four benefited significantly from the increasing cue condition and/or from the both-cue condition, and one benefited only from the both-cue condition. Only one participant showed a significant training effect from the vanishing cue condition, which was in addition to a significant effect from the increasing cue condition. Significant generalisation to untreated items was found for three of the participants. Interestingly they found that participants with the most severe naming impairments benefitted more than participants with moderate naming impairment.

Therefore, in contrast to their prediction the authors did not find any participant who improved only under the vanishing cue condition. The authors conclude that production of errors during word retrieval does not seem to be a factor of concern, and therefore the vanishing cue condition is unlikely to be required. However, they hypothesise that people with aphasia who have concomitant poor monitoring may benefit from the vanishing cue method.

In exploring reasons for the different outcomes of the two cueing hierarchies Abel et al. acknowledge that there were differences in the administration of the two conditions. Firstly, the vanishing cue condition was actually a mixture of increasing and decreasing cues, therefore there may have been a higher number of cue presentations and opportunities to name in this condition. Secondly, the authors note that items treated in the increasing cue condition encouraged participants to use semantic information about the word, whereas those treated in the vanishing cue condition may never reach the level at which semantic information is given.

In addition to the above limitations noted by the authors, the study suffers from other design errors that limit the interpretation of the results, for example, different sets were treated unequal number of times, the cueing hierarchies were of mixed semantic-phonological content restricting analysis of loci of effect, and all participants were in-patients of a specialist aphasia ward undergoing an intensive seven-week treatment programme. The effect of being in this environment may have affected results, and could explain the increase in naming observed for all participants between the post-therapy assessment and the follow up assessment. Plus of course the environment limits the study's external validity quite markedly.

In furthering their research, Abel, Willmes and Huber (2007) designed a model oriented treatment of anomia in which therapy was aimed at the level of impairment. The model under consideration was the connectionist model of Dell et al. (Dell, Schwartz, Martin, Saffran and Gagnon, 1997; Foygel and Dell, 2000), and impairment was considered within the parameters of two contrasting versions, namely semantic–phonological (SP) and weight-decay (WD). Abel et al. worked with ten participants with aphasia, four of whom received increasing and vanishing cues in a WD based model and the remaining six received semantic and phonological cues in the SP based model. Participants were assigned to these groups according to their results on a 160 item naming test administered prior to the start of therapy. Therapy lasted for four weeks with five daily training sessions. The different therapy methods were applied in different blocks, each lasting one week. Each block of therapy targeted 15 words, resulting in 60 words being treated in total. Naming of the 60 items was assessed at the end of each block and all 160 were re-assessed four to six days after completion of the treatment. Results demonstrated a general effectiveness of cueing for nine out of the ten participants, with five showing generalisation to untreated controls. Of the predictions regarding type of therapy and level of impairment, four out of six participants in the SP group and all four in the WD group improved most when stimulation related to lesion. However, lesion type did not correspond with predicted patterns of generalisation. Despite the general patterns for improvement, differences in effectiveness between treatments were small and corroborate the findings of Wambaugh *et al*. (2001) that semantic and phonological cueing therapies can be beneficial for all participants with aphasia.

In a series of studies further exploring the application of errorless learning for people with aphasia, Conroy, Sage and Lambon Ralph (2009 a and b) contrasted the technique with errorful learning for both nouns and verbs. Conroy et al., (2009a) hypothesised that given the relatively high cognitive and language demands of verb processing, minimising errors during therapy may be particularly helpful. Working with nine people with aphasia, they hypothesised that while errorless learning would produce equivocal results as errorful learning for nouns, there would be a significant advantage of errorless learning for verb naming. Selection criteria included the ability to repeat with 75% or above accuracy for a set of twenty items in order to reduce the chance of errors being produced during therapy. The errorful learning condition was structured to provide increased opportunities for participants to make errors thereby ensuring a greater contrast between this and the errorless condition. Both errorless and errorful therapies were administered in all therapy sessions. All nine participants' naming significantly improved following errorless and errorful conditions, with little evidence of generalisation. There was no difference between the word classes and the effect of the different conditions. Interestingly it was reported that all participants initially preferred the errorless condition, but as time went on participants with moderate naming impairment preferred the errorful condition, while those with a severe naming impairment continued to prefer the errorless condition. This relates to earlier mention of participant preferences in the Fillingham study.

In a follow up study, Conroy et al. (2009b) aimed to balance error production with effort required by the participant, by utilising an increasing and decreasing cueing hierarchy. It was hypothesised that a decreasing cueing hierarchy would produce a low error rate but still require a sustained effort by the participant. The hierarchy consisted of semantic and phonological/orthographic cues, with the same five levels applied in the increasing and the decreasing conditions, the former starting with the picture and no cue, and the latter starting with the picture and target name in spoken and written form. As in their previous study, all participants showed significant improvement to naming after both increasing and decreasing conditions, with equivocal results for accuracy and naming speed. Despite yielding similar degrees of improvement, participants stated preference for the decreasing condition. Conroy et al. concluded that decreasing cues are as effective as increasing cues, and concur with Abel et al. (2007) that error rate does not seem to impact naming for people with aphasia.

2.1.3.v: Predicting therapy outcome

Nickels (2002, page 954) notes that 'the ideal for the clinician would be the ability to unambiguously pair a particular functional impairment with a treatment task that has guaranteed success for that impairment...yet over and over again we find authors noting we cannot yet predict which therapy task will be effective for which impairment'. Progress has been made in answering this question but there are still inconsistencies across studies. As reported earlier, Raymer et al. (1993) found the language skill of oral reading to be related to therapy outcome, and this was supported by the results of Hickin et al. (2002). In contrast, Fillingham et al. (2005a;b) found that improved naming following errorless and errorful therapy was predicted by the cognitive skills of better recall memory, executive skills and self-monitoring and not by language skills.

Since then Lambon Ralph, Snell, Fillingham, Conroy and Sage (2010) have explored the issue by amalgamating the assessment and therapy results from thirty-three people with aphasia, all of whom had participated in a naming therapy in which progressive combined phonological and orthographic cues were provided. They found that contrary to the findings of Fillingham et al. (2005a;b) both cognitive and language factors are important predictors of response to anomia therapy. Specifically the best predictors of therapy outcome were found to be a cognitive factor (consisting of reasoning, problem-solving, attention, and visual recall) and degree of naming severity as measured by the Boston Naming Test (Kaplan, Goodglass and Weintraub, 1983).

While a definitive answer to the question of which factors predict therapy outcome is still far from clear, increasing evidence, and clinical experience, supports the notion that both language and cognitive abilities are important to consider when assessing people with aphasia and planning therapy goals. This supports the view of Best and Nickels (2000) that it would be naive to expect a one-to-one relationship between impairment and treatment task.

Whilst these are not the only issues to be addressed by the current literature investigating the impact of cues in improving naming, it is beyond the scope of this thesis to report on all the different issues. It is however acknowledged that there is ongoing work examining the intensity of therapy delivery required to achieve the best naming outcomes (for example, Sage, Snell and Lambon Ralph, 2010); how many words should be provided in anomia therapy (for example, Snell, Sage and Lambon Ralph, 2010); and which factors encourage and predict generalisation of therapy (for example, Raymer, McHose, Smith, Iman, Ambrose and Casselton, 2012; Greenwood, Grassly, Hickin and Best, 2010). These important issues are frequently considered within the framework of combined phonological and orthographic cues, which is increasingly considered to provide robust and replicable outcomes for anomia.

2.1.4: Summary

In summary, there is clear evidence that phonological therapy, and specifically cueing therapy, for word finding can be effective in improving verbal naming. However, it is still far from clear what underlying patterns of impairment are predictors of responsiveness to therapy, and how a cueing hierarchy can be delivered most efficaciously. There is strong enough evidence to suggest that probe studies/facilitation can be useful in providing some indication of who may benefit from different treatment protocols. It may be that cueing does derive its effect because active participation in the learning process is known to produce better retention than passive observation in people without language impairments (Basso *et al.,* 2001). However, there remains the need to monitor closely exactly *how* treatments are presented, the *feedback* provided and the *interactions* that occur during treatment sessions before we can reliably formulate a theory of therapy (cf. Byng and Black, 1995).

2.2: Feedback literature review

2.2.1: Introduction

During the course of interactions with family, friends, clients and colleagues, implicit and explicit feedback is constantly informing and modifying our responses. We are so accustomed to the presence of feedback that Glindemann and Springer (1995; cited in Davis, 2005) commented that the absence of correction in interactions is unnatural.

The use of feedback is suggested to be an important feature in general learning (Bandura, 1978; cited in Simmons-Mackie, Damico and Damico, 1999). Within the field of Speech and Language Therapy, clinician-client interactions have been found to be heavily influenced by feedback, both in monitoring performance and modifying therapy. Brookshire, Nicholas, Redmond and Krueger (1979) argued that key to conceptualisation of the therapist's role was an expectation that clinicians' behaviours impact on client behaviours in some way. However, to date within the field of aphasia therapy research there are relatively few examples of studies which have examined or manipulated feedback.

The following review aims to summarise the definitions of feedback found in the literature, give a brief description of the mechanisms by which feedback is proposed to have an effect, and give an overview of studies that have manipulated feedback both in the study of aphasia and other related clinical areas.

2.2.2: Definitions and mechanisms of feedback

2.2.2.i: Definitions of feedback

The term feedback is used to refer to a multifaceted construct and describes a range of different behaviours. In an early analysis of the subject, Brookshire (1973; cited in Simmons-Mackie et al., 1999) identified two functions of feedback in a therapy context: incentive feedback, which includes rewarding and punishing stimuli to elicit or eliminate behaviour; and information feedback which provides information about the performance of target responses. Subsequently other authors have expanded these categories to include general encouragement and reassurance (for example, Brookshire, 1992; Duffy, 1994).

Having observed that the role of feedback is not confined solely to the above categories, Simmons-Mackie, Damico and Damico (1999) identified a lack of specific investigation into the role of feedback in aphasia treatment, and consequently an absence of a framework capturing these additional functions. If feedback performs roles other than those previously identified, Simmons-Mackie et al. concluded that the effectiveness and efficiency of treatment could be affected in ways which were not understood. They hypothesised that in order to further understanding of the role of feedback in aphasia therapy the first step would be to provide a detailed description of its functions based on a qualitative research investigation.

Fifteen different aphasia therapy sessions were analysed involving six different clinicians and eleven different clients with aphasia. Sessions were analysed from videotape, audiotape and participant observation, with ethnographic and conversation analysis methods employed. As anticipated, feedback was found to occur across all of the sessions studied, but a range of different consistent patterns were observed. The outcome of the study was a description of seven functional categories of feedback, with acknowledgement that a single occurrence of feedback might have more than one effect. The results of the study are summarised here as they have important implications for this thesis in providing a descriptive framework of feedback.

The primary results indicated that feedback was multifunctional: individual feedback occurrences were often multifunctional, feedback involved more than verbal content, there were few instances of blatantly negative evaluation (for example, ‘no that’s wrong’), occurrence rates of direct feedback were asymmetrical with extremely high rates of clinician-delivered feedback and minimal instances of client-delivered feedback, and the success of feedback was dependent on a collaborative effort between the clinician and the client. The authors identified seven functions of feedback:

i. ‘the establishment of specific discourse routines’ – refers to the mechanism by which clinicians were able to control and/or limit the types of interactions that occurred in the session. In effect, feedback assisted in parsing the discourse into segments and framed the structure of the interaction. It supplied information on acceptability of responses and created the opportunity to move onto other items. Furthermore feedback was essential in completing correction sequences and on occasions where it was not provided the interaction did not move forward until it was given. Contributing to this role of feedback, paralinguistic markers were identified as conveying for example, ‘unacceptability’, through pauses, body position, gaze shifts and deliberate overemphasising and lengthening of fricatives.
ii. ‘encourage and boost confidence’ – this has long been recognised as a role of feedback and serves to support communicative attempts.

iii. ‘modify or maintain target communication behaviour’ – refers to provision of information regarding the accuracy or adequacy of a response. This role is widely recognised and serves as a primary mediation tool in improving communication.

iv. ‘solicit cooperation and affiliation’ – feedback was found to enable the clinician to maintain a connection with the client through creation of a positive and friendly atmosphere. It is perhaps for this reason that few directly negative occurrences of feedback were found to arise, with ‘incorrect’ responses being indicated by ‘veiled corrections’ such as changes in prosody and timing. Hence while feedback is perceived to be a ubiquitous feature of therapy it appears only to be so in providing positive reinforcement, using less direct and perhaps less transparent, methods when an ‘incorrect’ response is elicited.

v. ‘establish discourse tempo’ – the timing of the delivery of feedback was found to vary on occasion, allowing the clinician control over the timing of activities.

vi. ‘communicate rules and attitudes’ – feedback was found to be a primary method of communicating to clients the types of behaviour expected in treatment sessions. This role of feedback is likely to be most utilised at the beginning of each new activity, after which it may only be applied to serve as a reminder of the desired pattern of communication.

vii. ‘consolidate social rules’ – feedback resulted in reinforcement of the asymmetric roles of client and clinician within treatment sessions. It is not clear whether this was an overt goal of feedback or a by-product. It was reported that in one videotape the clinician produced 100 instances of feedback whereas the client produced none.

The work of Simmons-Mackie et al. (1999) was supported by Horton (2006) who also found feedback to be multifunctional and that it may be enacted in numerous ways, often implicitly through the interactional structure of a task. Horton (2008) suggested that the most straightforward way of understanding feedback is in conceptualising it as occupying the third turn of a three-part instructional sequence, which is core to aphasia therapy.

The work of Simmons-Mackie et al. provides an essential framework within which feedback can be considered. It outlines the range of roles that can be assumed by feedback, and demonstrates the need to be clear about which aspect of feedback is being referred to when discussing both its role and manipulation. Throughout this thesis the classification outlined here will be used when referring to feedback to specify the role being undertaken.

2.2.2.ii: Mechanisms of feedback

The study by Simmons-Mackie et al. provides an excellent framework within which the roles of feedback can be considered, however it does not hypothesise how each of the roles may have an effect, or suggest which types of feedback are critical components for optimising the success of given therapy programmes.

There are few hypothesises which consider the mechanism by which feedback may occur; two with relevance to the current study are summarised here. The first suggests how externally provided feedback may have an effect within Hebbian learning, and the second considers the way in which self-feedback may have an effect.

2.2.2.iii: Hebbian learning

The Hebbian theory predicts that when two events occur together associations are reinforced, which leads to maintenance of a response even when this is counter-productive. This is of relevance to people with aphasia as it suggests that production of an incorrect label for an object may serve to reinforce this association making the incorrect label all the more likely to be recalled on subsequent attempts at naming the object.

Following the Hebbian principle, McCandliss, Fiez, Protopapas, Conway and McClelland (2002) hypothesised that learning does not depend on externally provided feedback, but rather on associated responses which will be reinforced. In order to test this hypothesis they studied the ability to learn perceptual differences in a non-native language (r – l difference in English for Japanese speakers) and contrasted performance in a feedback condition with a no feedback condition. The study is discussed in more detail under the heading of ‘studies that manipulate feedback’ but is included here because of the outcome with regards to the Hebbian model of learning. In contrast to their hypothesis, the authors found that feedback had a significant positive impact on the ability to learn perceptual differences in non-native languages. Therefore they suggested a modified Hebbian model of processing which incorporates either error correcting learning models, or enables modulation by outcome information.

Fillingham, Hodgson, Sage, and Lambon Ralph (2003) in reviewing the work of McCandliss et al. questioned which cognitive processes are involved in the feedback modulation of Hebbian learning and in what way Hebbian learning is altered to filter out effortful trials. Fillingham et al. proposed that three underlying elements are required for successful feedback modulation of the learning mechanism:

i. Accurate self-monitoring of responses.
ii. Ability to store temporarily or prolong the activation of the original stimulus and the association response, while the underlying mechanisms are adjusted by the learning mechanism.
iii. Efficient verification and regulation of behaviour including deliberate manipulation of representations.

2.2.2.iv: Models of self-feedback

In 1992 Nickels summarised the models of spoken word production and recognition and in so doing identified two major classes of monitoring theory which consider the mechanisms by which self-feedback may occur:

- Connectionist theories

  These theories propose that there is no external system to the speech production mechanism that is involved in speech control. Instead self-control is hypothesised to occur through inherent feedback that occurs during the process of speech production, in which bottom-up priming from lower level nodes is fed back to higher level nodes in the network.

- Editor theories

  These theories propose that an external monitor is responsible for monitoring the result of the speech production. Butterworth (1992; cited in Nickels, 1992) proposes that an internal feedback loop passes the output of the speech production system to the speech comprehension system without it being articulated.

Marshall, Robson, Pring and Chiat (1998) worked with clients with jargon aphasia and discussed evidence from this client group which may influence models of mechanisms of self-feedback. The literature they reviewed demonstrated a double dissociation between monitoring and comprehension in jargon aphasia which is inconsistent with a proposal that auditory comprehension is the sole or even major means of monitoring speech. Cases where monitoring is poor despite good comprehension may point to a loss in ability to feed speech back into the input system. In order to assess this theory, an earlier study by Maher, Rothi, and Heilman (1994) worked with a client with jargon aphasia, AS. AS was required to name pictures and judge if his responses were correct (on-line), he then listened again as his responses were played back to him (off-line), and finally listened to his responses spoken back by the examiner (examiner off-line). In the on-line condition AS's immediate self-judgement was 25% accurate, in the off-line condition judgement accuracy improved to 65%, while in the examiner off-line condition judgement accuracy improved to 88%. This discrepancy between on- and off-line processing is suggestive that when cognitive resources are limited monitoring is less accurate as judgements improved significantly when production was not required. This indicates that some people with aphasia, particularly jargon aphasia may be more receptive to feedback when it is externally provided.

Sampson and Faroqi-Shah (2011) further examined the question of whether people who produce jargon aphasia are able to self-monitor. The relationship between self monitoring, quantity of jargon produced and auditory comprehension skills was assessed. Five people with fluent aphasia participated in the study, all of whom produced jargon as a characteristic feature of their output. Three production tasks were used: picture naming, non-word repetition and word repetition under two listening conditions: in quiet and in noise. After each verbal response, participants were asked to indicate if they thought that their final response was correct or incorrect by pointing to a tick or a cross. Specific feedback about the accuracy of responses was not provided by an external source. Findings demonstrated that the severity of self monitoring impairment was strongly negatively correlated with the amount of jargon produced in all participants. Additionally, masking auditory feedback resulted in poorer self-monitoring and increased jargon production in all tasks, but there was no relationship found between auditory processing deficits and self-monitoring score. However ability to self-monitor was found to correlate negatively with increased task demands. Sampson et al. argue for the use of a post-articulatory perceptual feedback mechanism to support self-monitoring, as use of white noise negatively impacted on this skill.

2.2.3: Feedback studies

2.2.3.i: Qualitative studies of feedback

In addition to the study described above by Simmons-Mackie et al. (1999), Horton (2008) has also carried out a qualitative study in which he explored the use and effects of feedback within day to day therapy sessions. Extracts were examined from fifteen sessions, involving ten clinician-client dyads. Feedback was found to be enacted in a number of ways, with repair of errors varying in degree of specificity and clear objective. Feedback for errors was found occasionally to contain the error in order to provide a contrast with the target item. The timing of feedback was found to be crucial with regards to the integrity of the intended learning context, with participants seeking feedback when it was not provided. Of interest, Horton found that feedback was calibrated responsively, often moment by moment, suggesting that clinicians do not pre-plan the nature, role or content of feedback. The findings of Horton support those of Simmons-Mackie et al. in finding that feedback is used in a multifunctional way. However, the degree of variation found within and between therapy sessions indicates that its use is not planned in the same way as the content of the therapy programme.

2.2.3.ii: Empirical studies that manipulate feedback

Maher, Rothi and Heilman (1994) as previously discussed, assessed the ability of AS to judge the accuracy of his naming in three manipulated conditions finding that off-line feedback from the examiner produced the most accurate results. The authors attempted to explain the mechanism for this finding. They found that previously proposed accounts such as impaired lexical-semantic representations, impaired auditory feedback, reduced attention capacity and psychological denial could not adequately explain their result. While unable to explain the mechanism of its effect it is hypothesised that feedback delivered by a clinician is likely to assist in naming.

Fink, Brecher, Schwartz and Robey (2002) studied the effects of clinician guided (CG) instruction with partially self guided (PSG) instruction in using a computer implemented protocol for treatment of naming disorders. The software used was MossTalk Words, a programme that can deliver a hierarchy of cues to facilitate naming. Working with six participants with aphasia, they employed a single subject, multiple baseline, error behaviours design, with three participants in each of the instruction conditions. After repeated testing 50 items were taken from the naming set and were divided into two sets of 20 (with 10 for control) matched for naming difficulty, frequency and length. The CG condition included feedback delivered by the clinician, although the exact nature of the feedback given is not specified. The study found improvements in naming for all participants, with acquisition and maintenance on average greater for the CG group than for the PSG group. At follow-up testing it was found that improvements were maintained in virtually all cases. The authors concluded that people with chronic aphasia can benefit from a computerised cued naming protocol, and independent work on the computer can be an effective adjunct to clinician guided therapy. The results of the study may suggest that in this case clinician delivered feedback was not an essential component in the success of improved naming, however due to the limited information regarding the type and role of feedback in the study any conclusion regarding feedback must be viewed with caution.

Breitenstein, Kamping, Jansen, Schomacher and Knecht (2004)'s study is the only one found by the author that directly looked at the effect of manipulating feedback in aphasia therapy. The study examined the ability of people with aphasia and normal language control adults to acquire novel words by intense frequency of exposure alone. Learning rates were compared for frequency of exposure alone (no feedback condition) with a condition in which participants additionally received on-line feedback in the form of visual representations of the words on the computer screen. Results showed that feedback led to a slight initial acceleration of learning but did not improve latency to peak performance or longer-term retention of lexical knowledge. They concluded that feedback is not a crucial factor for word re-learning in aphasia, and furthermore that economizing on feedback may prevent participants from becoming discouraged by continuous confrontation with their deficits. However these conclusions must be taken carefully as the feedback was only provided by a visual display on a computer screen thereby fulfilling the function of 'modifying or maintaining target communication behaviour' only (cf. Simmons-Mackie et al., 1999), and is not reflective of the type of clinician-delivered feedback in which Simmons-Mackie found little evidence of feedback which was blatantly negative as was delivered here.

Outside of the field of aphasia therapy, McCandliss et al. (2002) studied the effect of removing feedback from the learning environment. The aim of their study was to train Japanese speakers who had English as their second language in discriminating the perceptual difference between /l/ and /r/. Participants were assigned to one of three groups: a control group who received no training between pre- and post testing; an adaptive group who had the differences between the two glides /l/ and /r/ exaggerated; a fixed group who had a fixed pair of speech tokens with no exaggeration. The adaptive and fixed groups were then further divided into two subgroups; in each condition one group received feedback in the form of visual ticks or crosses appearing on their training screen, and the other group received no feedback. The results showed that when no feedback was provided the adaptive group made substantial improvements over those in the control and fixed groups. However when feedback was introduced both fixed and adaptive groups made clear improvements; feedback therefore eliminated the learning advantage for the adaptive technique. In addition, when feedback was provided generalisation occurred to non-treated words (although non-treated words were taken from a very limited set matched for target phoneme in initial position). While these results are from non-language impaired speakers, the finding that their learning was significantly, positively affected by feedback suggests that it is a critical component to the therapy process. Feedback was objective, giving clear information regarding accuracy of responses for correct and incorrect responses. Therefore, contrary to the suggestion of Fink et al. (2002) participants were not distracted by negative feedback but instead better learning effects were achieved.

As discussed in the cueing therapy literature review, errorless learning has contributed to our understanding of the role of feedback within the therapy process. The presence or absence of feedback is thought to be a key element in the application of errorless learning, with the Hebbian learning approach allowing learning in which there is no correct/incorrect feedback. Filllingham, Sage and Lambon Ralph (2006) hypothesised that the reason for not finding any difference between errorless learning and errorful learning, was that in the latter condition participants were given covert feedback by provision of response contingent cues. That is, the participants were able to surmise whether their response had been correct dependent on whether the next item was presented, in which case the response had been correct, or whether a cue was provided, in which case the response had been incorrect. In order to control for this variable, Fillingham et al. replaced the cueing hierarchy from the errorful technique with a single cue, in which the participant was not informed of their performance or of the correct response. Despite this removal of overt and covert feedback, errorless learning was again found to be comparable with errorful learning with both being equally successful. Fillingham et al. found that the relationship between memory and ability to benefit from errorful learning with covert feedback was variable and not straight forward as would be predicted by Baddeley and Wilson (1994).

Subsequently, McKissock and Ward (2007) compared three treatment conditions, with a matched untreated condition: one errorless condition in which the picture was presented with the target name, one errorful condition in which feedback was given after each naming attempt in the form of accuracy information and the target word, and one errorful condition in which no feedback was given regarding accuracy or target response. This latter condition was included to assess whether errorful retrieval attempts in themselves can help picture naming. Five people with aphasia participated in the study and stimuli were generated from a corpus of pictures that participants had failed to name on either one or two occasions. The authors found that errorless learning was successful in treating picture naming but that there was no long-term benefit of errorless learning over that obtained by errorful learning, provided that feedback was given to the participant. Furthermore it was found that there was little benefit in attempting to name pictures without being given feedback. In reviewing the relationship between response to therapy and underlying language profile, it was suggested that the precise profile may not be essential: all participants responded similarly to therapy despite different loci of impairment. McKissock and Ward propose that, in agreement with Abel et al. (2005), making errors in therapy does not seem to be important for achieving success in picture naming. However, they conclude that what does seem to be important is that a correct response is given as feedback stating that 'supplying the patients with a correct name has the largest effect on the rehabilitation of picture naming' (page 366).

In making this conclusion, McKissock and Ward consider only the beneficial effect of providing the whole word form without mentioning the influence of providing feedback relating to accuracy. It is not possible to determine from the study design whether accuracy feedback was actually the crucial factor in the feedback condition, as was found to be the case by McCandliss et al. (2002). However the study supports the notion that in providing feedback, clinicians can significantly benefit clients' naming ability.

2.2.3.iii: Feedback in conversation

Feedback is considered to be an everyday part of conversations between non-language impaired partners. Feedback has also been recorded in conversations between people with aphasia and non-language impaired partners with partners observed on some occasions to use pedagogic behaviours (for example, Burch, Wilkinson and Lock, 2002; Lock, Wilkinson and Bryan, 2001). It has been found that in changing a non-aphasic partner's conversational behaviour, it may be possible to facilitate change in the person with aphasia's conversational and linguistic performance (Wilkinson, Bryan, Lock and Sage, 2010). It is beyond the scope of this thesis to consider the ways in which feedback within conversations may influence communication ability, however it is acknowledged that this would be a useful goal of research to optimally benefit participation and activity.

2.2.4: Summary

While there is growing evidence that feedback plays a role in the learning process, we still know relatively little about how it contributes to therapy outcomes and how it may be related to cognitive and language profiles. The fact that it is multifunctional means that all aspects are rarely controlled within therapy studies or day to day therapy sessions. However as has occurred in the studies reported here, manipulation of just one aspect of feedback can lead to greater understanding of how this everyday occurrence may exert its influence.

This thesis aims to incorporate the findings of these studies to consider how feedback affects word retrieval within the context of a facilitation study. Under the role of modifying and maintaining a target communication behaviour, participants' naming attempts are either responded to with accuracy information in the form of a verbal yes or no, followed by the target response, or extra time in which no feedback, explicit or implicit is provided. The effect of overt self-feedback is also considered within a separate facilitation study, in which participants are encouraged to provide their own feedback and this is again compared to an extra time condition. Differences in response to these facilitation conditions are considered with regards to the relationship with underlying cognitive and language profiles.

2.3: Neuropsychological assessments: an overview with reference to people with aphasia

2.3.1: Introduction

Attempts to examine the complex mental processes undertaken by local brain areas began as early as the Middle Ages, when mental 'faculties' were localised in 'three cerebral ventricles'. In the beginning of the nineteenth century, Gall, an anatomist, described differences between white and grey matter in the brain and asserted that human 'faculties' are strictly localised to areas of the brain. Gall's subsequent phrenological chart of the brain represented his attempt to project the 'psychology of faculties' on to the brain, but was with little factual basis. It was not until Paul Broca (1861; cited in Luria, 1973) described a severe disturbance of motor (expressive) speech following damage to the posterior third of the left inferior frontal gyrus, that truly scientific investigation of the effects of damage to localised areas of the brain can be considered to have begun in earnest. Just over a decade later in 1873, Carl Wernicke (cited in Luria, 1973) described cases in which damage to the posterior third of the left superior temporal gyrus led to impairment in understanding speech.

These two pioneers in the study of language and the brain, Paul Broca and Carl Wernicke, were of the opinion that language and intellectual processing were separate entities. By extension they believed that people with aphasia were 'intellectually intact' but had impaired language processing. In contrast, Henry Head (1926) propounded the opposing view suggesting that the severity of aphasia was directly related to patients' performance on cognitive tasks. Since the days of these early pioneers, the debate over the relationship between cognitive impairment and language processing has continued. Recent research suggests that there is co-morbidity between sequencing in people with aphasia and cognitive processes such as attention, working memory and executive function (Keil and Kaszniak, 2002) but the relationship with the severity of aphasia is not clear.

Traditionally, when speech and language therapists work with people with aphasia, language skills have been considered in isolation from cognitive abilities, and most aphasia therapists are still guided solely by the use of language assessments (Helm-Estabrooks, 2002). However, growing theoretical knowledge and emerging empirical research data suggest that considering only the language skills of a person with aphasia will limit their potential through therapy. For example according to Sarno (1998, p. 615), 'aphasia rehabilitation must be viewed as a process of patient management in the broadest sense', and she elaborates that as part of that process neuropsychological deficits should be considered. Similarly, Purdy (2002, p. 556) states that ‘by understanding the cognitive abilities of our clients with aphasia as well as their linguistic abilities, we may be able to determine which patients are better candidates for intervention as well as which treatment approaches would be most efficient and beneficial’.

While there is growing opinion that neuropsychological assessment should be used alongside language assessment, the selection and use of appropriate assessments is not straightforward. For people with aphasia, assessment of cognitive skills may be confounded by the degree of language processing required for each task. More generally, within the field of neuropsychology there is ongoing debate about the construct of cognition, what it entails and how it can be measured.

Cognition

The term ‘cognition’ is widely used in reference to the ‘thinking’ processes of the brain. However, in order to further our understanding of this construct, a definition must be specific enough to encapsulate all the multifaceted processes by which it is underpinned.

At the broadest level, Neisser (1967, p. 4) described cognition as ‘all the processes by which sensory input is transformed, reduced, elaborated, stored, recovered and used’. Luria (1973), the founder of the discipline of neuropsychology, furthered the description of human cognitive processes by adopting a framework with three functional units, each of which has a distinct role. The first functional unit is involved in cortical arousal and attention processes (attention), the second in storage (memory) and the third in goal directed behaviour (executive function). Luria asserts that these units interact and cannot be seen in isolation, so that for example, a person with poor attention is likely to have problems with executive control function which may reveal itself clinically as erratic problem-solving. As a result of this interconnectivity Luria advocates the absolute importance of understanding where processes breakdown and how this affects other areas of functioning.

Luria’s theory of cognition continues to inform current thinking, and is used as the basis for many new theoretical discussions. Of note is the shift towards the inclusion of language within the definition of cognition. In 2002, Helm-Estabrooks reflected a general change in this position by stating that ‘cognition may be regarded as having *five* primary domains: attention, memory, executive functions, language and visuospatial skills’. She further argues that all five domains of cognition are integral to the treatment process for people with aphasia.

The following review focuses on the traditionally recognised elements of cognitive processes: attention, memory and executive function, with the relationship to language processing in aphasia considered within each of these domains. Each of these cognitive processes is considered under the headings of: definition, models, assessment and empirical studies.

2.3.2: Attention and aphasia

2.3.2.i: Definition

The cognitive function of attention is usually considered to be multidimensional, consisting of a number of basic and complex functions.

Basic functions include arousal and sustained attention. Arousal refers to physiological qualities such as heartbeat and blood pressure, while sustained attention refers to the ability to monitor for a target in a long, continuous and repetitive task (Murray, 1999).

Complex attention encompasses selective and divided attention, and is the overall ability that allows us to focus on and prioritise a certain stimulus while inhibiting competing or irrelevant stimuli. Specifically, selective attention enables selection and response solely to relevant stimuli, while divided attention enables attention and response to multiple stimuli, such as performing two or more cognitive operations simultaneously.

2.3.2.ii: Models

Hula and McNeil (2008, p. 173) describe attention as a resource which 'acts as a 'power supply' in the service of the machinery of the cognitive mind'. In order to describe this 'power supply' many models and definitions of the architecture of attention have been proposed, utilising different terminologies and hypotheses. Primarily, there are two groups of models: capacity theories and bottleneck theories.

Usually, capacity limited theories (for example see Kahneman, 1973) hold two underlying assumptions. First, there are one or more pools of attention resources that are quantitatively limited. Second, although the resources are limited they can be flexibly and simultaneously used and allocated to one or more activities. Task demands determine the amount of attention resources required and this is also influenced by factors including novelty of the task, intent to attend and arousal level.

In contrast, bottleneck theories (for example see Pashler, 1998) propose that concurrent performance is unfeasible for some cognitive operations. Therefore, attention limitations are attributed to a bottleneck at a specific processing stage which forces processing to switch from being carried out in a parallel manner to being carried out in a serial manner. Of these two theories, the capacity limited theory is most frequently referred to due to its longevity in the research literature and its ability to account for different phenomena.

2.3.2.iii: Assessment of attention

Both basic and complex parameters of attention have been assessed in people with aphasia. Laures and Odell (2001 cited in Murray, 2002) looked at behavioural and physiological responses from people with aphasia who completed auditory vigilance tasks. One task employed non-linguistic stimuli (identifying a target tone) whilst the other employed linguistic stimuli (identifying a target word). Compared to healthy control participants, people with aphasia demonstrated non-optimal arousal levels on both tasks (lower blood pressure, higher cortisol levels, and poorer vigilance accuracies), suggesting that these basic functions of attention can be affected in people with aphasia, which could subsequently further compromise communication levels, beyond the linguistic impairment. In a study examining complex functions of attention in people with aphasia, Murray, Holland and Beeson (1997a, cited in Murray, 2002) administered a semantic judgement task under three conditions: isolated stimulus presentation, stimulus presented with competing words and stimulus presented with competing tones. Competing stimuli were found to have little effect on healthy control participants, but caused reduced accuracy for people with aphasia compared to their performance in the isolated condition. Murray argues that these results provide evidence to the effect that not only do people with aphasia exhibit focused attention deficits, but that these deficits can affect the accuracy and efficiency of their language comprehension and production skills.

Divided attention is traditionally measured through use of a dual task paradigm in which participants complete a target task alone and then in competition with another task. To complete the task successfully, participants must have sufficient attention resources and have an efficient allocation strategy. Studies have shown people with aphasia display greater dual task interference than non-brain damaged participants (for example LaPointe and Erickson, 1991; Murray, Holland and Beeson, 1997). Poor dual task performance by people with aphasia has been shown for tasks involving auditory comprehension, speech production and processing of nonverbal stimuli (Murray, 2002).

Murray (2012) noted the diversity and novel nature of attention assessments used in aphasia studies as a major barrier to being able to compare across studies. In order to address this issue Murray (2012) set out to use formal measures of attention to compare a group of people with aphasia with a control group. Using the Test of Everyday Attention (TEA; Robertson, Ward, Ridgeway and Nimmo-Smith, 1994) Murray examined the diversity in the deficit pattern and the relationship between language and attention measures. Murray found a significant difference between the control group and the people with aphasia across all cognitive measures, with the people with aphasia performing worse. Additionally, performance on every TEA subtest correlated with severity of aphasia and complex attention skills were more strongly related than more basic attention abilities. Murray argues that the results support models in which an integral interrelationship among language and other cognitive domains are specified in adults with language disorders. Finally Murray suggests that clinicians should routinely use cognitive assessments, as performance of these domains cannot be predicted solely on the basis of the severity of an individual's language profile.

2.3.2.iv: Empirical studies of attention and aphasia

While the effect of attention training for people with aphasia is at an early stage of study, a meta-analytic examination (Rohling, Faust, Beverly and Demakis, 2009) has found sufficient evidence for the effectiveness of such training after traumatic brain injury which has encouraged further research into its rehabilitation potential for people with aphasia.

Studies have been carried out to assess the validity of such an approach not only on remediating the attention deficit but also on indirectly remediating linguistic skills. Most notably, Helm-Estabrooks, Connor and Albert (2000) developed the Attention Training Program (ATP) which consisted of a series of non-linguistic tasks, following a hierarchical progression. In a study with two participants with aphasia, improvement was found in nonverbal reasoning and auditory comprehension following completion of a twice weekly therapy program for approximately two months. The authors hypothesised that training focused on attention may positively impact other cognitive abilities. Other approaches have involved placing stimuli on the left side of participants and encouraging production of an action with the left arm to facilitate naming of the stimuli (e.g. Crosson, 2000). Such approaches have had some success.

In 2005, Ramsberger reviewed the evidence to support the notion that attention and executive function skills are remediable in people with aphasia and that there is an important relationship between these skills and ‘transactional success’ in conversation as measured by number of main ideas expressed successfully. Ramsberger’s interest in this field began in 1994 when she described two cases which supported the hypothesis that language impairment alone cannot account for the degree of functional success in conversation, and subsequently identified attention and executive function as contributing factors.

In a review of the literature aimed at remediating problems with attention, Ramsberger found that much of the research had been carried out with people with traumatic brain injury and that results had not demonstrated significant benefits to other areas of cognition. In order to identify whether the same was true for people with aphasia Hardin and Ramsberger (2004, cited in Ramsberger, 2005) carried out a case series study in which three individuals with chronic aphasia received computer-based, clinician-directed, attention and executive function treatment. All participants showed some benefit from the treatment as measured by assessment of the specific skills trained. Encouraged by the results, an additional case study was carried out to further examine the effect of generalisation. Participant M underwent the same computer-based training in attention and executive function skills and was found to improve not only on the training tasks, but also on untrained measures of attention and executive function. Furthermore, transactional success in conversation as measured pre- and post-therapy, was found to improve from 42% to 75% of main ideas expressed successfully. This provided Ramsberger et al. with evidence to support the idea that attention and executive function skills are remediable in people with aphasia, and furthermore that there is an important relationship between these skills and functional communication in people with aphasia.

Subsequently Murray, Keeton and Karcher (2006) carried out a single case study with a participant, RW, with mild aphasia and concomitant mild attention and working memory deficits. The authors used a structured treatment program for remediating attention impairments called Attention Process Training II (APT II; Sohlberg, Johnson, Paule, Raskin, and Mateer, 2001). The program is based on clinical models of attention, and accordingly targets a variety of functions, for example sustained, selective, divided and alternating attention, via hierarchical activities. At the time of conducting the research, previous research using this program had only been conducted with people who had a head injury. Murray et al. therefore set out to examine whether engaging in this program would not only improve the attention abilities of RW, but additionally whether there would be concomitant changes in auditory comprehension and other aspects of cognition. They were also interested in determining whether RW and his spouse would perceive any improvements in everyday attention and communication abilities. RW was described as having conduction aphasia, characterised by primary linguistic deficits in repetition, and high level auditory comprehension and spoken language formulation. Employing a multiple baseline design, Murray et al. (2006) administered APT II activities that targeted auditory sustained, selective, alternating and divided attention over a two month period. On completion of treatment, RW was found to have made gradual improvements in response accuracy and/or latency, indicating that language impairments did not preclude ability to complete the tasks. Furthermore, he was found to have improved on specific attention skills targeted by the APT II with similar success to that reported for traumatic brain injury patients and these improvements were also noted on tests similar to the trained activities. However, limited evidence was found to support generalisation to language tasks, with no change on the majority of auditory comprehension measures (only the probe task of paragraph listening was found to show any improvement). There was also little change in response to questionnaires administered pre- and post-therapy from either RW or his wife. Hence, Murray et al. were unable to replicate the findings of Helm-Estabrooks et al. (2000) and concluded that further research is needed to ascertain whether attention training may benefit linguistic deficits associated with aphasia, though they suggest that people with aphasia may be similar to those with TBI in response to attention training, in that their treatment effect may be limited to the specific attention skills trained, with changes in other cognitive domains and perceptions of improvement less likely.

Conversely, Coehlo (2005) found some evidence to support the idea of direct attention training improving linguistic skills in people with aphasia. Using the same APT-II eight week programme as Murray et al. (2006), Coehlo recruited one participant, MH, with aphasia who had a mild reading impairment. MH was described as having relatively intact reading processes but functional inconsistency or inefficiency prevented her from being able to enjoy pursuing her avid reading hobby. Following completion with the APT-II programme MH improved in measures of attention and showed a small improvement in reading comprehension. However, reading rate was reported to have decreased but was less variable post-treatment and this was hypothesised to reflect the fact that MH was no longer trying to read at her pre-stroke speed but instead was better allocating attention resources to reading comprehension. Functionally, MH reported that she experienced improved reading enjoyment post-treatment.

2.3.2.v: Summary of attention

Assessment and treatment of attention deficits in people with aphasia are still at an early stage, with published studies reporting outcomes for different aspects of attention. It seems clear that attention skills play a key role in determining success during therapy. However, at present it is not clear how best to measure functionally important attention skills in people with aphasia or what degree of success can be achieved by targeting remediation at these skills. The current situation demonstrates that attention should be considered an important aspect of neuropsychological processing to examine in order to further our understanding of therapy for people with aphasia.

Although studies have attempted to identify variables that may help predict which people with aphasia are most at risk for attention deficits, at present no significant specific relationships have been detected. However there is growing evidence suggesting that there is an association between people with aphasia and concomitant attention deficits, with models even proposing that attention impairments can intensify or even cause symptoms of aphasia (Murray, 2002). These findings highlight the need for clinicians to take into consideration the parameter of attention when assessing and treating aphasia.

2.3.3: Memory and aphasia

2.3.3.i: Definition

Two overlapping aspects of memory function are considered in this review: short-term memory and working memory. Short-term memory can be considered to refer to the memory component that maintains activation of language representations. It is usually thought of as a temporary, passive store. In contrast, working memory can be thought of as a work space that enables short-term storage and manipulation of new information or of previously learned information that has been reactivated to perform a cognitive task (Connor, MacKay and White, 2000). Short-term memory capacity is integral to the efficient functioning of working memory, which is further supported by executive processes (Martin and Reilly, 2012). The relationship between executive abilities and working memory may have some overlap but each may be considered to have some unique qualities: Connor et al. suggest considering the two cognitive skills in a hierarchical model in which working memory provides the storage and workspace for information, while executive abilities perform operations on the information held in working memory so that this information may be used efficiently. While working memory is a relatively recent concept in aphasiology, it has a long history in cognitive psychology (Wright and Fergadiotis, 2012).

2.3.3.ii: Models of working memory

Several models of working memory exist, the most studied of these being the multi-component model of working memory proposed by Baddeley et al. (Baddeley, 1986, 1992; Baddeley and Hitch, 1974). The key component of their model is the central executive, which represents the core of the system allocating attention and processing resources to two subsystems: the phonological loop and the visuospatial sketch pad. The former subsystem serves the maintenance of verbal information via two processes, a phonological store and a sub-vocal rehearsal mechanism, while the latter subsystem serves the maintenance of visual images. Studies have shown that the efficiency of the phonological loop can be affected by word length and interference from words that are phonologically similar (see Wright and Shisler, 2005 for a discussion). In 2002 Baddeley amended the original model by adding links to long-term memory and introducing an 'episodic buffer' that might provide a link between information from the slave systems and long-term memory.

Additional models of working memory exist such as Just and Carpenter's (1992) theory of language comprehension. They focused on the central executive system, in particular how language is stored and manipulated in working memory. Having observed that language performance differs across individuals with different working memory capacities, they proposed that individuals with a large working memory capacity perform better on language comprehension tasks than those with a smaller working memory capacity. Evidence for their theory comes from studies in which it has been demonstrated that individuals with lower working memory scores have greater difficulty interpreting complex sentences (King and Just, 1991). This model enables predictions about comprehension deficits due to neurological impairment; for example Miyake, Carpenter and Just (1994) suggest that syntactic comprehension deficits occur in people with aphasia because of reduced working memory capacity. To test their hypothesis, they exposed adults without aphasia to conditions in which there were high demands on the working memory (speeded speech rates) and consequently comprehension deteriorated, showing similar patterns to that of people with aphasia. This finding has important clinical implications, suggesting that by reducing processing demands people with aphasia may demonstrate improved comprehension.

However, Caplan and Waters (1999b) have argued that the Just and Carpenter theory cannot account for syntactic comprehension in people with aphasia. They proposed that working memory is not a unitary process as described by Baddeley (1992) and Just and

Carpenter (1992) but rather consists of a differentiated central executive system in which there are sub processes. In their 'separate language interpretation resource theory' they argue for two stages of processing language comprehension: an initial unconscious interpretation of the meaning and a subsequent conscious, controlled process which applies syntactic structure. In support of their theory, Caplan and Waters refer to an earlier study (Waters, Caplan and Hildebrandt, 1991) which found that people with aphasia who were poor on a reading span task were nonetheless able to use syntactic structure to resolve sentence meaning. This ability to manipulate complex sentences despite exhibiting impaired working memory, provided Caplan and Waters with evidence of working memory being a specialised system which incorporates different components, and that this dissociation could be accounted for by the 'separate language resource theory'.

The above theoretical frameworks are not the only ones to have been proposed. For example, Cowan's embedded processes model (1988, 1995, 2005) is influenced by Hebbian theory and proposes hierarchically arranged elements representing memory, while Hasher and Zack's (1988) theoretical framework has similarities with other models but places greater emphasis on inhibitory processes. Furthermore, findings from empirical studies are continuing to inform understanding of working memory, for example a recent study by Attout, Van der Kaa, George and Majerus (2012) has demonstrated a double dissociation between item information in short term memory (phonological, lexical and semantic characteristics) and order information in short term memory (serial order in which items are presented) suggesting a distinction between these two processes.

While there is not room here to provide a detailed account of all the models of working memory, it is acknowledged that commonalities exist between models, namely that working memory is a limited capacity construct and attention processes are central to explaining variations in ability in this construct. Where possible, assessment and therapy outcomes are interpreted with reference to these underlying theoretical frameworks.

2.3.3.iii: Assessment of working memory in aphasia

Connor et al. (2001) propose that the neuroanatomy underlying working memory is best thought of as a network of interacting brain structures and therefore highlight how important it is that professionals across disciplines have awareness that working memory may contribute to a range of cognitive problems. The authors suggest the Wechsler Memory Scale (WMS-III; Webster, 1988) subtests of digit span and spatial span as being appropriate clinical tools to assess working memory, with the latter being particularly beneficial for use with people with aphasia given its assessment of nonverbal skills. However, they acknowledge that both of these tasks may load heavily on the storage aspect (short term memory) of working memory rather than the manipulation aspect. This was corroborated by Martin, Kohen, Kalinyak-Fliszar, Soveri and Laine (2012) who suggest that while verbal span tasks are reflective of verbal short term memory capacity, these tasks do require some organisation of the sequence, which therefore requires a minimal amount of working memory involvement.

Furthermore, it is important to take into consideration the impact of testing memory non-verbally. Lang (1989, cited in Keil and Kaszniak, 2002) states that linguistic impairment makes verbal testing difficult, and while it is possible to test non-verbal memory this does not necessarily inform on overall/verbal memory. While there are these limitations to using such non-verbal tests of memory, at present there are no alternatives with proven validity for people with language impairment. Therefore, these assessments (digit span and spatial span) are often used for testing memory impairments in people with aphasia.

More recently the use of 'N back tasks' have been used with people with aphasia (for example Christensen and Wright, 2010; Wright, Downey, Gravier, Love and Shapiro, 2007). In these tasks, participants are presented with a continuous stream of words and are asked to respond to any token which is identical to a token either one, two or three positions back by pressing the space bar on a keyboard. For example, in a 2 back task in which the stream 'bat hat cat hat' is presented, participants are required to press the space bar after the fourth word 'hat' to indicate that it is the same as the word presented two items back. The nature of the processes involved in performing an N back task are currently unclear, leading to some difficulties in interpretation of performance. To help address this difficulty Mayer and Murray (2012) aimed to use n-back tasks to examine working memory performance of people with aphasia through manipulation of stimulus type (high/low frequency words and non-nameable stimuli) and working memory load. Two groups of participants were recruited: 14 people with aphasia and 12 age matched controls. Both groups showed greater accuracy for nameable over non-nameable stimuli, but the participants with aphasia showed a greater impact of working memory load compared to their age matched controls. Mayer and Murray concluded that n-back task shows positive signs for being a feasible clinical assessment tool but that further investigation is warranted to continue the exploration of the complex interdependence between language and working memory.

Finally the validity of using eye tracking to measure working memory capacity in people with aphasia has been the subject of preliminary examination by Ivanova and Hallowell (2012). They found eye tracking to be a valid and feasible measure to use with people with aphasia which avoids the need to involving language processing. However, the authors acknowledge that this technique requires further investigation to determine the relationship between working memory as indexed through this method and specific aspects of language impairments in aphasia.

While several methods to measure working memory ability in people with aphasia have been employed in the literature, there is still little consistency across studies and many unanswered questions. It is still not clear how non-verbal measures of working memory relate to verbal measures and the degree to which tests involve just short-term memory and/or working memory. At present, digit span and spatial span are commonly used to provide an indication of the functioning of this construct. Further research with these techniques will enable a greater understanding of the relationship between working memory, language and other cognitive skills.

2.3.3.iv: Empirical studies of working memory and aphasia

2.3.3.iv.a: Relationship between working memory, language processing and other cognitive skills

Historically, research has suggested that working memory plays a substantial role in vocabulary acquisition (Gathercole and Baddeley, 1989) and speech comprehension (Vallar and Baddeley, 1984). The following reviews some of the studies that have since examined this relationship in more detail with people with aphasia.

Beeson, Bayles, Rubens and Kaszniak (1993) studied memory impairment and executive control in people with aphasia, investigating whether it was possible to show dissociations between the two. The authors recruited fourteen people with aphasia and fourteen age matched controls. The participants with aphasia were categorised as having a posterior lesion (seven) or an anterior lesion (seven). Short-term memory was tested using the Digit Span test from the Wechsler Memory Scale-Revised (WMS-R) (Wechsler, 1988) and visual memory was tested using the Visual Memory Span (Tapping Forward, a precursor of the spatial span test) also from the WMS-R. A ‘Verbal Learning Test’ was used to measure long term memory, which requires participants to recall as many words as they can after each verbal presentation of a nine word list repeated for ten trials. Recalled words were defined as utilising long-term memory if they were recalled on two successive trials, and were defined as utilising short-term memory if they were only recalled following initial list presentation or following selective reminding. In a modified task, the Verbal Learning Test was supplemented with guided semantic encoding, in which participants were asked to point to a target item from a set of three pictures and were subsequently asked to recall that item. Both Verbal Learning Tests were followed with a recognition task.

Both groups of participants (anterior and posterior lesions) were impaired on verbal short term memory and long term memory compared to matched controls. Of the two groups, the participants with an anterior lesion exhibited greater impairment on verbal long term memory and conversely, participants with posterior lesions exhibited greater impairment on verbal short term memory. The results are suggested not to simply reflect severity of aphasia as the two groups differed significantly on memory measures while being well matched for aphasia quotients as measured by the Western Aphasia Battery (Kertesz, 1982). Whilst the anterior group had poorer performance on the verbal long term memory test, they were able to recognise the words, implying that the words were stored but there was a difficulty either with the organisation, or the retrieval, of words. Beeson et al. suggest that this indicates that the anterior group had impaired executive control rather than impaired memory per se.

In the Verbal Learning Test with guided semantic encoding, the posterior group benefitted from the guided encoding to the extent that their performance was not significantly different from the control group. The authors argue that the posterior group used the guided encoding to employ retrieval strategies which improved verbal recall ability. As the anterior group were not able to benefit from such strategies, they suggest that the anterior group performance is reflective of executive control deficits associated with frontal lobe damage. The findings led Beeson et al. to suggest that lesion location is a better indicator of verbal learning than any of the linguistic subtests on the WAB.

Tompkins, Bloise, Timko and Baumgaertneret (1994) developed a listening span task for use with people with aphasia in order to measure working memory capacity. The task was administered to people with aphasia who were divided into two groups: high comprehension ability and low comprehension ability. They found that the low comprehension group made significantly more errors on their working memory measure than the participants with high comprehension ability, leading the authors to conclude that there is a relationship between working memory and comprehension ability.

Laures-Gore, Marshall and Verner (2010) further examined the relationship between working memory and language processing by using a digit span task with two groups of participants: people with aphasia and people with right hemisphere brain damage. They found that the group of people with aphasia recalled significantly fewer items on both the forward and backward span tasks, compared to the right hemisphere group, and that performance on the digit span task was significantly related to aphasia severity as measured by the WAB. In a review of the study, Wright and Fergadiotis (2012) hypothesised that within the Baddeley model of working memory, this pattern of performance may relate to an impaired phonological loop in people with aphasia. However, they acknowledge that from the study it is not clear which aspects of linguistic processing and working memory correlate with each other.

Other studies have also found there to be a link between working memory and language skills in people with aphasia. For example, Caspari, Parkinson, LaPointe and Katz (1998) found that working memory was able to predict language ability and Sung, McNeil, Pratt, Dickey, Hula, Szuminsky et al. (2009) found a link between working memory and sentence comprehension. In a review of the literature examining working memory in people with aphasia, Wright and Fergadiotis (2012) note that there is a general agreement that people with aphasia present with working memory deficits and that these may partly account for language characteristics. However the majority of studies have concentrated on the relationship between working memory and language comprehension tasks, and Wright et al. advocate that the role working memory plays in verbal production with people with aphasia should also be considered.

One exception is the study by Seniow, Litwin and Lesniak (2009b) who set out to examine whether two cognitive factors, visuospatial working memory and problem solving ability, were related to both input and output language processing. These two factors were selected for their strong association with patients': learning ability, intelligent understanding of various rehabilitation aims and critical appreciation of their situation. Seniow et al. recruited 78 people with aphasia, of whom 47 went on to complete a three week program of daily speech and language therapy targeted at their individual needs. It was found that participants' baseline working memory performance was significantly correlated with degree of improvement in comprehension *and* naming. While the design of Seniow et al.'s study did not allow for the investigation of the effects of working memory on recovery, the outcomes indicate that further research is warranted into the role of working memory in the process of recovery from aphasia.

2.3.3.iv.b: Rehabilitation of working memory for people with aphasia

As acknowledged by Martin and Reilly (2012) there have been only a small number of treatment studies reported that have focused on direct or indirect approaches to remediation of short term memory or working memory deficits for people with aphasia.

Murray (2012) notes that motivation for treating impairments of memory in people with aphasia comes from research with healthy adults in which it has been shown that performance in this domain improves after practice, suggesting that there is plasticity in memory function. Murray identified two different approaches to treating memory: treating short term memory or the phonological loop by increasing the amount of information or duration that information is temporarily maintained, and treating the central executive system in working memory by practising manipulation of information for example, updating, shifting and inhibiting behaviours.

Several studies have been carried out to assess whether treating impaired short term memory/phonological loop in people with aphasia can positively impact on memory abilities, and whether there is any generalisation to language skills. Using an utterance repetition protocol, Francis, Clark and Humphreys (2003) worked with one participant with aphasia and aimed to target directly their auditory verbal working memory and indirectly their auditory comprehension. Following intervention, treatment had improved not only working memory but also auditory comprehension. Functional gains were also reported anecdotally by the participant. Using a similar protocol, Koenig-Bruhin and Studer-Eichenberger (2007) replicated and extended this result finding that their participant with aphasia demonstrated an improved auditory-verbal working memory span, and encouragingly use of increased sentence length in a post-therapy language sample.

The benefits of treating the central executive system component of working memory in people with aphasia have been examined by Mayer and Murray (2002). The authors administered two different treatments aimed at improving reading to one participant with aphasia: reading therapy and a working memory task in which the participant was required to read sentences while performing two tasks, a grammaticality judgement and a semantic categorisation task. They found that both treatments resulted in faster reading rates but there were no changes to comprehension observed following either treatment. Disappointingly, there was only a nominal increase reported in functional reading ability.

The outcomes of the study were questioned by Murray (2012) given that an alternating treatment design was used making it difficult to determine the specific effects of the working memory treatment, and therefore suitability to clinical practice.

In contrast, Vallat, Azouvi, Hardisson, Meffert, Tessier and Pradat-Diehl (2005) found encouraging results to suggest that targeting working memory can have an impact on day-to-day activities. Working with one person with aphasia, identified as primarily having a deficit in working memory, they carried out treatment with eight training tasks focused on improving working memory. They found that their participant improved not only on these training tasks, but also reported an increase in everyday activities including participation, reading and writing.

2.3.3.v: Summary of Memory

While there is increasing evidence to suggest that short-term memory and working memory are remediable in people with aphasia, the evidence to date is limited by small participant numbers and minimal information pertaining to which clients may be able to benefit most from such treatment approaches. Murray (2012) notes that further research is needed before these early research findings can be translated to clinical practice.

2.3.4: Executive function and aphasia

2.3.4.i: Definition

The terms frontal lobe tasks and executive function tasks are often used interchangeably (Keil and Kaszniak, 2002) although the frontal lobes encompass many functions in addition to those considered executive. Luria (1980, p.263) states that the frontal lobes 'synthesise information about the outside worlds...and are the means whereby the behaviour of the organism is regulated in conformity with the effect produced by its actions'. Whereas Shallice and Burgess (1996, p.1405-1406) describe executive function as 'high-level processes that modulate lower-level ones…critically involved in coping with novel situations in contrast to routine ones.'

At its most basic, executive function can be thought of as a process that optimises performance in situations requiring multiple cognitive processes (Robbins, James, Owen, Sahakian, McInnes and Rabbitt, 1997). Lezak (1995) defined four components of executive function: volition (including self-awareness and self-monitoring), planning, purposive action and effective performance. However Keil and Kaszniak (2002) expand and refine this definition stating that executive functioning encompasses working memory (although see earlier discussion), self-monitoring and self-regulating, inhibiting irrelevant stimuli, shifting between concepts or actions, generation and application of strategies, temporal integration, and recruiting or integrating multimodal inputs from throughout the brain.

With so many fundamental skills under the control of executive function, it is not surprising that impairment in this construct can significantly impair an individual's ability to function. Lezak (1995 p.43) summarises the serious consequences of executive function impairment as 'impaired capacity to initiate activity, decreased or absent motivation (anergia), and defects in planning and carrying out the activity sequences that make up goal directed behaviours'.

2.3.4.ii: Models

There are many different ways of conceptualising executive skills, making assignment of executive function to a single location challenging and potentially misleading due to the multiple processes involved (Keil and Kaszniak, 2002). At present many of the sub-processes lack operational definitions and may in fact overlap, and it is unknown how much the sub-processes interact or are independent (Purdy, 2002). As a result most theories of executive functioning are limited to definitions and descriptions.

As such, Hodges (1994) suggests that executive function skills can be thought of in terms of stages:

1. Forming intentions or goals - a desired end state.
2. Planning – identification and organisation of the steps and resources needed to implement the plan.
3. Implementation – moving beyond intention to action.
4. Assessment and verification - ongoing monitoring of the implementation of the plan and ability to shift in response to the demands of the situation.

2.3.4.iii: Assessment of executive function

2.3.4.iii.a: Executive function assessment criteria

Keil and Kaszniak (2002) state that although there are many tests to assess the underlying construct of executive function, due to the diversity of executive function constructs in the literature, there is little agreement as to which processes each executive function test measures. Therefore, while the literature does not offer a definitive description of executive function, Purdy (2002) recognises that there is a need for studies to define operationally the sub-processes of executive functioning and their interrelationships.

When assessing executive function, there are a number of criteria that may need to be considered. First and perhaps most crucial, is the requirement that it places novel or non-routine demands on the subject (Luria, 1973).

Second the task must be complex, as research has shown that patients with frontal lobe damage can perform normally on tests of intelligence and some simpler cognitive tasks (Stuss, 1993). However, increasing task complexity may require the recruitment of additional cognitive skills thereby creating difficulties for interpretation of performance (see also the fourth criterion below).

The third criterion is for tasks to be similar to real life, in order to elicit functional deficiencies in executive ability (Keil and Kaszniak, 2002), and such tasks should have greater ecological validity.

Fourth, measures of executive function need to be specific, to enable poor performance on a test to be interpreted as impaired executive function. To illustrate this, Keil and Kaszniak (2002) give the example of a patient who performs poorly on the Rey-Osterrieth Complex Figure (Meyers and Meyers, 1995) because of visual neglect due to occipital or parietal lesions, while another patient does equally poorly due to organisational inadequacies from a frontal lesion. In this instance the differences may be identified from qualitative information about the patients, but at other times two conditions may mimic each other reducing the specificity of such assessments. This complexity highlights the need for administration of control tasks alongside assessments of executive function.

Finally, tests need to be sensitive to impairments of the skill being measured. This has been highlighted as a concern as patients with known frontal lobe deficits have not shown impairment on assessments purporting to measure executive function (see Keil and Kaszniak, 2002 for examples).

Due to the problems outlined above, and until such time that assessments are developed that are demonstrably sensitive and specific, Bigler (1988, cited in Keil and Kaszniak, 2002) recommends that clinicians use multiple neuropsychological measures.

2.3.4.iii.b: Assessment of executive function and aphasia

Many commonly used neuropsychological tests have linguistic processing and/or production demands that make them largely inappropriate for people with aphasia. Even tests that do not have specific verbal output requirements may have language elements involved that pose difficulties in comprehension or reading for some people with aphasia.

For example, as previously suggested, an important feature of any test of executive function may be that it presents novel information or stimuli, but this may lead to difficulties in understanding instructions. In addition, as it is necessary for such assessments to be complex, involving multiple steps or rules, comprehension demands are increased. A complicated, novel task such as the Wisconsin Card Sorting Test (WCST; Grant and Berg, 1993) is therefore likely to present a high possibility for misunderstanding task instructions (Keil and Kaszniak, 2002). Even elderly participants with normal language abilities have found the WCST so hard to understand that they perform at floor (Bhutani, Montaldi, Brooks and McCulloch, 1992, as cited in Keil and Kaszniak, 2002).

The relationship between language ability and executive processing is complex, and the separation of inner speech from the construct of executive function may be difficult to determine. As with testing memory, testing executive function non-verbally may not be totally representative of this construct, and may even represent a different construct to that elicited through testing executive function verbally. Despite this, Keil and Kaszniak (2002) suggest that performance of participants with varying profiles of aphasia on executive function tests could provide insight into the nature of the interaction between linguistic skills and executive function.

2.3.4.iii.c: Assessment of executive function designed for people with aphasia

Due to the growing evidence supporting the need for assessment of neuropsychological skills with people with aphasia, a number of researchers have designed their own assessments that take into account linguistic demands.

Early researchers in this field were Van Mourik, Verschaeve, Boon, Paquiers and Van Harskamp (1992) who were motivated by people with global aphasia to develop an assessment of cognition that could be specific enough to identify impairments in concentration, memory, attention, intelligence and visual and auditory non-verbal recognition, in the presence of severe language impairment. Their clinical experience with this client group was such that they noted common cognitive features such as reduced attention capacity, reduced memory span and disturbed figure recognition, which in turn limited the success of treatments such as the use of a communication book, the use of symbols and the use of visual action therapy. Therefore, Van Mourik et al. developed the Global Aphasia Neuropsychological Battery (GANBA). In developing the test Van Mourik et al. set a number of criteria to adhere to; of note were the requirements that all responses should be manipulative or yes/no answers and that all tasks should have face validity, which meant that all material would unequivocally show what is required of the patient. Six tasks were chosen, five of which came from published sources and one which was designed by the investigators.

Van Mourik et al. recruited 17 people with global aphasia to whom they administered the GANBA and a test of auditory comprehension. They found that almost all participants were able to perform the tasks, and that performance was independent of spoken language comprehension. When looking for correlations in their data, they found that high scores on their non-verbal tasks correlated with the ability to walk. However, other than this unusual correlation, overall performance profiles were found to be heterogeneous in the majority of patients. They conclude that the GANBA can be a useful tool for assessing basic cognitive function in people with global aphasia, as most of their patients were able to perform the tasks. However, the authors' state that the test does not measure cognitive function per se, but rather measures cognitive skills as required for communication. They also suggest that results on the GANBA can be used to assign people with global aphasia into three different treatment approaches, with those performing well being suitable for impairment therapy, those showing a variable pattern needing training in the cognitive skills in which they are impaired prior to engaging in language therapy, and those who are unable to complete the assessment warranting work with their communication partners. While these suggestions are based on theoretical assumptions they provide useful indications for future research. Although their investigations were carried out with people with global aphasia, Van Mourik et al. recommend that neuropsychological assessment is carried out with all people with aphasia.

In a follow up study, Hinckley and Nash (2007) described the performance of adults with different severities and types of aphasia on the GANBA. They recruited twenty-nine people with aphasia and found that the GANBA was able to detect cognitive impairment in people with mild to moderate aphasia, not just global or severe aphasia. The performance patterns identified led the authors to conclude that there was a high degree of variability in performance on cognitive tasks that was not related to either aphasia severity or fluency category. Hinckley et al. therefore conclude that the results highlight the need to assess individuals with aphasia for cognitive impairment as language assessment alone does not predict cognitive skills.

Helm-Estabrooks (2002) recognised the importance of considering the individual domains of cognition when trying to assess this construct. As previously outlined, she considered there to be five primary domains of cognition: attention, memory, executive functions, language and visuospatial skills, each of which are used to varying degrees during the process of aphasia rehabilitation. Recognising that ideally clinicians would have access to neuropsychological test results as carried out by experienced neuropsychologists, but that this is rarely available, Helm-Estabrooks developed the Cognitive Linguistic Quick Test (CLQT). The aim of the CLQT is to provide information about the relative status of attention, memory, executive functions, language and visual spatial skills in people with aphasia in a short space of time (administration time is 15-30 minutes). Consequently, both linguistic and non-linguistic tests are incorporated. Setting out to study the relationship between linguistic and non-linguistic skills in a group of individuals with aphasia, Helm-Estabrooks administered eight of the subtests (four linguistic and four non-linguistic) to a group of 13 people with aphasia. Analysis of the data using correlations revealed no significant correlation between linguistic and non-linguistic scores, and furthermore there were no significant correlations between non-linguistic scores and years of education, time post onset or age. Of the non-linguistic tasks, the group found the tests of symbol cancellation and design memory to be the easiest to perform. Helm-Estabrooks concludes that her study adds to the growing evidence that it is not possible to predict the status of non-linguistic skills on the basis of language skills. The results of the tests suggest that second to language, executive functions are the cognitive skills most vulnerable to the effects of brain damage associated with aphasia. Helm-Estabrooks therefore concurs with the view that these skills are likely to become important contributors to clinical decision-making about the type and amount of therapy given to people with aphasia. In summary, Helm-Estabrooks states that it is right to move away from the conceptualisation of language as being separate from cognition and, instead accept that language is one aspect of cognition. She further notes that there is still much to be learned about the relation between aspects of cognition and aphasia treatment outcomes.

2.3.4.iv: Empirical studies

2.3.4.iv.a: Studies examining the relationship between language and executive function

Early studies investigating the correlation between language and executive function were mainly carried out with participants with traumatic brain injury (TBI). For example, Coehlo, Liles and Duffy (1995) recorded a narrative from 32 adults with TBI without aphasia, and found a significant correlation between one factor score from the Wisconsin Card Sorting Test and a measure of story structure, suggesting that addressing deficits in executive functioning would be logical when remediating such deficits in discourse.

In examining the association between executive function and aphasia, Hinckley, Carr and Patterson (2001) studied the relationship between cognitive abilities and specific treatment types. Eighteen people with chronic aphasia were recruited to the study and were assigned to either a context-based (individualised compensatory strategies) or a skill-based (cueing hierarchies) therapy programme. The goal for both groups was the same: to improve ability to order from a catalogue. Hinckley et al. (2001) found that lower scores on their measures of executive function (Raven's Progressive Matrices (Raven, 1976) and Wisconsin Card Sort Test (Grant and Berg, 1993) were associated with a longer duration to achieve the performance criterion with their context based therapy. This association continued to be evident six months after the end of treatment, when those in the context based group were reassessed on their ability to order from a catalogue. Those who had performed well on tests of executive function were significantly better able to carry out the functional task than those who had performed less well.

Over the last decade there has been increasing interest in the executive function abilities of people with aphasia. For example, Purdy (2002) recognised the importance of considering executive functioning ability in clients with aphasia and attempted to determine the influence of executive function skill on communicative performance. As Purdy commented, executive function skills are required to monitor communicative attempts, understand feedback from a communication partner and implement cognitive flexibility to switch between communication modalities. This assertion was partly based on an earlier study in which Purdy, Duffy and Coelho (1994) worked with participants with aphasia in carrying out functional communication tasks in three modalities (verbal, gestural and pictorial) and examined the relationship with cognitive flexibility. They found that participants acquired the symbols in at least two of the three modalities, but were unable to switch modalities when they failed to communicate their message verbally.

Purdy (2002) examined not only the accuracy of people with aphasia at performing tests of executive function, but also the efficiency and speed. Purdy recruited 15 people with aphasia and 12 healthy control subjects, and administered four non-verbal tests of executive function: Porteus Maze Test (PM, Porteus, 1959), Wisconsin Card Sorting Test (WCST, Grant and Berg, 1993), Tower of London (TOL, Shallice, 1982) and Tower of Hanoi (TOH, Shallice, 1982). The two groups (people with aphasia and healthy controls) performed the PM and TOL tests with equal accuracy. However while efficiency (number of trials to achieve the target) was similar between the groups for the TOL task, people with aphasia required significantly more trials to complete the PM task than the healthy controls, leading Purdy to conclude that while both tasks, PM and TOL, purport to assess planning, the former must involve additional processes, for example, inhibition and working memory.

Performance on the WCST was significantly different between the two groups with nine of the 15 people with aphasia not being able to complete more than two categories. Interestingly, Purdy reports that following formal administration of the test she gave a minimal prompt to the people with aphasia by asking them if they could sort the cards in a different way. This minimal prompt allowed six of the participants to complete additional categories, suggesting that their difficulty was not in categorisation but in initiating switching behaviour. The efficiency data also revealed a significant difference between the two groups with people with aphasia using more cards per category than control subjects. The TOH task caused greater difficulty amongst participants from both groups, but nonetheless the people with aphasia performed significantly less well which may be a result of a deficit in cognitive flexibility or reduced working memory.

Overall, people with aphasia were found to perform each task at a significantly slower rate than the control subjects. As this was true for all participants with aphasia, Purdy suggests that this finding may represent a generalised slowing of response, as is typically associated with any type of brain damage, rather than a reduction in executive function.

Purdy concludes that people with aphasia demonstrate some characteristics of impaired executive function, particularly in the areas of cognitive flexibility and, to a lesser extent, planning. However, Purdy acknowledges that her study reports the findings for the group, which do not necessarily reflect the patterns of individual variation. Indeed, she points out that some of the people with aphasia appeared unimpaired on measures of accuracy, efficiency and speed. However, her findings suggest that when administering assessments of executive function, the parameter of efficiency in addition to accuracy may give a greater understanding of cognitive ability.

Maeshima, Ueyoshi, Matsumoto, Boh-Oka, Yoshida and Itakura (2002) report on a study in which they recruited 46 people with aphasia and assessed their ability to copy a picture of a cube. They found 42 of the 46 participants demonstrated some abnormality in this task and furthermore they found this to correlate significantly with lower performance on the Wechsler Adult Intelligence Scale (WAIS-R; Wechsler, 1990) and the Raven’s Coloured

Progressive Matrices (RPCM; Raven, 1976). Maeshima et al. suggest that this latter task could be used routinely with all people with aphasia to provide a rough prediction of non-verbal IQ. However, from the study the specificity of the test is not clear, nor is the relationship between this test and individuals' response to rehabilitation.

To investigate whether performance on the nonverbal tests used to assess cognitive skills in people with aphasia simply reflect severity of language impairment, Fucetola, Connor, Strube and Corbetta (2009) investigated the factor structure of the WAIS and the WMS. By recruiting 136 people with aphasia and administering subtests of the WAIS and the WMS, Fucetola et al. set out to determine the degree to which language competence accounted for nonverbal skill. It was found that a single factor model representing nonverbal constructs provided the best model, with language competence having been demonstrated to account only for a minority of the variance in nonverbal skills. Thus, Fucetola et al. conclude that cognitive deficits can be distinguished from aphasia severity and that these skills should be further investigated in relation to aphasia rehabilitation and specifically in relation to everyday functioning.

Exploring the relationship between executive function skills and communication in daily living, Frankel, Penn and Ormond-Brown (2007) used a single case study to analyse potential correlations between performance on an executive function assessment battery and results from conversation analysis. As there was no precedent in this field of study, the authors had to hypothesise which executive function skills might correspond with which features of conversation. On assessment with the executive function battery, their participant, MS, showed preserved sustained attention, suppression, memory and planning. Frankel et al. propose that these skills are analogous with preserved topic management and turn-taking skills observed in conversation. MS showed deficits in the cognitive skills of shifting attention, verbal and nonverbal working memory, generation and concept formation, and it was hypothesised that these deficits accounted for poor results of self-initiated repair in conversation. Frankel et al. conclude that their paper supports the view that executive function deficits are likely to account for numerous aspects of communication difficulty for people with aphasia, particularly in conversation, and they argue that executive function testing provides not only an explanatory basis for communication symptoms, but also a facilitating framework for focusing therapy.

In another study analysing the relationship between functional communication and executive function skills in people with aphasia, Fridriksson, Nettles, Davis, Morrow and

Montgomery (2006) recruited 25 participants with aphasia to undergo a battery of language, executive function and functional communication tests. In order to assess the executive function skills of their participants they used the Colour Trails Test (CTT; D'Elia, Satz, Uchiyama and White, 1996), a test based on the Trail Making Test but using colours and numbers instead of letters and numbers, and the Wisconsin Card Sorting Test-64 card version. Fridriksson et al. found a correlation between performance on the CTT and functional communication ability. However, they found that more than half their participants were only able to complete a single category on the WCST-64 leading the authors to suggest that this is not a feasible measure of executive function in people with aphasia. In addition, there was a strong relationship between performance on the language impairment measures and the functional communication measures for the group. However, for two participants the opposite pattern was true: there was a negative correlation between language impairment and functional communication performance. Therefore, the authors support the view that language impairment may not always correlate with an individual's real life communication ability and that for such individuals executive function skills may be a better predictor.

2.3.4.iv.b: Studies examining executive function abilities and relationship to therapy outcomes

Given that people with aphasia may be more likely to have deficits of executive function skills, by virtue of having brain damage, then it seems logical to question how these deficits impact not only their ability to participate in therapy, but also their ability to use alternative and augmentative communication systems. Nicholas, Sinotte and Helm-Estabrooks (2005) did just that when they examined the correlation between executive function disorders, language skills and ability to use C-Speak Aphasia. C-Speak Aphasia is a picture-based software programme designed to provide an alternative means of communication for people with aphasia, by allowing them to select icons from semantic category groups and put them together to create novel messages in the form of statements, commands and questions. Nicholas et al. used a multiple baseline design with five participants, all with severe non-fluent aphasia. Following participation in a six-month training programme, during which time training was undertaken in modules including generating language, telephone use and assisted writing, participants were reassessed on language (Boston Diagnostic Aphasia Examination; Goodglass, Kaplan and Barresi, 2000), cognitive (Cognitive Linguistics Quick Test, CLQT; Helm-Estabrooks, 2000) and probe tasks that were designed to assess the impact on real life communication activities. Some participants significantly improved communicative performance by using the C-Speak Aphasia programme, and these participants had better preserved non-linguistic cognitive skills. In contrast, participants' scores on the language measures from the Boston Diagnostic Aphasia Examination and experimental semantic tasks showed little correlation with communicative performance on the probe tasks. On further examination of these relationships, Nicholas et al. found one subtest, the Design Generation task from the CLQT to correlate significantly with participants' scores post therapy, while the Symbol Cancellation subtest approached significance. Hence, participants with more intact executive function skills responded best to treatment with this alternative communication method, with executive function skill measured by the CLQT Design Generation task appearing to be the most relevant indicator of treatment response. The authors conclude that their findings corroborate the view that non-linguistic measures of executive functioning should be part of every aphasia assessment.

In a follow up study, Nicholas, Sinotte and Helm-Estabrooks (2011) aimed to replicate and extend their earlier findings in a larger study investigating which cognitive factors may be relevant to treatment outcomes. Employing a multiple baseline design with 10 participants with severe aphasia, a series of language skills (BDAE), nonverbal cognitive skills (CLQT), semantic knowledge and functional communication were assessed. Participants then embarked on a six month treatment program to learn to use C-Speak Aphasia. At follow up testing, four of the ten participants were found to communicate more information post-therapy using the C-Speak Aphasia program than without it, with another two participants making modest gains. Analysis revealed that neither auditory comprehension nor semantic categorical knowledge were significant predictors of response to treatment. Measures of nonverbal executive function skills alone related to changes across time in treatment. Hence the findings provide further evidence to suggest that people with relatively intact executive function skills are more likely to respond better to treatment, and in this case more likely to become independent users of programs such C-Speak Aphasia. However, Nicholas et al. do not advocate using assessments of executive function to identify who not to use such programs, but rather to identify which people may require more support. Finally, Nicholas et al. acknowledge that continued investigation in this area is important to determine whether other cognitive skills also affect treatment outcome.

Purdy and Koch (2006) also examined the correlation between executive function deficits and ability to use alternative communication systems. Using data from a previous study

(Purdy, Duffy and Coehlo, 1994), they developed a novel way of assessing cognitive flexibility using the Communicative Ability of Adults in Daily Living (CADL). Participants with aphasia were scored for the number of times that they demonstrated switching behaviour to another modality in order to communicate a message as a ratio with the number of times they had an opportunity to switch. This measure of cognitive flexibility was found to correlate significantly with scores on the Wisconsin Card Sort Test, giving the authors cause to argue that their measure is a valid one for assessing cognitive flexibility. Furthermore, the authors found a significant correlation between the cognitive flexibility measure and number of successful switches of modality observed in their original symbol use communication task. Such a correlation was not found for severity of aphasia, leading the authors to conclude that strategy usage is more dependent on cognitive flexibility than specific language function.

Furthering this area of research by investigating the relationship between response to impairment therapy and cognitive skills, Fillingham, Sage and Lambon Ralph (2006) administered a set of neuropsychological assessments alongside language assessments in a study for people with word finding difficulties resulting from aphasia (see cueing therapy literature review for a full discussion of the work carried out by Fillingham et al.). Non-verbal assessments were used to study the cognitive skills of episodic memory (recognition for faces, pictures, words and landscapes), working memory (digit span), nonverbal problem solving and reasoning (WCST), and attention (elevator counting with and without distraction). In addition a thorough range of language assessments was carried out. Therapy protocol was designed to enable a comparison of word finding ability for their participants following errorless and errorful learning. Following therapy, three comparisons were made to determine which background assessments correlated with immediate therapy effect, long-term therapy effect and the difference between errorless and errorful therapy at follow up. Interestingly Fillingham et al. found that none of the language assessments correlated with therapy outcome. Instead there were significant correlations with some of the neuropsychological assessments. Of particular note immediate therapy effect significantly correlated with the topographical and word subtests of the Camden Memory Test, the number of categories completed on the WCST and the test of self rating. Fillingham et al. conclude that this indicates that patients who responded well to both therapies immediately post-treatment had better recognition memory, executive function and memory skills. A similar pattern was found when the overall long term therapy gains were examined, suggesting that in this study immediate and long term therapy effects are related to recognition memory and executive function skills. The results led Fillingham et al. to the conclusion that executive skills are crucial for rehabilitation.

Subsequent studies have explored this relationship further. For example, Yeung and Law (2010) examined the relationship between the outcomes of anomia treatment and executive functions. Twelve Cantonese speaking anomic individuals were recruited to a multiple baseline, case series design study. A series of language, memory and cognitive tests were administered prior to administration of an orthographic-phonological cueing therapy. It was found that 10 of the 12 participants responded positively to the cueing therapy, and 6 maintained the improvement one month post treatment. Statistical analysis showed that performance on their measure of cognitive skill (Test of Nonverbal Intelligence -3; TONI-3, Brown, Sherbenou and Johnsen, 1997) was significantly correlated with all measures of treatment outcomes (for example, improvement in naming and generalisation) except for length of treatment required to meet specified target improvement. Yeung et al. suggest that their findings reinforce the view that it is important to carry out a detailed assessment of aphasic individual's executive function abilities in order to select a suitable treatment approach, determine prognosis and predict rehabilitation outcomes.

2.3.4.v: Summary of executive function

While still at a relatively early stage of research, studies so far have demonstrated that executive function plays an important role in the communicative abilities of people with aphasia. Associations have been found not only with functional communication skills and conversation measures, but also with response to therapy. These findings reinforce the need for clinicians to be aware of clients' cognitive skills when assessing and planning therapy for people with aphasia.

However, at present, research has been carried out with diverse client groups, examining a wide range of treatment approaches and using varied assessment tools, resulting in difficulties for translation to clinical practice. Further research is needed with larger numbers of people with aphasia, with a range of severity, to systematically explore the nature, role and rehabilitation potential of executive function.

3: Methods and Procedures

3.1: Language assessments: description, administration and rationale

The language assessments have been separated according to whether they primarily tap into input processes or primarily tap into output processes. It is, however, accepted that there is some degree of both input and output processing required with a number of these tasks. Furthermore, the assessments are subdivided according to those that require mainly semantic processing and those that require mainly phonological processing, and again it is acknowledged that there is overlap between the two.

3.1.1: Input

Phonological

Sound to letter matching

This unpublished assessment was included following use in the work of Best et al. (for example, Best, Herbert, Hickin, Osborne and Howard, 2002; Greenwood, Grassly, Hickin and Best, 2010).

The examiner says a phoneme plus schwa and instructs the participant to point to the corresponding grapheme from a choice of 4. The graphemes comprise of the target item, and three distractors which differ from the target item by 1, 2 and 3 features. There is one practice item and 14 test items. The examiner presents each phoneme once only.

This assessment provides information on participants' ability to access the orthographic form from the spoken form. As no word form is used, successful completion of this task does not require access to the semantic system. Poor performance suggests impaired pre-lexical auditory processing or impaired sublexical phonological to orthographic conversion.

Semantic

Pyramid and Palm Trees (Howard and Patterson, 1992)

The three picture version of the Pyramid and Palm Trees Test was used. Participants are shown pages with three black and white line drawings on, one at the top and two at the bottom. The examiner asks the participants to associate one of the pictures at the bottom of the page with the one at the top. Three practice items are administered followed by 52 test items. Responses are scored as correct or incorrect, with 49 and above considered within normal limits.

Good performance necessitates recognition of the input and the ability to focus on the target association while ignoring competing semantic information, such as shared features. Performance outside the normal limits on this task may indicate underspecified semantics, but results need to be interpreted in the context of other semantic tasks in order to be certain of impairment at the level of semantics.

Lambon Ralph, Snell, Fillingham, Conroy and Sage (2010) found this test correlated significantly with therapy gain, both immediately and long-term, and hypothesised that this may have been due to the executive function component.

Spoken word to picture matching (SWPM)

This test was taken from a pre-publication version of Comprehensive Aphasia Test (CAT; Swinburn, Porter and Howard, 2004). The participants are shown four black and white line drawings on a page. The examiner says the name of one of the four pictures and the participant is instructed to point to the corresponding picture. The three distractor items comprise of one semantically related item, one phonologically related item and one unrelated item, which is semantically related to the phonological distractor. The participant has one practice item and thirty test items. The first response given by the participant is recorded, and is scored as correct or incorrect (the three point scoring system used in the published version of this test is not used).

The pattern of errors is recorded and used to provide information about participants' language profile. Selection of the phonologically related distractor suggests impairment with pre-lexical auditory processing or with the phonological input lexicon. Where the semantic distractor is frequently selected there may be difficulties in accessing the semantic system or there may be impaired lexical semantic representations.

Written word to picture matching (WWPM)

In order to assess written word to picture matching, the pre-publication version of the CAT subtest was administered which follows the same procedure as SWPM. The main difference between the two assessments is the modality of presentation of the target word, which is presented as a written word in the centre of the page in WWPM. The distractors also differ, with the phonological distractors being both phonologically and visually related to the target word.

Poor performance on this task needs to be considered in the context of the type of errors being made. Consistent selection of the visually related distractor indicates impairment in lexical or pre-lexical visual processing. Consistent selection of the semantic distractor indicates either impaired access to the semantic system or impaired semantic representations. Comparison with SWPM allows for increased understanding of the loci of impairment.

Spoken sentence to picture matching

This subtest from the CAT (Swinburn et al., 2004) follows the same format as SWPM, but this time the pictures depict events and the examiner says a sentence to the participant, who must then select the picture which most closely matches.

The stimuli are designed to contain high-frequency vocabulary in order to be selective for assessing syntactic impairments rather than lexical impairments. The sentences include a range of structures which may be challenging for people with aphasia, and increase in length through the test. The majority of the test stimuli are presented as black and white line drawings, however for several items coloured pictures are used to illustrate important differences in meaning. There is one practice item and 16 test items.

Poor performance on this test may indicate impaired verb access, which would result in a random error pattern, or specific impairment with certain sentence structures may be identified through the selection of certain distractors, for example selection of a reversible distractor in the reversible sentences.

3.1.2: Output tasks

Phonological

Non-word repetition

This unpublished test was used in the work of Best et al. (for example, Best, Herbert, Hickin, Osborne and Howard, 2002; Greenwood, Grassly, Hickin and Best, 2010) and was included to assess participants' ability to convert between input and output sub-lexically.

Participants are instructed that they will hear a series of 'made-up' words spoken by the examiner, and that they must repeat the words as they hear them, one at a time. If the participant repeatedly converts the non-words into words, they are reminded on one occasion that all the words are not real words. There are no practice items, and 26 test items, which vary between one, two and three syllables in length. Participants' responses are marked on whole word correct and also on initial phoneme correct.

Poor performance specific to this task, and not repetition of words, would most likely indicate impairment in the ability to use the sublexical auditory to phonological pathway. However, determining the specific loci of impairment is only possible through interpretation of the results in the context of other assessments.

Non-word reading

This unpublished assessment, sourced from the work of Best et al. as above, follows the same procedure as for non-word repetition, but on this occasion participants are presented with the test stimuli in the written modality and instructed to read the non-words aloud as they might sound. The same test stimuli are used for this task and non-word repetition, therefore these assessments are not administered in the same session.

Poor performance on this task in the context of unimpaired word reading, is indicative of a phonological dyslexia. Impaired performance on this task and repetition of non-words may indicate impaired phonological assembly.

Word repetition

In this unpublished assessment, sourced from Best et al., the examiner presents 52 words for the participant to repeat, one at a time. Stimuli are a subset of items from the naming assessment, and vary in length from one to three syllables. Participants are instructed that they will hear each target item once only. Participants' responses are transcribed, and scored as being correct or incorrect. Errors are analysed and recorded as being semantically related to the target word, phonologically related to the target word or unrelated.

Poor performance on this task needs careful interpretation as both auditory input and phonological output impairments can affect repetition ability. Repetition can be achieved either through sublexical auditory to phonological conversion or by lexical repetition routes. If repetition of words is better than repetition of non-words, then it can be hypothesised that the lexical route is being used to some degree. If a length effect is observed, it may be hypothesised that phonological output is impaired, a pattern which would also be seen in reading aloud and naming. Impaired auditory input processing may also be associated with phonological errors, but in such cases longer words are often more accurate than shorter words due to a reduced neighbourhood density. Finally, observation of semantic errors in repetition may suggest a ‘deep dysphasia’ (cf. Howard and Frankin, 1987).

Word reading

This unpublished assessment uses the same 52 items as repetition. Participants are given the list of target items on a page and asked to read them aloud in the order presented. Analysis proceeds as for repetition.

Poor performance on this task may indicate a number of different impairments, and again requires careful interpretation in the context of performance on other assessments. Early stage input impairment, such as difficulty with letter recognition is likely to impact on all reading tasks, including WWPM and sound to letter conversion. Regularisation errors may be associated with reliance on the sublexical orthographic to phonological pathway, and, along with better performance on regular than irregular words, would indicate ‘surface dyslexia’ (Patterson, Marshall and Coltheart, 1985). Conversely, ‘deep dyslexia’ (Coltheart, Patterson and Marshall, 1980) typically leads to production of semantic errors. Phonological errors, in particular when worse with longer words, may reflect impaired phonological assembly, and would be typically associated with all output tasks.

Semantic

Naming

Participants are shown a total of 200 black and white line drawings on two separate occasions, 100 items on each occasion. Test materials were taken from a previous set of facilitation and cueing studies (see Best, Herbert, Hickin, Osborne and Howard (2002) and Greenwood, Grassly, Hickin and Best (2010) for examples) and were sourced from a number of naming tests including Nickels (1992), European Naming Test (unpublished) and the authors’ (Best, Herbert, Hickin, Osborne and Howard) own materials.

Participants are shown one item at a time and asked to name each item. A 10 second cut-off is used throughout the task. Correct responses are counted, and errors are scored on a number of parameters including being phonologically related, semantically related or unrelated to the target item. All items have information regarding psycholinguistic variables available, which are subsequently analysed to inform hypotheses regarding each participant’s locus of impairment.

Production of phonologically related words is indicative of either impairment in the phonological output lexicon or in phonological assembly. Semantic errors indicate impairment within the semantic system or in access to the phonological output lexicon.

Written naming

Written naming was assessed using a subset of 40 items taken from the 200 picture naming set.

Participants are presented with one item at a time and asked to write the name of the item. A ten second cut-off is used. The correct number of responses is recorded and each error is categorised according to a number of parameters including being orthographically related, semantically related or unrelated to the target item.

Written naming was not presented in the same session as spoken naming due to the overlap of items.

Poor performance on this task may indicate impaired semantic processing or impaired mapping to the orthographic output lexicon, both of which may lead to semantic errors. An increased difficulty with longer words indicates impairment at the graphemic output buffer. Therefore the pattern of performance must be interpreted alongside performance in other tasks.

3.2: Neuropsychological assessments: description and administration

The neuropsychological assessments used in the current study are considered under the cognitive domains of attention, memory and executive function. However, it is well acknowledged that there is significant overlap, with each assessment likely to involve more than one cognitive domain. For example, the digit span test is widely used as an assessment of auditory verbal short term (working) memory, however Hodges (2007) states that the skill measured is more closely related to the efficacy of phonological and attentional processes than to what is commonly thought of as memory. The categorisation of assessments below is based on what is generally regarded as the primary domain being assessed, and for this reason Digit Span is considered to be an assessment of memory. Each sub-domain is introduced followed by a description of each assessment tapping cognitive processes within this domain.

3.2.1: Memory

Memory is not a single all-encompassing system. Consequently there have been many attempts and terminologies used to describe the components within the system. Broadly the system can be divided into two. The first component can be considered to be memory that is available to conscious access and reflection, and is termed explicit or declarative memory. The second refers to the types of learned responses such as conditioned responses, motor skill acquisition and priming which are not available for conscious reflection and are referred to as implicit or procedural memory.

The first component, explicit memory, can be further broken down into episodic memory and semantic memory. Episodic memory is the laying down and recall of personally experienced and temporally specific events, whereas semantic memory is responsible for our permanent store of representational knowledge of facts and concepts, objects and people, as well as words and their meaning. Both of these elements of memory, episodic and semantic, are part of the long term memory system.

Short term memory is the working memory component of the system and is responsible for the immediate recall of small amounts of verbal or spatial information.

Picture span (unpublished)

This test consists of nine pictures presented in three rows of three. The items are all common nouns. Prior to the test commencing, the examiner names each item one at a time whilst pointing to the corresponding picture. To confirm the participant recognises and knows the name for each picture, the participant is then required to point to each picture in turn as the examiner verbally presents the name. Once picture comprehension of the nine items is established, the test commences.

The participant is instructed that the examiner will say aloud a series of items. The participant must wait until the examiner has finished saying the series, and then point to the pictures in the same order as spoken by the examiner. The participant is instructed that the examiner will say each series of picture names once only. The examiner starts the test with a series of two picture names. If the participant points to the corresponding pictures in the correct order, then the examiner increases the series of items to three for the subsequent turn. The examiner continues to increase the series of items by one until the participant makes an error, at which time the series is decreased by one. This pattern of increasing and decreasing series is continued until ten trials have been completed. The score is calculated as an average by summing the number of items presented in trials two through to ten and adding the number of items that would have been presented in trial 11, and dividing this score by ten.

There are no norms known for this test, therefore z scores have been calculated in order to give an indication of performance level for each participant.

Letter span

This test consists of eight graphemes, presented in upper case forming the outline of a square. The test protocol is the same as for STM picture pointing, but test items are letter names and their corresponding grapheme rather than nouns and their corresponding pictures.

Weschler Memory Scale-III (WMS-III; Wechsler, 1997)

The WMS-III is a published, standardised tool for assessing suspected memory impairment. The scale consists of six core tests and five optional tests. Of the core tests, two are used in the current study; Spatial Span and Faces. Of the optional tests, a further two are used in the current study; Digit Span and Visual Reproduction. The four selected tests were chosen on the basis of requiring the least amount of language processing. There is normative data based on 1250 subjects, with an upper age bracket of 85-95 years.

Digit Span, forwards and backwards

Digit span is assessed by asking the participant to repeat a progressively lengthening sequence of digits, in the same order as presented by the examiner. Each digit in a sequence is read at a rate of one per second, and the examiner must be careful to avoid clustering the digits. The sequence starts with two digits, and there are two trials for each sequence length. If the participant successfully recalls the digits in the correct order in the first or the second trial, then the next-length trial is administered. If a participant fails both trials of a given length, then the assessment is discontinued.

Exactly the same technique is employed in the digit span backwards test however, in this instance the participant is required to repeat the numbers in the reverse order to that presented by the examiner.

Normal digit span is six +/- one, depending on age and general intellectual abilities. In the elderly and those of low intellectual ability, five can be considered normal. Normal backwards digit span is five +/- one.

Spatial span forwards

This task uses a board on which there are ten blue blocks. The examiner touches a sequence of the blocks and requests the participant to repeat the sequence in the same order. The examiner starts with a sequence of two blocks, and presents two trials at this level. If the participant correctly performs the sequence on one or both of the trials, the examiner extends the sequence to three blocks. Again two trials are presented at this level. An increasing sequence of blocks is presented until the participant fails both trials at one level. Participants are scored on the number of trials correctly repeated.

Spatial span backwards

This task proceeds as for spatial span forwards, but participants are required to touch the same sequence of blocks in the reverse order.

Faces (recognition of Faces I and recognition of Faces II)

The participant is shown a series of photographs of faces, one at a time and asked to remember each one. There are 24 target faces and each one is shown to the participant for two seconds.

Faces I

Immediately following the presentation of target faces, the participant is shown a second series of 48 photographs, again one at a time, comprising the 24 target photographs and 24 distractor photographs. The participant is only asked to identify each face as either one that they were asked to remember or a new one, by saying ‘yes’ or ‘no’ respectively. If the participant is uncertain they are instructed to ‘make your best guess’. The participant’s responses are scored as the total number correct.

Faces II

At a delay of 25-35 minutes after Faces I is administered, during which time other unrelated tasks can be administered, Faces II is administered. The participant is again presented with 48 photographs one at a time, comprising the 24 target photographs and 24 distractor photographs, which are different distractors from those shown in Faces I. Administration then proceeds following the same protocol as for Faces I.

Visual reproduction I

The participant is shown a black and white line figure and instructed to study the figure for ten seconds. The figure is then covered over and the participant is instructed to draw the figure from memory. This procedure is repeated for a total of five figures which increase in complexity.

Visual reproduction II

At a delay of 25-30 minutes following completion of visual reproduction I, the participant is required to recall the five figures from memory and draw them on separate sheets of paper.

Visual reproduction – recognition

Following completion of visual reproduction I and II, the participant is shown 48 figures, and asked to identified which are part of the original figures shown and which are not, by answering yes and no respectively.

Visual reproduction – copying

To complete the visual reproduction section, participants are shown the original figures, and with the figures still visible are asked to copy them.

3.2.2: Attention

Cognitively attention is a complex ability. There have been many attempts to describe the sub-processes. The following classification is considered to be useful for considering the components of attention in a clinical setting:

1. arousal which is the general state of responsivity and wakefulness.
2. sustained or simple attention, which refers to the ability to maintain attention activity over prolonged periods of time.
3. divided attention is the ability to be able to respond to more than one task at once.
4. selective attention is the ability to respond to more than one task at once, while ignoring distractions.

The Test of Everyday Attention (TEA; Robertson, Ward, Ridgeway and Nimmo-Smith, 1994)

The TEA is a battery of eight tasks designed to measure the attention subsystems in as ecologically valid way as possible, by using tests which closely relate to day to day activities. Normative data is provided for subjects ranging in age from 18 to 80.

For the current study, three of the tasks were selected on the basis of requiring reduced language processing.

Elevator counting (simple attention)

Participants are told that they are in an elevator, but the floor-indicator is not working. Therefore, the participants are required to count a series of tones presented on a tape recorder in order to determine what floor they are on. At the end of each series of tones, the participant must state what floor they are on.

Elevator counting with distraction (divided attention)

In this scenario, the participants are instructed that they must count the low tones as in the previous task and that each tone represents a floor. However, low tones are now interspersed with meaningless high tones, and the participants are instructed that they must count the low tones while ignoring the high tones. Again, at the end of each series of tones, the participant must state what floor they are on by stating how many low tones they have counted.

Map search

Participants are presented with a detailed map of an area of America, which consists of a series of symbols. Participants are required to search for a particular type of symbol, for example restaurant symbols, in amongst distracters. Participants have two minutes to find as many of the target symbols as possible, with the total number being 80.

Trail Making Test part A

See description below.

3.2.3: Executive function

Executive skills can be thought of in terms of stages, starting with forming intentions or goals, then planning, implementation and finally assessment and verification, which includes ongoing monitoring of the implementation of a plan and ability to shift plans in response to the demands of a situation.

As discussed in the literature review, assessment of executive function is complex. The main criterion seems to be that it places novel or non-routine demands on the subject (Luria, 1973). A second criterion may be task complexity as research has shown that patients with frontal lobe damage can perform normally on tests of intelligence and some simpler cognitive tasks (Stuss, 1993). However, increasing task complexity may result in many abilities being employed, thereby creating problems for differentiating cognitive processes.

Despite the complexities, the Brixton spatial anticipation test and the Trail Making Test part B are considered to be good assessments of executive abilities, and importantly for the current study, require no verbal output.

Trail Making Test (TMT)

The Taylor Number Series was the original form of the test which consisted of connecting a series of numbers from 1 to 50. Partington revised the test and renamed it ‘A Test of Distributed Attention’, but not long after, the name of the test was once again changed, this time to the ‘Partington Pathway Test’. Around 1944, the test became part of the ‘Army Individual Test of General Ability’ and was given the name ‘Trail Making Test’ (TMT), which is now part of the Halstead-Reitan Test Battery (Reitan and Wolfson, 1985).

The TMT is a quick, quantitative measure of visuo-motor tracking, conceptualisation and mental ‘set shifting’. There are two parts to the test, part A and part B. Both parts of the test consist of 25 circles distributed over a sheet of paper. In part A, which is considered to be an assessment of attention, the circles are numbered 1 – 25, and the participant is required to draw lines to connect the numbers in ascending order as quickly as possible and without lifting the pen or pencil from the paper. The participant is initially presented with a trail with eight practice items to complete, prior to being given the full Trail A with twenty-five test items. In part B, which is considered to be an assessment of executive function, the circles include both numbers (1 – 13) and letters (A – L). As with part A, the participant draws lines to connect the circles in an ascending pattern, but with the added task of alternating between the numbers and letters (i.e., 1-A-2-B-3-C, etc.). If the participant makes an error, they are immediately informed and allowed to correct it. Errors affect the participant's score only in that the correction of errors is included in the completion time for the task. The test is usually discontinued if the participant takes longer than 5 minutes to complete either part.

It is acknowledged that, as with any test dependent on response time, performance depends markedly on age. Impairment on either part of the test can result from motor slowing, in-coordination, visual scanning difficulties, poor motivation or frontal executive problems.

Results for both part A and part B are reported as the number of seconds required to complete the task, therefore, higher scores reveal greater impairment. These scores are then converted to percentile equivalents according to the normative data reported by Tombaugh (2003) in which norms are stratified for 11 age groups.

Brixton Spatial Anticipation Test

The Brixton Spatial Anticipation test was developed by Burgess and Shallice (1997) as part of The Hayling and Brixton Test, to assess executive function, in particular the ability to detect rules in sequences of stimuli and concept formation. The test consists of 56 nearly identical cards. Each card has ten circles printed in the middle of the page and within a box. The circles are organised in two rows of five, and on each page one of the circles is coloured blue while the others are all white (on a white background). The position of the blue circle moves around according to different rules, and the rules change without warning. The aim of the test is for the participant to identify where the blue circle will be appear on the next page, by working out what rule is being applied. The test is made more complicated by changing of the rules without warning. Therefore after a sequence has been adhered to for a number of items, the rule will change and the participant must then identify the new rule. In the simplest sequence the blue circle advances one position on successive cards. In more complex sequences the blue circle alternates between two positions.

Participants are shown the front of the test book and instructed that they will be shown a series of cards with the same basic layout of ten circles, with one always coloured blue. The participants are told that the blue one moves around according to various patterns which come and go without warning. Instructions are then given to inform the participant that they must try and pick up on the pattern as best they can, by pointing to the where they think the blue one is going to appear on the next page.

The participants are told that the pattern is not completely random, but that from time to time the pattern changes without warning, and then they must try and pick up the new pattern.

No practice items are given, but the examiner does give an example of a pattern in which the blue one moves up one circle with each page.

Prior to commencing the test, the participants are asked to confirm if they have understood the instructions. If they have not, the manual advises the examiner that they may continue to give assistance until the participant has understood, including showing a page from the middle of the book to demonstrate how the blue one moves around.

This test is not timed, and pages are only turned over once an answer has been provided by the participant.

The manual notes that the test can be performed easily by people with major speech production difficulties, but does not make any comment about language impairments.

The test is scored by adding up the number of errors made by a participant. This score is then given a scaled score which can be used to classify the participant on a scale ranging from impaired to very superior.

3.2.4: Self-monitoring

This assessment was included as a measure of participants' ability to monitor their own naming responses, cf. Fillingham, Sage and Lambon Ralph (2005). Participants are presented with 40 black and white line drawn test items from the Psycholinguistic Assessment of Language Production in Aphasia (PALPA; Kay, Lesser and Coltheart, 1992) picture naming test (subtest 53). Participants are instructed to name each item, and after each item has been named, or a time limit of ten seconds has elapsed, participants are asked to judge whether their response is correct, close (used for semantic or phonological errors) or incorrect. Participants are asked to use a visual scale comprising of written and pictorial information to show their judgement. The recorded scores represent the participants' self-monitoring accuracy, not the correct number of spoken naming responses (for example, a participant who correctly names 35/40 target items, but correctly judges all their productions as correct/close/incorrect would score 40/40).

Poor performance on this task suggests that the participant has impaired self-monitoring ability.

Summary

Thus, a total of 19 neuropsychological assessments were administered with each participant: twelve tapping into memory processes, four tapping into attention processes, two tapping into skills of executive function and one measuring self-monitoring ability.

3.3: Facilitation Design

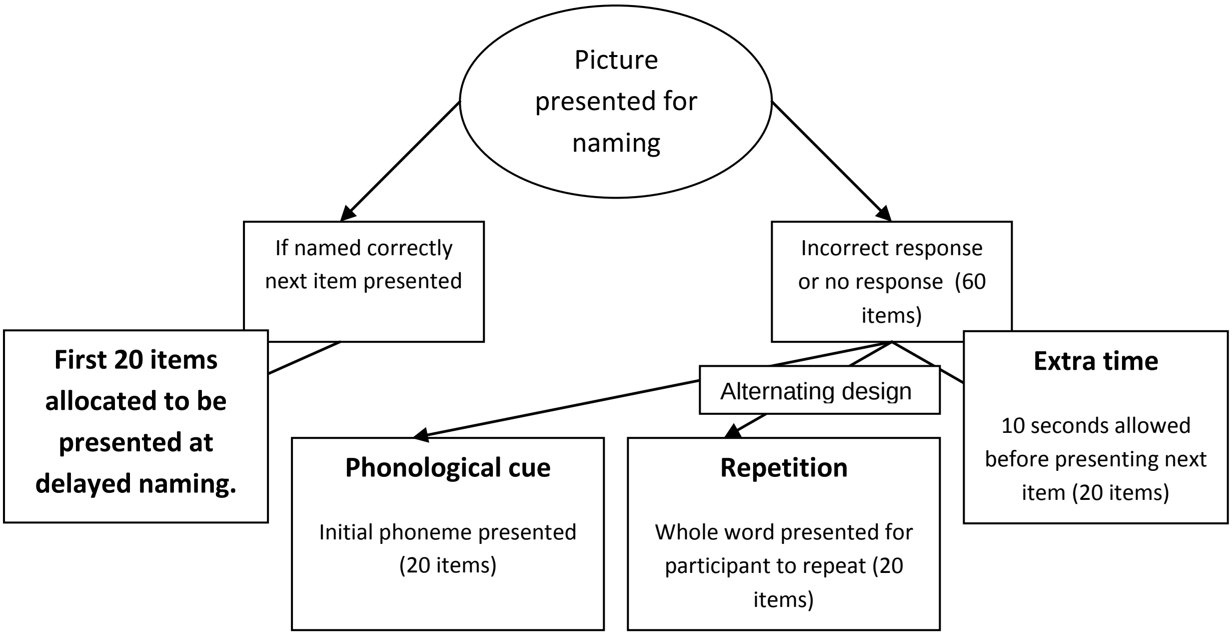
Five facilitation studies were carried out with each participant, each lasting one to two sessions (minimum of one hour in total). During each facilitation study the participants were presented with a set of pictures to name, when unable to name a picture the clinician acted according to the protocol below.

The picture stimuli were a set of 200 pictureable CVC items as used by Best, Herbert, Hickin, Osborne and Howard (2002). The pictures were presented in a different order for each facilitation study, thus participants did not see all the same pictures in each study. The order in which the facilitation studies were presented was randomised across participants.

3.3.1: Facilitation with phonological cueing and repetition compared to extra time

Participants are presented with a black and white line drawn picture and asked to name the picture. If named correctly the next item is shown. If named incorrectly, or no response is given within 5 seconds, the item is allocated to one of three conditions in an alternating design, see Figure 2 for an illustration. In the first condition items are cued with the first phoneme, plus schwa, of the target word. In the second condition items are cued with the whole word presented for repetition. In the third condition participants are allocated an extra 10 seconds to name the item. The study continues until there are 20 items in each condition. All responses are recorded on a score-sheet (see example score-sheet (1)).

Figure 2: Allocation of stimuli for facilitation with a phonological cue, repetition or extra time



After a delay of at least 30 minutes 20 items from each condition are presented at delayed naming. In cases where there are more than 20 items in a condition the first 20 items are presented at delayed naming.

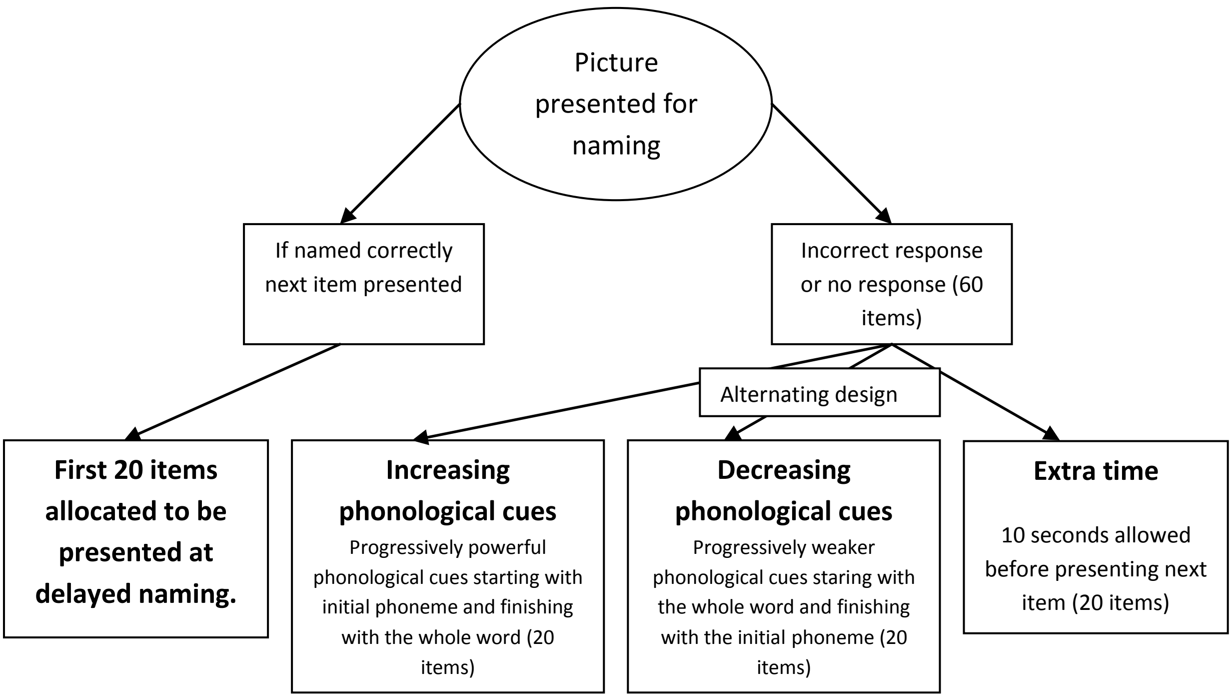
Example (1): score-sheet for phonological cues compared with repetition and extra time

	Target	Response in 5 seconds	Cued with initial phoneme	Cued with repetition	Extra time (10 secs)	Delayed naming
1	Sail					
2	Bowl					
3	Cap					
4	Ring					

3.3.2: Facilitation with increasing and decreasing cueing hierarchies compared with extra time

Participants are shown a picture and asked to name the picture. If named correctly the next item is shown. If named incorrectly, or no response is given within 5 seconds, the item is allocated to one of three conditions in an alternating design, see Figure 3 for details of how stimuli are allocated. In the first condition items are cued with progressive phonological cues increasing in power. This cueing hierarchy commences with the initial phoneme plus schwa and finishes with the whole word. In order to ensure a comparable number of naming attempts between conditions, all cues in the hierarchy are provided with the participant having an opportunity to name the item at each stage. In the second condition items are again cued with a phonological hierarchy, but this time cueing order is reversed, with the most powerful first, i.e. the whole word, decreasing in strength until the participant is required to name the picture after hearing the first phoneme. Therefore, the number of naming opportunities should be the same in both the decreasing and increasing cue conditions. In the third condition participants are allocated an extra 10 seconds to name the item. Participants' responses are recorded on a score-sheet for every opportunity they have to name the target item (see example score-sheet (2)).

Figure 3: Allocation of stimuli for facilitation with an increasing cue, decreasing cue or extra time



After a delay of at least thirty minutes, 20 items from each condition are presented at delayed naming. In cases where there are more than 20 items in a condition the first 20 items are presented at delayed naming.

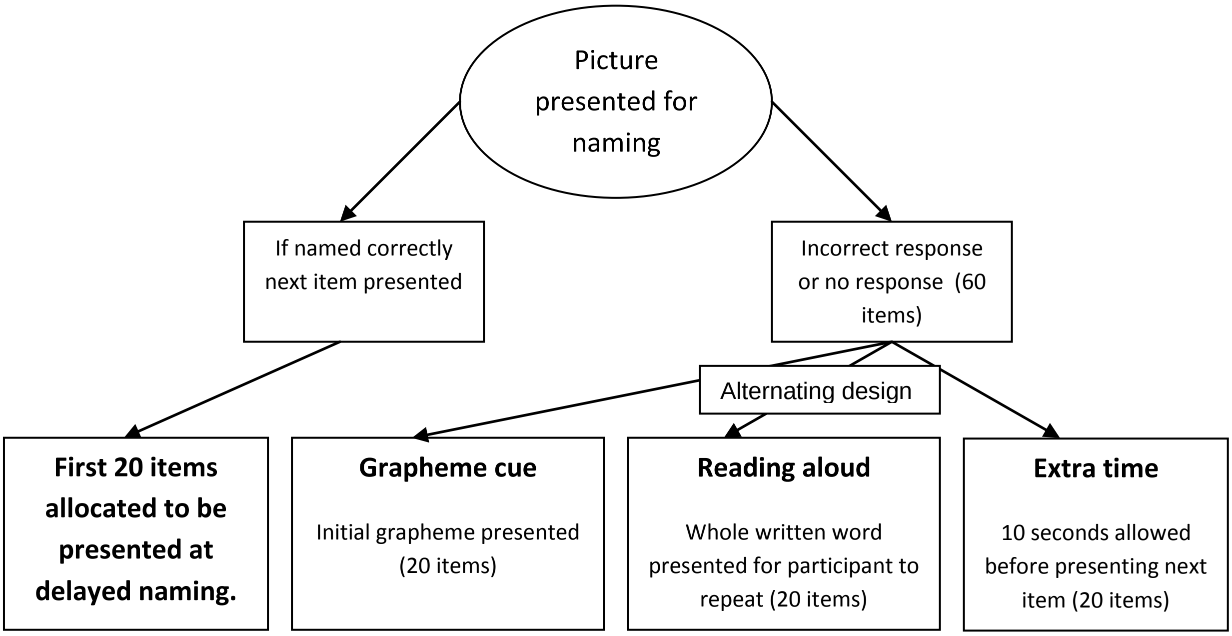
Example (2): score-sheet for increasing cues compared with decreasing cues

	Target	Response in 5 seconds	Incorrect or no response			Delayed naming
			Cued with increasing cues	Cued with decreasing cues	Extra time (10 secs)	
1	Leg		1 2 3	1 2 3		
2	Nail		1 2 3	1 2 3		
3	Cap		1 2 3	1 2 3		
4	Box		1 2 3	1 2 3		

3.3.3: Facilitation with initial grapheme and whole written word compared to extra time

Participants are shown a picture and asked to name it. If named correctly the next item is shown. If named incorrectly, or no response is given, the item is allocated to one of three conditions in an alternating design, see Figure 4 for details of how stimuli were allocated. In the first condition items are cued with the first grapheme of the target word. In the second condition items are cued with the whole written word presented for reading aloud. In the third condition participants are allocated an extra 10 seconds to name the item. The study continues until there are 20 items in each condition. All responses are recorded on a score-sheet (see example score-sheet (3)).

Figure 4: Allocation of stimuli for facilitation with an initial grapheme cue, whole written word or extra time



After a delay of at least thirty minutes 20 items from each condition are presented at delayed naming. In cases where there are more than 20 items in a condition the first 20 items are presented at delayed naming.

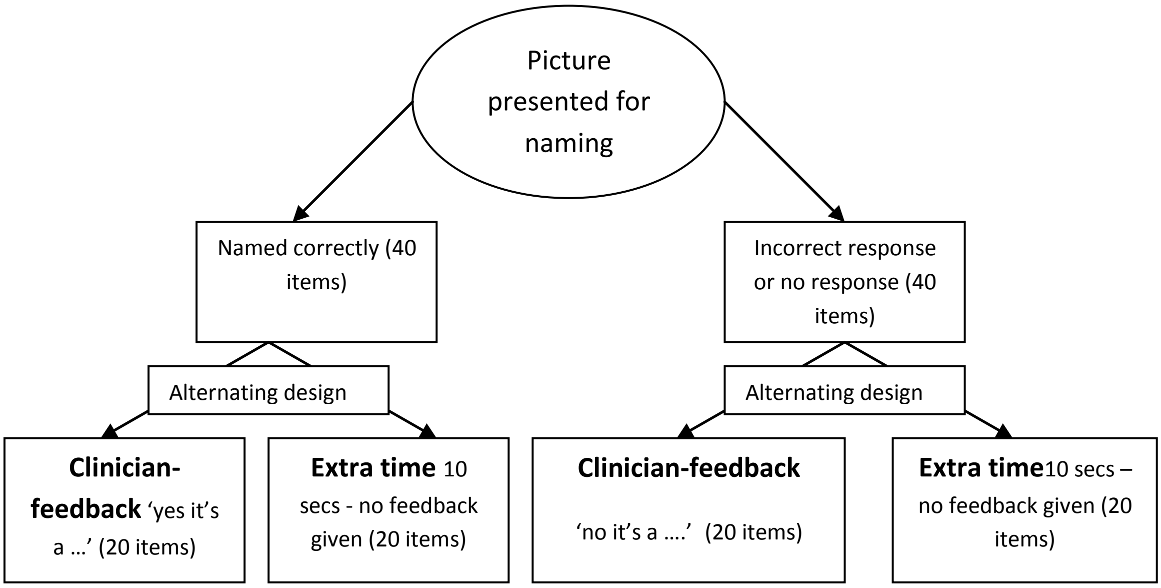
Example (3): score-sheet for phonological cues compared with repetition and extra time

	Target	Response in 5 seconds	Cued with initial grapheme	Cued with whole written word	Extra time (10 secs)	Delayed naming
1	Wall					
2	Heart					
3	Shoes					
4	Goat					

3.3.4: Facilitation with clinician-feedback compared with extra time

Participants are shown a picture and asked to name it. When a correct response is given (as judged by the clinician) items are allocated to either the clinician-feedback condition or extra time, in an alternating design. In the clinician-feedback condition, a specific response framework is used 'yes, it's a ….'. In the extra time condition the participant is told that they are being allowed an extra 10 seconds. When an incorrect response or no response is provided, items are again assigned to either clinician-feedback or extra time condition, in an alternating design (see Figure 5 for details of stimuli allocation). In the clinician-feedback condition participants are told 'no, it's a ….'. The extra time condition proceeds exactly as its corresponding condition for a correct response, ensuring that no feedback is given unintentionally. Items continue being presented until 20 items have been presented in each condition. In cases of a condition finishing with more than 20 items the first 20 items are presented at delayed naming.

Figure 5: Allocation of stimuli for facilitation with clinician-delivered feedback or extra time



Prior to commencing this facilitation participants are given clear instructions that they will on some occasions be given extra time regardless of whether they have given a correct or incorrect response. In addition participants are instructed that on hearing the target word spoken by the clinician in the feedback conditions, they may repeat that word. Occasions of repetition of target words are recorded on the score-sheet along with spontaneous responses (see below for example (4) of the score-sheet).

Example (4): score-sheet for clinician-feedback compared with extra time

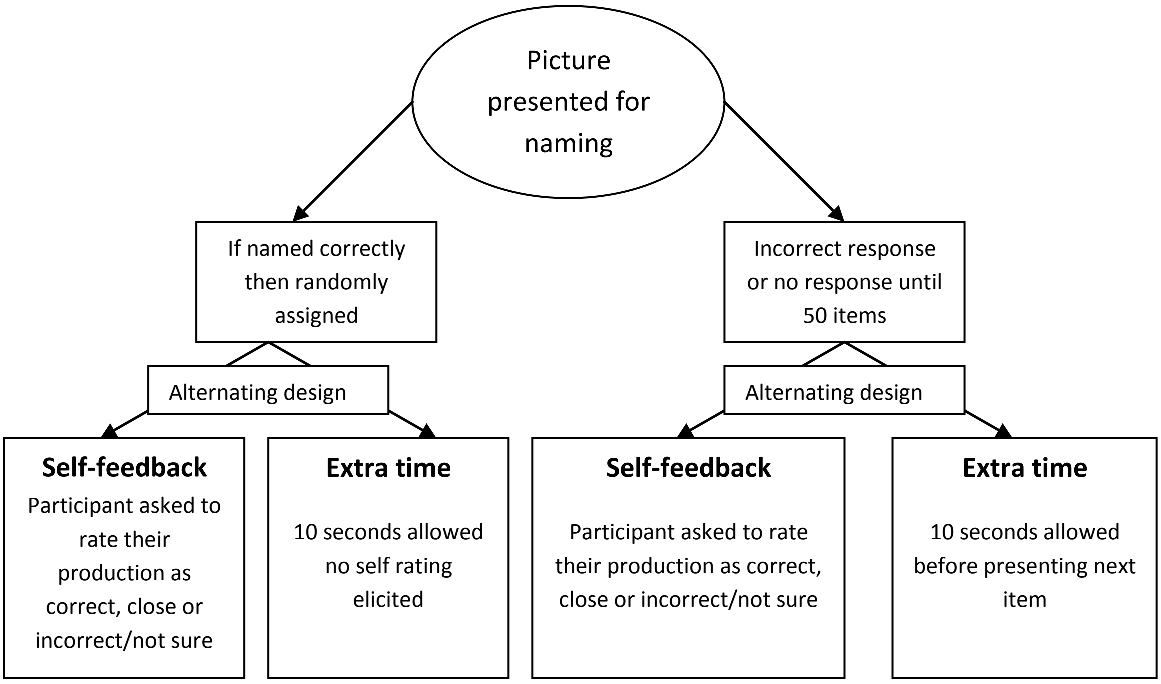
	Target	Response in 5 seconds	Correct response		Incorrect response		Delayed naming
			Accurate feedback	Extra time (10 secs)	Accurate feedback	Extra time (10 secs)	
1	Cork						
2	Rose						
3	Boot						
4	Girl						

At least 30 minutes after completion of initial naming attempts all items are re-presented for naming (delayed naming). At delayed naming each picture is presented for a maximum of 5 seconds, or until the correct response is given, before then next picture is presented.

3.3.5: Facilitation with self-feedback compared with extra time

Participants are shown a picture and asked to name it. After a response has been given, or a maximum of 5 seconds has elapsed, participants are asked to rate their response (self-feedback) or given extra time. The participant's response and subsequent self-feedback is recorded by the clinician on a score-sheet (see example (5) score-sheet). Allocation to self-feedback or extra time is based on an alternating design. When allocated to the self-feedback condition, participants are asked to rate their response from one of three choices: correct, close and incorrect/not sure. These choices are presented in written format with pictorial support. The three response choices were provided to avoid under-estimating participants' ability to self-monitor when they knew the target response but were unable to articulate it precisely (see Sampson and Faroqi-Shah (2011) who found that all participants reported that their responses were accurate on almost all their productions even though there were often a significant number of errors). In the extra time condition participants are given an extra 10 seconds to consider the target name. As in facilitation with clinician-feedback, prior to commencing clear instructions are given so that participants are aware that on occasion extra time is given both when a correct response and an incorrect response has been made. If an error is one of no response then self-feedback still has to occur otherwise the feedback will be inherent. In these cases participants will be instructed prior to the study to indicate incorrect/not sure. See Figure 6 for details of allocation of stimuli.

Figure 6: Allocation of stimuli for facilitation with self-feedback or extra time



At least thirty minutes after completion, 20 items from each condition are presented at delayed naming. In cases where a condition has more than 20 items the first 20 items are presented at delayed naming.

Example (5): score-sheet for self-feedback compared to extra time

	Target	Response in 5 seconds	Correct response		Incorrect response		Delayed naming
			Self feedback	Extra time (10 secs)	Self Feedback	Extra time (10 secs)	
1	Map						
2	Tin						
3	Dice						
4	Gym						

3.4: Statistical analysis

3.4.1: Assessment battery

- **Naming**

As the naming test used is a non-published assessment, no standardised scoring was available. The effects of a number of psycholinguistic variables were analysed for each participants' naming responses. The variables for each item were the number of syllables; word frequency (from Francis and Kucera, 1982); familiarity and imageability (from the MRC Psycholinguistic Database, Coltheart, 1981) and ratings of age of acquisition and operativity (taken from Howard, Best, Bruce and Gatehouse, 1995). For each participant number of correct responses was compared for items with a high and low rating for each variable and analysed using the Wilcoxon paired samples test. The exception was the number of syllables data, for which there were three possible categories, and this was therefore analysed using the Jonckheere Trend Test. Variables that affected individuals' naming responses are reported in the participants' results.

- **Language impairment groupings**

Participants' results on the language assessment battery were subsequently analysed for patterns to indicate the primary loci of impairment: phonological, semantic or mixed. Based on the method used by Howard, Hickin, Redmond, Clark and Best (2006) the number of errors made by each participant was compared to the group by calculating the z scores relative to the group on a particular set of tasks.

In order to ensure this method was sensitive to the domain being measured, assessments were assigned to either the semantic or phonological domain. The following assessments were included in the semantic analysis:

- proportion of semantic errors made on the 200 picture naming test
- number of errors on the picture association version of Pyramid and Palmtrees Test (Howard and Patterson, 1992)
- proportion of semantic errors on the test of spoken word to picture matching (pre-publication version of Comprehensive Aphasia Test (CAT; Swinburn, Porter and Howard, 2004))
- proportion of semantic errors on the test of written word to picture matching (pre-publication version of Comprehensive Aphasia Test (CAT; Swinburn, Porter and Howard, 2004)).

The selection of assessments, and error data used, was based on that used by Howard et al., (2006) but differed in two key ways: Howard et al. included two additional assessments in their analysis which were not used in the current study (Shallice and McGill spoken word comprehension of concrete words, and a word-picture verification task); the current analysis allowed analysis of the proportion of semantic errors made, rather than the total number correct, on the tests of spoken word to picture matching and written word to picture matching (the tests used by Howard et al. did not allow for such a breakdown). As a consequence of using the proportion of errors, participants were considered to have impairment in a particular domain if their summed z score was greater than zero (as opposed to less than zero when number of correct responses is considered).

As the focus of Howard et al. was on relative degree of semantic impairment, phonological impairment was not considered. Therefore, the work of Best, Herbert, Hickin, Osborne and Howard (2002) was used as a reference for selection of assessments to be included in the phonological analysis, in particular with regards to proportion of errors in naming that bore a phonological relationship to the target. However, assessments using non-words were not included in the current analysis, although they had been used by Best et al., due to the possible involvement of processes other than pure phonological output processing. Therefore, the following assessments were included in the phonological domain:

- proportion of phonological errors made on the 200 picture naming test
- proportion of phonological errors made on the test of word repetition
- proportion of phonological errors made on the test of word reading.

The inclusion of these assessments was based on an understanding that successful performance on these measures requires intact phonological output processing.

Those participants who had a positive summed z score for the semantic assessments were assigned as having a primary impairment in the semantic domain, and those participants with a positive summed z score for the phonological assessments were assigned to having a primary impairment in the phonological domain. Where participants had a positive z score for both domains, semantic and phonological, they were assigned to the mixed impairment group. Similarly, participants with a negative z score in both domains were also assigned to the mixed impairment group.

3.4.2: Facilitation

The outcome for each facilitation study was naming accuracy for items in different cueing conditions, on a binomial (right/wrong) scale. Results were combined across participants using the combined S test (Leach, 1979). The data were firstly analysed to see if there had been an effect of treatment versus non-treatment, by combining cues in each facilitation study and comparing these data to the extra time condition. Analysis was subsequently carried out to investigate the effect of each individual cue compared to the extra time condition. This method of statistical analysis was used as it makes optimal use of the available data, while making no assumptions about the distribution (cf. Howard et al., 2006).

Correlations between response to facilitation and background assessments

A number of specific, theoretically-motivated, hypotheses were formed about relationships within the data, pertaining to: language assessments and response to facilitation; language assessments and neuropsychological assessments; neuropsychological assessments and response to facilitation; and patterns between neuropsychological assessments. In order to investigate these relationships, Spearman's correlation coefficient was used. The strength of the correlations was interpreted in line with Cohen (1988, pp79-81) who suggests the following guidelines:

- small rho = .10 to .29
- medium rho = .30 to .49
- large rho = .50 to 1.0.

On all the data, preliminary analyses were carried out to ensure no violation of the assumptions of normality, linearity and homoscedasticity.

Analysis of relationships between response to facilitation and language impairment groups

The next questions involved analysis of both the within-subjects variable and the between-subjects variable, by asking whether there is an effect of different facilitation cues, but also whether the effect is different for the different language impairment groups.

A mixed between-within subjects analysis of variance (ANOVA) was conducted (cf. Tabachnick and Fidell, 2007)to assess the impact of two different language impairment profiles (phonological impairment and semantic+mixed impairment combined) on participants' naming following facilitation with two different cues (for example, phonological cue and repetition).

Subsequently, a one-way between-groups analysis of variance (ANOVA) was conducted to explore the impact of type of language impairment in response to facilitation with different cues as measured by number of items correctly named at a delay. Participants were divided into three groups according to their type of language impairment (Group 1: phonological impairment; Group 2: semantic impairment; Group 3: mixed impairment).

Robustness of facilitation data

In order to establish the stability of results obtained from the facilitation studies, the facilitation data were split into two sets. For each facilitation study, results were split for responses to cued items 1-10 and responses to cued items 11-20.

Paired-samples t-tests were conducted to evaluate the robustness of response to facilitation for items 1-10, compared to items 11-20, by looking at naming at a delay for all cued responses combined across three facilitation studies (phonological cue/repetition, increasing/decreasing cue, initial grapheme/whole written word). The stability of naming accuracy was analysed across the two sets of data (items 1-10 and items 11-20), along with comparability of the psycholinguistic variables: length, neighbourhood density and frequency.

Multiple comparisons

It is acknowledged that there is a wide range of practices and opinions in the literature regarding when corrections should be applied. As the analyses performed for the current study are based on specific, theoretically-motivated hypotheses, planned in advance, it was not considered necessary to carry out corrections.

3.5: Participant biographies

3.5.1: Introduction

Participants were referred to the current study by Speech and Language Therapy clinicians in an NHS Trust to the west of London. Criteria for inclusion was as follows: be at least 6 months post onset of aphasia, be able to give informed consent to participation, score above baseline and below ceiling on a 24 item naming test, not have a significant dyspraxia. Participation involved weekly, one-to-one sessions with the Speech and Language Therapist researcher, with sessions lasting between an hour and an hour and a half. On average participants were involved in the study for 5 months, allowing for breaks taken for holidays and illness. Over the course of involvement participants completed a range of neuropsychological and language assessments, and partook in five facilitation studies. Where possible, participants were seen in the outpatient hospital clinic, but participants who were unable to make their way independently to clinic were seen at their home.

All participants were required to give informed consent after receiving written information about the study and having had the opportunity to speak to the Speech and Language Therapist carrying out the study. Participants were informed that they could withdraw from the study at any time, and without future care being affected (see appendix 1 for a copy of the written information). All protocols and consent forms were reviewed and approved by the local REC committee.

Thirteen people with aphasia were screened for inclusion in the study, and ten were subsequently recruited. The reason for non-inclusion of the three additional participants was due to scoring at ceiling on the naming screen, leaving insufficient scope for improvement with cues. Of the ten people with aphasia recruited to the study, eight completed the study. The two participants who were unable to complete the study withdrew, one due to a return to alcohol abuse and the other by mutual agreement after demonstrating obvious signs of fatigue during sessions.

Each of the participants who completed the study is described below, along with an account of their language processing. The response to language assessment measures are considered in the order in which they are described in the language assessment chapter.

3.5.2: Anne

Anne is a 69 year old woman who had a stroke six years prior to participating in the study. She is a widow, lives alone in an apartment and has two children with whom she is not in regular contact.

Anne’s stroke resulted in a right-sided hemiplegia which affects her arm and, to a lesser degree, her leg. She is independent for most of her activities of daily living, although she is supported by friends for tasks around the house that she is unable to manage, and has just started having hot meals delivered once a day. Anne’s aphasia is characterised by non-fluent speech, with spoken output consisting mainly of content words. Anne’s comprehension is functional in conversation, but breaks down when there is an increase in processing load. In addition to her aphasia, Anne has dyspraxia but it is not considered to prohibit spoken word production once a word form is retrieved.

Prior to her stroke Anne was a retired secretary who enjoyed spending her time pursuing her hobbies of stamp collecting and gardening, and enjoyed eating out. Since her stroke, Anne has joined a local, stroke survivors’ support and social group, through which she has made many friends and enjoys a busy social calendar. In addition, Anne attends a weekly group for people with communication difficulties.

3.5.3: Derek

Derek is an active 81 year old man who had a stroke two years prior to participating in the study. He lives with his wife, and they have a daughter who lives nearby.

Derek’s stroke resulted in aphasia, right-sided upper limb weakness and right-sided neglect. His spoken output is fluent but filled with neologisms and jargon. Derek requires minimal support from his wife for activities of daily living.

Prior to his stroke, Derek was retired from a varied career which included being a pilot in the Royal Air Force and working as a chartered surveyor. He retired at 60 years of age, and enjoyed pursuing his hobbies of gardening, reading and socialising. Since his stroke, Derek has been attending a weekly group for people with communication difficulties and working in his garden. Derek has been unable to read since his stroke and misses this greatly. He has tried to pursue his love of literature by listening to audio tapes but has discontinued with this due to self-identified difficulties in attention and comprehension.

3.5.4: Jon

Jon is a 56 year old man who had a stroke one year prior to participating in the study. He lives with his wife, their 12 year old son and Jon's 20 year old son from his first marriage.

Jon has no marked physical weakness and is independent for all activities of daily living. He has fluent aphasia with marked anomia characterised by semantic and phonological errors, and lack of retrieval. His comprehension is good when information is presented in a paced manner in the absence of distractions, but breaks down when distractions are present or if too much information is presented at once.

Prior to his stroke, Jon owned his own business which he had to sell as a result of his stroke. Jon now fills his time with volunteering for a number of different local organisations and attending further education courses in dancing and British Sign Language.

3.5.5: Steve

Steve is a 25 year old man who suffered a head injury as a result of a road traffic accident, six years prior to participating in the study. He lives alone in a house very near his parents, with his extended family also close by.

Steve's head injury resulted in aphasia, a mild right-sided upper limb weakness, mild cognitive impairment and right-sided neglect. Steve's aphasia is characterised by non-fluent production, with semantic and phonological errors. Since his head injury, Steve has had a daily carer to support him with everyday tasks.

Prior to his head injury, Steve worked as a mechanic, which was both his job and his hobby. Although no longer able to drive, Steve maintains an active interest in cars and has his own car which he enjoys working on. Every week Steve attends a support group, engages in rehabilitation programmes and works with his father at his garage.

3.5.6: Ernie

Ernie is a 73 year old man who had his stroke five years prior to participating in the study. He lives with his wife and mother-in-law. He has a son and a daughter living nearby with their families, with whom they are in regular contact.

Ernie's stroke resulted in aphasia and mild right-sided upper and lower limb weakness. Ernie is independent for all activities of daily living. Ernie has fluent spoken production with marked anomia, characterised primarily by phonological errors. His comprehension is good for informal conversation, but can break down when there are distractions, or if too much information is presented.

Prior to his stroke, Ernie was a retired businessman who had run his own building company. He enjoyed socialising, meeting friends most evenings for a drink. Since his stroke, Ernie spends his time with his family and only occasionally meets his friends, finding this difficult due to his aphasia.

3.5.7: Paul

Paul is a 76 year old man who had a stroke four years prior to participating in the study. Paul lives with his wife, although she works away from home leaving Paul alone for five days in every seven. He also has two sons.

Paul's stroke left him with no marked physical disability, although he reports generalised residual weakness on the right side. Paul is independent for all activities of daily living and uses local public transport to get around. Paul has fluent aphasia with marked anomia. His word finding difficulties are characterised by both semantic and phonological errors.

Prior to his stroke Paul was a retired businessman from the building trade, who enjoyed playing golf and bridge. Since his stroke, Paul has found he is no longer able to pursue these hobbies. He now attends a weekly social group for stroke survivors and sees one of his sons regularly. He enjoys taking bus trips into town to browse shops and visit cafes. In addition, he is in regular contact with his family in Ireland, and makes frequent trips to Dublin to visit them.

3.5.8: Tony

Tony is a 72 year old man who had his stroke four years prior to participating in the study. Tony lives with his wife, and together they have two children and several grandchildren with who they are in regular contact.

Tony's stroke resulted in mild right-sided weakness and right-sided neglect. He is independent in activities of daily living. Tony's aphasia is characterised by fluent speech containing both semantic and phonological errors. In addition, he has a mild dyspraxia.

Prior to his stroke, Tony was enjoying retirement from a varied career, which was mainly in the farming industry, primarily pursuing his passion for gardening. Since his stroke, Tony has been attending a weekly group for stroke survivors and is able to continue enjoying gardening.

3.5.9: Richard

Richard is a 58 year old man who had his stroke three years prior to participating in the study. Richard lives with his wife, and has his son, daughter, grandchildren and parents all living nearby.

Richard's stroke has left him with a moderate aphasia but no marked physical weakness. His aphasia is characterised by fluent speech filled with neologisms and use of jargon. His comprehension is impaired and he makes use of cues in multiple modalities to facilitate his understanding. Richard's impairment of spoken word processing is mirrored, but more severe, in his comprehension and output of the written word.

Prior to his stroke, Richard was running his own business in computing, which he had set up twenty years previously. Since his stroke, Richard's son and wife have taken over the running of the business. Initially, Richard was unable to contribute to the business, but over time he has increased his role there, working at first on the practical side and moving increasingly into customer relations. Outside of work, Richard enjoys spending time with his family, watching motorsports and walking.

See Appendix 2 for a summary table of participants' background information.

4: Results

4.1: Results: Introduction

The results that follow are reported in the following sub-sections:

- language assessments
- facilitation
- neuropsychological assessments
- relationships between language profiles and facilitation
- relationships between language profiles and neuropsychological profiles
- relationships between neuropsychological profiles and facilitation
- responses to feedback.

A note about correlations

A series of Spearman's correlation coefficients was performed in order to investigate the hypotheses for each of the three areas under investigation in the thesis: language, neuropsychology and facilitation. The strength of all the correlations is interpreted in line with Cohen (1988, pp79-81) who suggests the following guidelines:

- small rho = .10 to .29
- medium rho = .30 to .49
- large rho = .50 to 1.0.

In each case preliminary analyses were carried out to ensure no violation of the assumptions of normality, linearity and homoscedasticity. Where a violation was found this is noted in the text.

For each relationship investigated, a specific, theoretically driven hypothesis is tested.

4.2: Results: Language Assessments

4.2.1: Results: Participants' Language Profiles

Participants are ordered throughout the thesis in the order in which they were recruited to the study.

4.2.1.i: Anne

Input tasks

On a test of sound to letter matching, Anne scored 13/14. Her one error was related to the target in voicing, but not in place or manner.

On the three picture version of the Pyramid and Palm Tree Test, Anne scored 51/52 which is within normal limits for this task.

On spoken word to picture matching (SWPM), Anne scored 28/30 with both errors arising from selection of the distractor semantically related to the target word. A similar pattern was observed in written word to picture matching (WWPM), in which Anne scored 27/30 with all three errors being semantically related distractors.

At the sentence level, Anne scored 11/16 on spoken sentence to picture matching, with incorrect responses occurring due to lexical and reversal errors.

Output tasks

On assessments using non-words, Anne scored 5/26 for repetition and 2/26 for reading aloud. Access to the initial phoneme was better for repetition than for reading (14 and 8 respectively). Anne's poor performance on these tasks, considered alongside her relatively good performance on sound to letter matching, suggests impaired phonological output processing.

On assessment of word repetition, Anne scored 11/52. Of the total of 52 items, Anne correctly accessed the initial phoneme for 29 (including the 11 completely correct repetitions), and 39 of the 41 incorrect responses contained over 50% of the target phonemes. Overall, errors were broken down as 40/41 (98%) phonologically related to the target and 1/41 (2%) no response. Anne's performance was better on word reading with 21/52 correct. Twenty four of the 31 incorrect responses contained over 50% of the target phonemes. Error breakdown revealed 29/31 (94%) of productions to be phonologically related to the target item, with 2/31 (6%) arising from no response. This pattern of errors suggests that Anne was able to access partial information about the words, but was unable to either fully retrieve, or maintain the complete lexeme for successful production.

On the 200 picture naming test, Anne named 104 correctly. Anne's responses were scored as correct even when there was a difference of one phoneme between her response and the target item, in order to allow for errors arising as the result of her dyspraxia. The majority of her errors on this test were phonological in nature, 41/96 (43%), with semantic errors accounting for 27/96 (28%). Analysis of variables that affected naming revealed age of acquisition ($z = 1.84$, $p=0.03$) and operativity ($z = 2.20$, $p=0.01$) to be significant factors. Anne also demonstrated a significant length effect with longer words being more difficult to name ($z = -2.05$, $p = 0.02$).

On assessment of written output, Anne correctly wrote the name for 15/40 pictures. The majority of errors were orthographically related to the target, 14/25 (56%) with semantic errors accounting for 7 (28%) of the total errors.

Summary

Anne's overall pattern of processing suggests that for input tasks she has good sub-lexical and lexical processing but a mild semantic impairment, as shown by error analysis of SWPM and WWPM. With regard to spoken word production, primary locus of impairment appears to lie at the output phonological level with the majority of errors on all output tasks being phonologically related to the target item. As productions often share a large percentage of phonemes with the target items, it is suggested that there is impairment either within the phonological output lexicon or in the phonological output buffer. Further evidence for a phonological impairment comes from the variables affecting Anne's naming, with both age of acquisition and length known to be reflective of phonological impairment. In addition to the primary phonological impairment, a secondary impairment at the semantic level is indicated by error analysis of spoken production tasks. Although such errors could be accounted for by an impaired phonological output lexicon resulting in semantically related competitors being activated, the finding of semantic errors on input tasks, suggests that these semantically related output errors arise from impaired semantic processing.

4.2.1.ii: Derek

Input tasks

On assessment of sound to letter matching, Derek scored 12/14. Both errors differed from the target phoneme by one parameter only (voice and place respectively).

On the three picture version of the Pyramid and Palm Trees Test, Derek scored 49/52, which is within normal limits. On assessment of spoken word to picture matching Derek scored 27/30, with all errors resulting from selection of the semantic distractor. On written word to picture matching Derek scored 28/30, and again both errors were semantically related to the target.

At the sentence level, Derek scored 12/16 on the auditory sentence to picture matching test from the Comprehensive Aphasia Test (CAT; Swinburn, Porter and Howard, 2004). Two of his errors resulted from incorrect lexical retrieval whilst the other two were the result of reversal errors.

Output tasks

Of the two assessments using non-words, Derek scored 1/26 for repetition and 15/26 for reading, showing an advantage for written over spoken input for this task. Breakdown of errors shows that Derek did have better access to the initial phoneme for both tasks, with 19/26 initial phonemes accessed successfully for non-word repetition and 25/26 initial phonemes accessed successfully for non-word reading. This indicates that Derek is able to access partial information about the words, even when unable to access the whole word form.

On assessment with a set of 52 words, Derek scored 15 for repetition and 42 for reading, demonstrating again an advantage for written over spoken input for this type of test. The majority of the errors were phonologically related to the target for both assessments (30/37 (81%) on repetition and 10/10 (100%) on reading).

When presented with 200 black and white line drawings for naming within 10 seconds, Derek named 68 correctly. His largest category of errors was that of no response within the time limit (66/132 (50%)), followed by semantic then phonological errors (43/132 (33%) and 14/32 (11%) respectively). His naming was found to be significantly affected by three variables; imageability (z = 1.89, p = 0.03), familiarity and frequency (z = 2.57, p = 0.0005) and age of acquisition (z = 1.89, p = 0.03). On a 40 item cohort presented for written naming, Derek scored 8/40. Again the largest category of errors was no response (19/32 (59%)), followed by an equal proportion of semantic and orthographic related errors (6/32 (19%)).

Summary

Derek's input processing indicates relatively unimpaired sub-lexical processing with a mild sematic impairment as indicated by error analysis of SWPM and WWPM. His performance on repetition compared to reading, considered alongside his input processing abilities, suggests that he using a sub-lexical or lexical route for both of these tasks, and this route is impaired for phonological conversion more than orthographic conversion. The finding that he makes few or no semantic errors in these tasks, yet makes semantic errors on input processing, supports the hypothesis that he does not use a semantic route to perform these tasks.

With regards to spoken word production, in particular errors on spoken naming, impairment at the level of semantics or access to the phonological output lexicon is indicated, and this is corroborated by the variables that affect his naming. However, error patterns suggest an additional impairment with phonological output processing.

4.2.1.iii: Jon

Input tasks

Jon scored 12/14 on the test of sound to letter matching, both errors resulted from selecting graphemes that differed from the target sound by just one key feature.

On the three picture version of the Pyramids and Palm Trees Test, Jon scored maximum marks, 52/52, suggesting good semantic processing when accessed via pictorial input. Further tests of semantic processing also suggest good access to this system via spoken and written input, with Jon scoring 30/30 on both spoken word to picture matching and written word to picture matching. At the sentence level, Jon scored 14/16 on the CAT spoken sentence to picture matching test, both errors involving lexical items.

Output tasks

On the tests using non-words, Jon scored 14/26 on the test of repetition and 12/26 on the test of reading. Access to the initial phoneme was better than access to the whole word for both tasks, 24/26 and 22/26 respectively, suggesting that in both cases Jon was able to retrieve partial information about the word.

Using words, Jon scored 42/52 on repetition, and 46/52 on reading. Across these tests, all errors were phonologically related to the target word.

On assessment of spoken naming for a set of 200 pictures, Jon named 151 correctly. Error breakdown revealed the majority of errors to be phonological in nature, 22/49(45%) with semantic errors accounting for 7/49 (14%) of total errors and no response a further 10/49 (20%) of the total errors. Jon's naming was found to be affected by the variables of age of acquisition ($z = 3.12$, $p = 0.0009$) and length ($z = -1.67$, $p = 0.05$) with longer items being more difficult to name than shorter words. On written picture naming, Jon wrote 35/40 correctly. The breakdown of errors presented a different profile to that of spoken picture naming, with semantic errors accounting for 4 of the total errors, and use of a homonym (pale for pail) being the other error.

Summary

Jon's performance suggests good input processing at the single word level but a possible mild impairment at the auditory acoustic level as indicated by a below ceiling performance on sound-to-letter matching. Jon's better performance with words compared to non-words on repetition and reading, suggests that he uses a semantic route for these tasks which is less impaired than the sub-lexical route used for non-word processing. His production of phonological errors in repetition, reading and spoken naming tasks, combined with his ceiling level performance on semantic input tasks, indicate a primary locus of impairment along the phonological output processing route. Furthermore, the finding that phonological variables affect naming suggests primary impairment to be located along this route.

4.2.1.iv: Steve

Input tasks

Steve scored 8/14 on assessment of sound to letter matching indicating impairment in this peripheral aspect of input processing.

Using the three picture version of the Pyramid and Palm Trees Test, Steve scored 44/52. This result falls outside the normal limits and suggests impaired semantic processing. On assessment of spoken word to picture matching, Steve scored 25/30, with all errors resulting from selection of the semantic distractor. Assessment of written word to picture matching resulted in the same performance level, 25/30, however errors were split between selection of the semantic distractor (3) and selection of the orthographic distractor (2). At the sentence level, Steve scored 11/16 on assessment of spoken sentence to picture matching. Breakdown of errors reveals one error to have arisen from a problem with lexical access; the remaining four errors all resulting from selection of the reversed sentence.

Output tasks

Steve scored 16/26 on assessment of non-word repetition, and accessed the initial phoneme correctly for 8/10 incorrect responses. Assessment of non-word reading was abandoned due excessive difficultly and stress caused by this task.

Using words, Steve scored 43/52 on repetition and 11/52 on reading. Analysis of errors shows all errors from the repetition assessment to be phonologically related to the target (9/9), whilst this accounts for only 6/41 (15%) of errors on the reading assessment. The two other largest error categories on the reading assessment were categorised as being semantically related to the target 7/41 (17%) or no response 24/41 (59%). This error pattern indicates that Steve uses a lexical and/or semantic route for reading but not necessarily for repetition.

On assessment of spoken word naming, Steve named 72/200 correctly. Steve's largest category of errors resulted from retrieval of words semantically related to the target, 63/128 (49%), with the next largest error category being that of no response within the time limit, 45/128 (35%). Errors phonologically related to the target accounted for just 9/128 (7%) of the total number of errors. Steve's naming was found to be affected by familiarity and frequency of the target items ($z = 1.69$, $p = 0.05$). An assessment of written naming was abandoned after six items, with no correct responses, as Steve found this too strenuous.

Summary

Steve's overall performance on the language assessments is consistent with impaired semantic processing. Additionally, performance on sound to letter matching and non-word repetition suggest impaired phonological input processing as well as possible impaired phonological output processing, as indicated by his error pattern on word repetition and reading, and the variable affecting spoken naming.

4.2.1.v: Ernie

Input tasks

Ernie was 100% accurate on a test of sound to letter matching, scoring 14/14.

On the three picture version of the Pyramid and Palm Tree Test, Ernie scored 50/52 which is within normal limits.

On spoken word to picture matching and written word to picture matching, Ernie scored at ceiling, 30/30, indicating intact processing at the single word level. At the sentence level, Ernie again scored maximum marks, 16/16, on spoken sentence to picture matching, suggesting no impairment at the sentence level as assessed by this test.

Output tasks

On assessment with non-words, Ernie scored 4/26 for repetition, but correctly accessed 16/26 initial phonemes. His error breakdown indicated that he was using a lexical route to perform this task with 17/22 errors being lexicalisations. On non-word reading, Ernie scored 4/26, with only 4/22 errors being lexicalisations. Access to the initial phoneme was better than access to the whole word with 23/26 accessed correctly, suggesting that Ernie was able to retrieve partial information about the word.

Using words, Ernie correctly repeated 40/52 single words, and correctly read aloud 50/52 of the same items. All errors, on both assessments, were phonologically related to the target.

Ernie correctly named 181/200 black and white pictures. Analysis of the errors revealed 8/19 (42%) of the total errors to be semantically related to the target word and 6/19 (32%) were phonologically related to the target word. He produced no response within the time limit for the remaining items. His naming was affected by familiarity and frequency ($z = 2.10$, $p = 0.02$).

On assessment of written naming, Ernie correctly wrote the name for 19/40 pictures. All 21 errors were orthographically related to the target word.

Summary

Overall, Ernie's performance on input tasks was at ceiling for all but the Pyramid and Palm Tree Test, which was still within normal limits, suggesting relatively intact input processing. However, anecdotal reports of comprehension breaking down when processing demands increase indicates that supporting cognitive processes may be impaired. His poor performance on assessments using non-words, and his error pattern for repetition and reading of words, suggests his primary locus of impairment is located within the sub-lexical processing route. In addition, his errors on picture naming indicate a secondary impairment either within the semantic system or in access to the phonological output lexicon.

4.2.1.vi: Paul

Input tasks

On the test of sound to letter matching, Paul scored at ceiling (14/14).

On the three picture version of the Pyramid and Palm Trees Test, Paul scored 48/52, a score which is just outside normal limits and indicates a mild impairment of semantic processing.

On spoken word to picture matching and written word to picture matching Paul scored 28/30. The two errors made on both assessments were semantically related to the target word.

At the sentence level, Paul scored 16/16 on the test of spoken sentence to picture matching.

Output tasks

On the assessments using non-words, Paul scored 4/26 on the test of repetition and 6/26 on the test of reading aloud. Access to initial phoneme was better for both tests being 19/26 and 17/26 for repetition and reading, respectively. Error analysis shows a greater tendency towards lexicalisation for repetition than for reading (6 errors and 1 error, respectively), while errors phonologically related to the target word were the most common for both repetition and reading (20 and 16, respectively).

Using words, Paul scored 41/52 on assessment of repetition and 29/52 on assessment of reading aloud. Error analysis reveals the most common error type for both tests to be production of words phonologically related to the target (10/11 (91%) and 20/23 (87%) for repetition and reading respectively).

On the picture naming assessment of 200 black and white line drawings, Paul named 115 correctly. Error analysis shows a fairly even number of phonological and semantic errors (27/85 (32%) and 33/85 (39%) respectively). Other errors were accounted for by no response within the time limit, 16/85 (19%) and unrelated words, 9/85 (11%). His naming was affected by the variables of familiarity and frequency ($z = 2.87$, $p = 0.002$) and length ($z = -1.79$, $p = 0.04$).

On assessment of written naming, Paul scored 4/40 correctly. The majority of errors were orthographically related to the target (21) with just 2 semantically related to the target word. The remaining errors were mixed or no response.

Summary

Paul's performance on the input tasks is indicative of an impairment either in access to, or within, the semantic system. Further evidence of an impairment at the level of semantics is provided by the number of semantic errors made in spoken naming, although this could be reflective of impairment in accessing the phonological output lexicon. Overall performance on the output tasks suggests an additional impairment in phonological processing, as suggested by the number of phonologically related errors made on repetition, reading and spoken naming, and the variables that affect his naming. The finding of better access to initial phoneme on non-word reading and non-word repetition than whole word production suggests an additional breakdown in the phonological output buffer.

4.2.1.vii: Tony

Input tasks

Tony was identified as having difficulty with the phonological input task of sound to letter matching, scoring 9/14 on this test. Errors were mainly out by just one feature (4/5) with the exception of one error which differed from the target by all three features (place, manner and voice). Tony wears a hearing aid, but reported that he could hear adequately to perform this task, however it is not possible to definitively exclude this as the reason for his poor performance on this task.

On the three picture version of the Pyramid and Palm Trees Test, Tony scored 51/52, which is within normal limits. On spoken word to picture matching Tony scored 27/30 and on written word to picture matching he scored 29/30. The errors on both tasks were semantically related to the target item.

Output tasks

On testing with non-words, Tony scored 10/26 on repetition and 0/26 on reading, strongly suggesting impaired orthographic to phonologic conversion. This pattern was reflected in access to initial phoneme with 13/26 accessed correctly in the repetition task and only 5/26 accessed correctly in the reading task. Error analysis revealed a tendency towards lexicalisation in both tasks with six occasions of lexicalisation in the repetition task and five in the reading task (e.g. ‘blice’ became ‘blood’).

Using real words, Tony scored 45/52 on a test of repetition and 49/52 on a test of reading aloud, showing that impaired orthographic-to-phonologic conversion was not evident when using words. This suggests that Tony uses a lexical route for reading aloud. Error analysis of the word tasks shows all errors on the repetition test to be words phonologically related to the target word. This was not true for the three errors on the reading test: two of the errors were with three syllable words, suggesting a length effect and the remaining error was of morphology with the word ‘ski’ being read as ‘skiing’.

On spoken picture naming, Tony scored 121/200. Error analysis shows that the majority of errors were semantically related to the target word, 37/79 (47%), closely followed by no response within the time limit, 36/79 (46%). Errors that were phonologically related to the target word accounted for just 4/79 (5%) errors, revealing a striking disparity in error pattern between repetition and reading tasks, and naming tasks. Furthermore, analysis of variables affecting naming revealed the semantically orientated variable of imageability to significantly affect Tony’s spoken picture naming ($z = 2.16$, $p = 0.02$).

Written naming was found to be more impaired than spoken naming, with Tony completing 5/40 correctly. Error analysis demonstrates that Tony has partial access to the orthographic form, with the largest number of errors, 16/35 (46%), being orthographically related to the target word (for example, LAFERS for LOAF and JARRET for PARROT). A further 14/35 (40%) of errors were the result of no response within the time limit, and just 2/35 (6%) of errors were semantically related to the target word (for example, DINER for TABLE).

Summary

Tony’s input processing suggests a relatively mild impairment at the semantic level, with semantic errors made on both spoken word and written word to picture matching. However, additional indications for a primary locus of impairment at the semantic level is evidenced by the large number of semantic errors made on spoken naming and the fact that imageability significantly affects naming. Finally, a degree of impairment within the phonological system is suggested by the errors made on both repetition and reading aloud.

4.2.1.viii: Richard

Input tasks

On a test of sound to letter matching, Richard scored 14/14 indicating no impairment at this peripheral level of processing.

On the three picture version of the Pyramid and Palm Trees Test Richard scored 47/52, which is outside normal limits, indicating impairment either in this access route to the semantic system or in the semantic system itself. However, on spoken word to picture matching Richard scored 30/30 and he scored 29/30 on written word to picture matching (the one error being semantic in nature) indicating better access to the semantic system via these pathways.

At the sentence level, Richard scored 12/16, with two of the errors being made on reversible sentences and two errors arising at the lexical level.

Output tasks

On the assessments using non-words, Richard showed a marked discrepancy in performance between tasks, scoring 14/26 on repetition and just 1/26 on reading aloud. Access to the initial phoneme was also markedly different with 25/26 initial phonemes accessed correctly on the repetition task, and 12/26 initial phonemes accessed correctly on the reading task.

Using words, Richard showed a similar discrepancy in performance scoring 44/52 on repetition and just 5/52 on reading aloud. Again, access to the initial phoneme was better in the repetition task with 50/52 accessed correctly, compared to 38/52 accessed in the reading task. In both tasks the majority of errors were phonologically related to the target word (7/8 (88%) for repetition and 26/47 (55%) for reading). The results of the assessments with non-words and words suggest better processing for spoken word input over written word input. Additionally, as the results were similarly impaired for both words and non-words, it would suggest that either Richard uses the same processing route for words as for non-words, i.e. sublexical, or that he has impairment in both the sublexical and lexical reading route.

Richard's performance on picture naming was markedly impaired as he named 12/200 correctly. The largest number of errors fell into the 'other' category, 72/188 (38%) which included 28 unrelated real words (for example, face for grass) and 41 unrelated non-words.

‘No response’ accounted for 58/188 (31%) errors, and phonological errors accounted for a further 48/188 (26%), with semantic errors making up just 10/188 (5%).

On written naming, Richard scored 10/40, with the largest group of errors being orthographically related to the target word, 18/30 (60%).

Summary

Richard’s pattern of performance shows relatively good input processing from the auditory peripheral level through to semantics. Performance on the Pyramids and Palm Trees Test indicates impairment either in access to the semantic system via pictures, or within the semantic system itself. With regards to spoken output, performance was better for processing of both words and non-words when the target item was presented in the spoken rather than written modality, suggesting impairment in the orthographic sublexical route. Error analysis of repetition and reading tasks indicates impairment in phonological processing, either within the phonological output lexicon or in the phonological output buffer. Hence, Richard’s pattern of performance suggests different loci of impairment, within both the semantic and phonological system.

See appendix 3 for a summary table of participants’ language assessment scores.

4.2.2: Language Impairment Grouping

A z score analysis was carried out using the participants’ results above, and following the method described on page 108. Participants were assigned as having a primary semantic impairment, a primary phonological impairment or a mixed impairment. Where participants have a positive z score it is indicative of impairment, compared to the group, in the domain being measured. The positive z scores are highlighted in table 4.2.i.

A positive z score in one domain, phonological or semantic, is interpreted as indicative of a primary impairment in this domain. A positive, or negative, z score in *both* domains is interpreted as a mixed impairment.

Table 4.2.i: summed z scores for semantic and phonological assessments for each participant

Participant	Semantic summed z score	Phonological summed z score
Anne	-0.33	3.285271
Derek	1.57	-2.57311
Jon	-5.07	0.541597
Steve	3.62	-2.94139
Ernie	-2.48	2.925446
Paul	2.36	0.891156
Tony	1.66	-0.24699
Richard	-1.33	-1.88199

Based on this analysis, Table 4.2.ii below shows the primary impairment classification for each participant.

Table 4.2.ii: classification of primary impairment for each participant based on z scores.

Primary semantic impairment	**Primary phonological impairment**	**Mixed impairment**
Derek	Anne	Paul
Steve	Jon	Richard
Tony	Ernie	

The participants' assignment to different impairment groups, as above, is used to carry out analysis of the data in the following results sections.

4.3: Results: Facilitation

4.3.1: Response to facilitation

Combined S Tests

The facilitation data were analysed for the group by combining, across participants, response to different facilitation cues using the combined S test (Leach, 1979). The method of analysis is described on page 110. For each subsection, a table is provided to show the raw data used to perform the S test. The tables show the number correct and the number incorrect of naming responses at a delay for each participant, in each facilitation condition. In each condition (for example, repetition) the number correct and the number incorrect for any participant totals 20.

The results below refer to, and follow the order of, the five facilitation studies described in the methods section, page 98.

4.3.1.i: Phonological cue and repetition facilitation

The effect on delayed naming of initial phoneme and repetition facilitation was compared to extra time for the group, see Table 4.3.i for data.

Table 4.3.i: Table showing the delayed naming results as number correct and number incorrect for each participant in phonological cue, repetition and extra time facilitation.

Participant	extra time		repetition		phonological cue	
	correct	Incorrect	correct	incorrect	correct	incorrect
Anne	11	9	14	6	9	11
Derek	6	14	5	15	0	20
Jon	15	5	17	3	14	6
Steve	5	15	9	11	3	17
Ernie	10	10	9	11	9	11
Paul	10	10	12	8	9	11
Tony	6	14	14	6	7	13
Richard	1	19	1	19	4	16

For the participants taken together, there was no main effect of treatment for combined phonological and repetition cues compared to extra time ($z = 0.37$, $p = 0.36$), and this was reflected in the individual results with no participant finding the combined effects of these cues more beneficial than extra time. For the group, the effect of repetition was found to be significantly better than extra time ($z = 2.12$, $p = 0.02$) and significantly better than phonological cues ($z = 3.71$, $p = 0.0001$). This latter effect was reflected in the results for three of the individual participants in which there was a significant difference between delayed naming following repetition and delayed naming following phonological cueing: Derek ($p = 0.02$), Steve ($p = 0.04$) and Tony ($p = 0.03$). It is of interest to note that these three participants were all classified as having a primary semantic deficit.

4.3.1.ii: Increasing and decreasing cues facilitation

The effect on delayed naming of increasing and decreasing cues facilitation was compared to extra time for the group, see Table 4.3.ii for data.

Table 4.3.ii: Table showing the delayed naming results as number correct and number incorrect for each participant in increasing cues, decreasing cues and extra time facilitation.

Participant	extra time		increasing cues		decreasing cues	
	correct	Incorrect	correct	incorrect	correct	incorrect
Anne	8	12	12	8	16	4
Derek	5	15	4	16	4	16
Jon	12	8	18	2	14	6
Steve	2	18	5	15	5	15
Ernie	7	13	9	11	16	4
Paul	4	16	12	8	11	9
Tony	12	8	9	11	11	9
Richard	2	18	5	15	3	17

For the group there was a main effect of treatment (increasing + decreasing cues) over extra time ($z = 3.52$, $p = 0.0002$). This was reflected in the individual results of three participants who either had a significant difference between treatment and extra time: Anne ($p = 0.026$), Ernie ($p = 0.041$) and Paul ($p = 0.006$). Of particular interest here is the finding that of the individuals who benefitted most from the combined effect of this facilitation, two (Anne and Ernie) were categorised as having a primary phonological deficit, while Paul was assigned to the mixed phonological/semantic impairment group.

For the group there was no significant difference between increasing and decreasing cues ($z = 0.74$, $p = 0.23$), although considering the individual responses one participant, Ernie, did benefit significantly more from decreasing cues that increasing cues ($p = 0.02$).

4.3.1.iii: Initial grapheme and whole written word facilitation

The effect on delayed naming of initial grapheme and whole written word facilitation was compared to extra time for the group, see Table 4.3.iii for data.

Table 4.3.iii: Table showing the delayed naming results as number correct and number incorrect for each participant in initial grapheme, whole written word and extra time facilitation.

Participant	extra time		written word		initial grapheme	
	correct	incorrect	correct	Incorrect	correct	incorrect
Anne	6	14	19	1	12	8
Derek	3	17	5	15	5	15
Jon	9	11	15	5	15	5
Steve	3	17	11	9	7	13
Ernie	9	11	15	5	12	8
Paul	5	15	9	11	6	14
Tony	4	16	6	14	8	12
Richard	2	18	1	19	3	17

For the group there a significant main effect of treatment (initial grapheme + whole written word) over extra time ($z = 4.83$, $p = 0.0000$). Of the two treatments, there was a significant improvement in naming following cueing with the whole written word compared to cueing with the initial grapheme ($z = 2.17$, $p = 0.015$), although when considering the individual participants, this latter finding only reached significance for Anne ($p = 0.01$).

4.3.1.iv: Clinician delivered feedback

The effect of clinician delivered feedback was compared to extra time for the group following both incorrect and correct responses at delayed naming, see Table 4.3.iv for data.

Table 4.3.iv: Table showing the delayed naming results as number correct and number incorrect for each participant in clinician delivered feedback for correct and incorrect responses at immediate naming, and extra time following correct and incorrect responses at immediate naming.

Participants	Clinician feedback for items correctly named at immediate naming		Extra time for items correctly named at immediate naming		Clinician feedback for items incorrectly named at immediate naming		Extra time for items incorrectly named at immediate naming	
	correct	incorrect	correct	incorrect	correct	incorrect	correct	incorrect
Anne	17	3	16	4	15	5	6	14
Derek	10	10	12	8	1	19	4	16
Jon	16	4	19	1	14	6	10	10
Steve	16	4	15	5	6	14	2	18
Ernie	17	3	18	2	11	9	8	12
Paul	18	2	16	4	7	13	6	14
Tony	20	0	14	6	8	12	6	14
Richard	10	10	8	12	0	20	2	18

For the group there was no significant effect of feedback over extra time following correct responses at delayed naming ($z = 0.83$, $p = 0.21$) but there was a significant effect for the group for feedback following incorrect responses ($z = 2.29$, $p = 0.01$). However, as Table4.3.iv shows, there were two participants: Derek and Richard, for whom the opposite pattern was true numerically with there being a small advantage of extra time over feedback for those items named incorrectly at immediate naming.

4.3.1.v: Self-feedback

The effect of self- feedback was compared to extra time for the group following both incorrect and correct responses at delayed naming, see Table 4.3.v for data.

Table 4.3.v: Table showing the delayed naming results as number correct and number incorrect for each participant in self-feedback for correct and incorrect responses at immediate naming, and extra time following correct and incorrect responses at immediate naming.

Participant	Self-feedback for items correctly named at immediate naming		Extra time for items correctly named at immediate naming		Self-feedback for items incorrectly named at immediate naming		Extra time for items incorrectly named at immediate naming	
	correct	incorrect	correct	incorrect	correct	incorrect	correct	incorrect
Anne	17	3	15	5	8	12	6	14
Derek	14	6	14	6	2	18	3	17
Jon	18	2	14	6	16	4	13	7
Steve	16	4	12	8	4	16	4	16
Ernie	20	0	19	1	13	7	16	4
Paul	18	2	17	3	2	18	7	13
Tony	15	5	19	1	3	17	7	13
Richard	16	4	8	12	3	17	1	19

For the group there was a significant effect of self-feedback over extra time following correct responses at delayed naming (z = 2.00, p = 0.0221). This suggests that encouraging participants to reflect on their production, through self-feedback, following a correct response strengthened the association between the stimulus and the target leading to greater success at delayed naming. For the group the effect of self-feedback following incorrect responses compared to extra time was not significant (z = -0.60, p = 0.27). This indicates that when the correct response is not available, encouraging reflection on production does not help word retrieval at a delay.

This double dissociation found between clinician delivered feedback and self-feedback for correct compared to incorrect responses, suggests that following a correct response it is beneficial to encourage people with aphasia to reflect on their response, but following an incorrect response externally delivered feedback is most likely to improve word retrieval on a subsequent occasion.

4.3.2: Validity and robustness of facilitation

T-tests on facilitation data

Since this study was undertaken Nickels, Bachmann, Makin, McDonald, Moses and Taylor (2011, oral presentation at BAS conference) have questioned in their own data the reliability of facilitation as a technique for predicting the outcomes of therapy. Nickels et al. administered the same facilitation task, repetition, and found considerable differences in response to the cue over two presentations, with only two of their fifteen participants showing significant benefits following both presentations.

As it was not possible to repeat the administration of any of the facilitation tasks in the current study, instead the data were divided in two to look at stability of performance. Data were also combined across three of the facilitation studies: phonological cue/repetition, increasing/decreasing cue, and initial grapheme/whole written word. The results from all participants were then combined and cued items 1-10 were compared with cued items 11-20. A series of t-tests was carried out on the stability of naming accuracy, and on three psycholinguistic properties of the cued items in order to identify whether there was any unintentional variability across the two sets.

4.3.2.i: Naming at a delay

A paired-samples t-test was conducted to evaluate the robustness of response to facilitation for items 1-10, compared to items 11-20, by looking at naming at a delay for all cued responses, combined across three facilitation studies and across participants. There was no statistically significant difference in naming scores from items 1-10 (M = 4.75, SD =2.64) to 11-20 (M = 4.31, SD =2.69), t (47) = 1.52, p= 0.13 (two-tailed). The relationship between the results from the two sets of items was investigated using Pearson product-moment correlation coefficient. There was a strong, positive correlation between the two sets of data across participants, r = 0.72, n = 48, $p <$ 0.0005, showing high levels of stability in delayed naming response from item 1-10, to items 11-20.

This result does not replicate the findings of Nickels et al., suggesting that there was a greater stability in response for participants in the current study across two sets of data. This supports the use of facilitation as a valid technique to represent participants' response to intervention.

4.3.2.ii: Psycholinguistic variables

The cued stimuli for all the facilitation studies were not pre-selected. For each participant stimuli were presented until an item was not named successfully and naming for this item was then facilitated with a cue. Use of this method allows items to be facilitated for naming in the moment that word retrieval has broken down. However, it prevents items from being pre-sorted into sets that are balanced for psycholinguistic variables. Therefore, using the same method for dividing the data as used to analyse stability of naming response, further t-tests were carried out to examine the comparability of three key psycholinguistic variables known to affect naming: length, neighbourhood density and frequency.

1. **Length**

   Using a paired-samples t-test to investigate the relationship between the two sets of data and the syllabic length of items, no statistically significant difference was found in facilitated items across participants and studies: 1-10(M = 1.50, SD =0.70) to 11-20 (M = 1.61, SD =0.65), t (47) = -1.43, p= 0.16 (two-tailed). The relationship between the results from the two sets of items was further analysed using Pearson product-moment correlation coefficient. There was a strong positive correlation between the two sets of data, r = 0.69, n = 48, $p <$ 0.0005, showing that items 1-10, were very similar in length to items 11-20.

2. **Neighbourhood**

   Using a paired-samples t-test, there was a statistically significant difference in the neighbourhood density of items 1-10(M = 10.25, SD =6.61) to 11-20 (M = 8.75, SD =6.62), t (47) = 2.23, p< 0.05 (two-tailed). However, investigation of the relationship between the results from the two sets of items using Pearson product-moment correlation coefficient, showed that there was still a strong positive correlation between the two sets of data, r = 0.75, n = 48, $p <$ 0.01.

   While the neighbourhood density was found to differ between the two sets of data, the fact that naming performance across the data was not significantly different implies that for this group of participants neighbourhood density was not a crucial factor in naming success.

3. **Frequency**

A paired-samples t-test was used to investigate the relationship between the two sets of data and the frequency of items. Results showed that while there was a tendency for items 1-10 to have a greater frequency than items 11-20, there was no statistically significant difference between the two sets: 1-10(M = 33.14, SD =39.30) to 11-20 (M = 21.29, SD =22.33), t (47) = 1.91, p= 0.06 (two-tailed).

4.3.2.iii: Summary of t-tests

The results from the t-tests demonstrate that while the methodology used in the current study does not allow for control of psycholinguistic variables through the pre-selection of items, there does not seem to be a significant impact on naming. For two of the three variables analysed, length and frequency, there was not a statistically significant difference between items 1-10 and items 11-20, combined across participants and across facilitation studies. The third variable, neighbourhood density, did differ significantly across the two data sets, however the sets were still found to correlate highly for this variable.

The consistency in delayed naming results across the two data sets, cued items 1-10 and 11-20, supports the use of this methodology for facilitation studies.

4.4: Results: Neuropsychological assessments

4.4.1: Introduction and scaled score

As outlined, there is no universal agreement as to which component of cognitive processing is activated when assessments are employed. Table 4.4.i below assigns assessments to a cognitive domain, according to that which is considered to be the primary cognitive skill being measured. It is however acknowledged that in order to successfully complete each task, participants must employ additional cognitive skills.

Table 4.4.i: assessments and the corresponding primary cognitive domain being assessed

Assessment	Cognitive skill tested
STM picture pointing	Memory
STM letter pointing	Memory
Digit span forwards (WMS–III)	Memory
Digit span backwards (WMS-III)	Memory
Recognition of faces I (WMS-III)	Memory (short term)
Recognition of faces II (WMS-III)	Memory (long term)
Spatial span forwards (WMS-III)	Memory
Spatial span backwards (WMS-III)	Memory
Designs recognition (WMS-III)	Memory
Elevator counting (TEA)	Attention (simple)
Elevator counting with distraction (TEA)	Attention (divided)
Map search (TEA)	Attention
Trail Making Test part A	Attention
Trail Making Test part B	Executive function
Brixton spatial anticipation test (the Hayling and Brixton tests)	Executive function

Each participant's assessment results are reported in the order presented in the Table 4.4.i.

For subtests of the TEA and WMS-III, where scaled scores are provided, Table 4.4.ii shows the conversions used to classify performance levels and enable comparison across tasks.

Table 4.4.ii: scaled scores and classifications for results from the TEA and the WMS-III

Scaled score	%ile ranges	Classification
19	98+	Very superior
18		
17		
16		
15	91-97	Superior
14		
13	75-90	High average
12		
11	26-74	Average
10		
9		
8	10-25	Low average
7		
6	3-9	Borderline
5		
4	0.1-2	Impaired
3		
2		
1	0-0.1	Severely impaired

The Trail Making Test was scored by the number of seconds taken to complete each part. Duration was then converted to percentile ranks using the normative data as reported by Tombaugh (2003). Using Table 4.4.ii, these percentile scores were then assigned a classification. For readability, both part A and part B are reported under the domain of executive function for each participant below, but the results are separated out within the tables into their respective domains of attention and executive function.

The Brixton spatial anticipation test uses a scoring system in which errors are assigned scaled scores on a scale of 1-10, which are interpreted as shown in Table 4.4.iii.

Table 4.4.iii: scaled scores and their corresponding classification as used by the Brixton spatial anticipation test

Raw score (errors)	Scaled score	Classification
0-7	10	Very superior
8	9	Superior
9-10	8	Good
11-13	7	High average
14-17	6	Average
18-20	5	Moderate average
21-23	4	Low average
24-25	3	Poor
26-31	2	Abnormal
>31	1	Impaired

4.4.2: Participants' Neuropsychological Profiles

4.4.2.i: Anne

Memory

Anne's average score across 10 items in the STM picture pointing test was 3.1. In the STM letter pointing test her average score was 2.9.

On the digit span forwards subtest, Anne scored 6 out of a possible 16, while on the digit span backwards subtest, she scored 2 out of a possible 14. This gives Anne a total score of 8, which is converted to a scaled score of 5, classified as 'borderline'.

Anne reported finding it very difficult to recognise faces but this was not reflected in her performance of face recognition. On recognition of faces I Anne scored 38/48, equivalent to a scaled score of 12 (high average) and on recognition of faces II she scored 40/48, equating to a scaled score of 14 (superior).

On the spatial span forwards subtest, Anne scored 7 out of a possible 16, equivalent to a scaled score of 10 and classified as 'average'. On the spatial span backwards subtest Anne scored 5 out of a possible 16, a scaled score of 8, which is classified as 'low average'.

In visual reproduction I, Anne scored 70 out of a possible 104, giving a scaled score of 10 (average). In visual reproduction II, Anne's performance level dropped, with a score of 16 out of a possible 104, converted a scaled score of 7 (low average). Anne's score for copying the designs was 90 out of 104, equivalent to a scaled score of 6 (borderline), suggesting that Anne had some difficulties with the output component of this section which may exaggerate the presence of any memory impairment for this task. In the final component of this task, recognition, Anne scored highly, correctly recognising 44 out of the 48 designs shown, which equates to a scaled score of 14 (superior).

Attention

Anne's simple attention skills as assessed by the elevator counting task were classified as abnormal with a score of 5/7. Anne was one of only two participants in this study not to score at ceiling on this task.

Further assessment of this cognitive domain using the elevator counting with distraction task showed impaired divided attention with Anne scoring 4/10, equivalent to a scaled score of 6 (borderline).

While performing the map search task, Anne found 10 symbols in the first minute, giving a scaled score of 6 (borderline). In the second minute she found a further 10 symbols, giving her a total of 20 out of a possible 80, a scaled score of 3 (impaired) for the two minute total. Anne's comparative worsening performance on this task indicates difficulties with sustaining attention beyond one minute.

Anne has reported that since her stroke she has found it difficult to maintain attention on everyday tasks and this anecdotal report seems to be corroborated by her performance on these tasks in which she consistently performed below average.

Executive function

Anne reported finding the Trail Making Test very challenging, and took 165 seconds to complete part A, a score which falls below the tenth percentile and is therefore classified as being 'impaired'. On administration of part B, Anne became increasingly frustrated and it was abandoned after 187 seconds with only 7 of the 25 items having been connected.

On the Brixton Spatial Anticipation Test, Anne made 26 errors out of a possible 54. This gives Anne a scaled score of 2 which the test manual classifies as abnormal.

Table 4.4.iv: Summary table of Anne's performance on tests of cognitive skills

Assessment	Cognitive domain	Maximum score	Anne's score	Scaled score	Classification
Picture span	Memory	**n/a**	3.1	n/a	
Letter span		**n/a**	2.9	n/a	
Digit span - forwards		**16**	6	n/a	
Digit span - backwards		**14**	2	n/a	
Digit span - total score		**30**	8	5	Borderline
Faces I		**48**	38	12	high average
Faces II		**48**	40	14	Superior
Spatial span - forwards		**16**	7	10	Average
Spatial span - backwards		**16**	5	8	low average
Spatial span - total score		**32**	12	8	low average
Visual reproduction I		**104**	70	10	Average
Visual reproduction II		**104**	16	7	low average
Copying		**104**	90	6	Borderline
Visual reproduction - recognition		**48**	44	14	Superior
Elevator counting (auditory stimulus)	Attention	**7**	5	n/a	'abnormal'
Elevator counting (with distraction)		**10**	4	6	Borderline
Map search 0-60 seconds		**n/a**	10	6	Borderline
Map search 60-120 seconds		**n/a**	10	n/a	
Map search total		**80**	20	3	Impaired
Trail Making A		**n/a**	165	<10 %ile	Impaired
Trail Making B	Executive function	**n/a**	Abandoned	n/a	Severely impaired
Brixton spatial anticipation test		**54 (errors)**	26	2	Abnormal

From Table 4.4.iv above, it is clear to see that Anne performed below average on all assessments of attention and executive function. However, her performance on the memory tasks was mixed, and she was classified at or above average for half of the tasks.

4.4.2.ii: Derek

Memory

Derek's average across 10 items on the STM picture pointing task was 3.1, and his average on the STM letter pointing span was also 3.1.

On assessment with the digit span forwards subtest, Derek scored 4 out of a possible 16 and 3 out of a possible 14 on the digit span backwards subtest. This gives a total score of 7, which equates to a scaled score of 5 (borderline).

Derek reported finding it very difficult to recognise faces following the presentation of the target items in the recognition of faces tasks. This is reflected in his score on the recognition of faces I subtest on which he scored 28/48, which corresponds to a scaled score of 7 (low average). However, his performance on the second subtest, recognition of faces II, improved with a score of 35/48, a scaled score equivalent of 14 (superior). It is possible that on this third presentation of the target faces, Derek had become more familiar with them, and was better equipped to rule out the novel faces.

Derek scored 5 out of a possible 16 on the spatial span forwards subtest, which converts to a scaled score of 7 (low average). Derek performed better on the spatial span backwards subtest, scoring 6 out of a possible 16, which converts to a scaled score of 11 (average). It is possible that Derek's improved performance on the backwards version of this test was related to a degree of learning what was required, as there were no practice items with this task.

On the designs recognition section, Derek scored 69 and 48 on visual reproduction I and II respectively, both out of a possible 104. This equates to scaled scores of 11 (average) and 13 (high average) respectively. On the copying version of the test, Derek scored 93 out of 104, a scaled score of 10 (average). Finally, on the recognition subtest, Derek scored 43/48, a scaled score equivalent of 14 (superior) and reported finding this much easier than the faces recognition subtests. Derek demonstrated an aptitude for this section of tasks with all of his scores being classified at or above average.

Attention

Derek scored at ceiling (7/7) on the elevator counting subtest, indicating a 'normal' performance.

On assessment of divided attention as measured by elevator counting with distraction, Derek scored 9/10, which equates to a scaled score of 11 (average).

Derek found 16 symbols on a map in the first minute of the map search task (scaled score 8, low average) and 14 symbols in the second minute, giving him a total of 30 symbols found out of a possible 80. His two minute total equates to a scaled score of 5 (borderline).

Executive function

Derek completed part A of the Trail Making Test in 90 seconds, approximately equivalent to the 11th percentile (low average). He completed part B in 220 seconds, approximately equivalent to the 16th percentile for his age group (low average).

On the Brixton Spatial Anticipation Test Derek made 25 errors out of a possible 54. This equates to a scaled score of 3, a performance which the test manual classifies as poor.

Table 4.4.v: Summary table of Derek's performance on tests of cognitive skills

Assessment	Cognitive domain	Maximum score	Derek's score	Scaled score	Classification
Picture span	Memory	**n/a**	3.1	n/a	
Letter span		**n/a**	3.1	n/a	
Digit span – forwards		**16**	4	n/a	
Digit span – backwards		**14**	3	n/a	
Digit span - total score		**30**	7	5	Borderline
Faces I		**48**	28	7	low average
Faces II		**48**	35	14	Superior
Spatial span - forwards		**16**	5	7	Low average
Spatial span – backwards		**16**	6	11	Average
Spatial span - total score		**32**	11	9	Average
Visual reproduction I		**104**	69	11	Average
Visual reproduction II		**104**	48	13	high average
Copying		**104**	93	10	Average
Visual reproduction – recognition		**48**	43	14	Superior
Elevator counting (auditory stimulus)	Attention	**7**	7	n/a	Normal
Elevator counting (with distraction)		**10**	9	11	Average
Map search 0-60 seconds		**n/a**	16	8	Low average
Map search 60-120 seconds		**n/a**	14	n/a	
Map search total		**80**	30	5	Borderline
Trail Making A		**n/a**	90	11^{th} %ile	Low average
Trail Making B	Executive function	**n/a**	220	16^{th} %ile	Low average
Brixton spatial anticipation test		**54 (errors)**	25	3	Poor

Table 4.4.v demonstrates that Derek's strongest cognitive domain is that of memory, and his weakest is executive function.

4.4.2.iii: Jon

Memory

On assessment of STM picture pointing span, Jon's average score across 10 items was 4.1. Jon's average for STM letter pointing span was 3.5, suggesting that it is more difficult for Jon to hold letters in his STM than picture names.

Jon found the digit span forwards and backwards subtests to be particularly challenging. His score for digit span forwards was 2 out of a possible 16, and he scored 2 out of a possible total of 14 for the digit span backwards subtest. The total score for these subtests is equivalent to a scaled score of 3 (impaired). This impaired classification was not synonymous with his performance on the other memory tasks, suggesting that Jon has a particular impairment with number processing (dyscalculia) resulting in this task not being sensitive to measuring the domain of memory for Jon.

Jon reported enjoying the recognition of faces subtests and felt that his background of working in customer focused roles helped him carry out this task well. On recognition of faces I Jon scored 42/48, a scaled score of 15 (superior) and on recognition of faces II he scored 43/48, which equates to a higher scaled score of 17 (very superior).

Jon scored 10 out of a possible 16 on the spatial span forwards subtest, reporting that he found this much easier than the digit span task. His performance equates to a scaled score of 14 (superior). On the spatial span backwards subtest, Jon again performed well with a score of 11 out of a possible 16, a scaled score equivalent to 17 (very superior). His discrepancy in performance between these two span tasks, digit and spatial, suggests that the task requirements are different from one another.

On the designs recognition subsection, Jon was scored above average throughout, and he reported enjoying these tasks. His scores were 95/104 on visual reproduction I (scaled score 14, superior), 63/104 on visual reproduction II (scaled score 12, high average), 99/104 on copying (scaled score 12, high average) and 46/48 on the copying subtest (scaled score 14, superior).

Jon's above average performance on all but the digit span task indicates excellent retained memory skills for information presented in the visual modality.

Attention

On assessment of simple attention using the elevator counting subtest, Jon scored at ceiling, 7/7, a score considered to be 'normal'.

Jon also scored at ceiling, 10/10 (scaled score 12, high average), on the elevator counting with distraction subtest, suggesting his divided attention skills are unimpaired.

In the first minute of the map search subtest, Jon found 42 symbols, which equates to a scaled score of 13 (high average). In the second minute he found a further 32 symbols, giving him a total of 74 out of a possible 80 symbols, which equates to a scaled score of 15 (superior).

Jon's overall performance on these assessments of attention was above that of the other participants. It is interesting to note that Jon reported he had carried out what he considered to be similar type tests, prior to his stroke in making job applications.

Executive function

Jon completed the Trail Making Test part A in 38 seconds, approximately equivalent to the 24th percentile for his age group (low average). He went on to complete part B in 76 seconds, which is equivalent to 38th percentile (average).

Jon's raw score for errors was 11/54 on the Brixton spatial anticipation test. This gives Jon a scaled score of 7 which means his performance is classified by the test manual as high average.

Table 4.4.vi: Summary table of Jon's performance on tests of cognitive skills

Assessment	Cognitive domain	Maximum score	Jon's score	Scaled score	Classification
Picture span	Memory	**n/a**	4.1	n/a	
Letter span		**n/a**	3.5	n/a	
Digit span - forwards		**16**	2	n/a	
Digit span - backwards		**14**	2	n/a	
Digit span - total score		**30**	4	3	Impaired
Faces I		**48**	42	15	Superior
Faces II		**48**	43	17	Very superior
Spatial span - forwards		**16**	10	14	Superior
Spatial span - backwards		**16**	11	17	Very superior
Spatial span - total score		**32**	21	16	Very superior
Visual reproduction I		**104**	95	14	Superior
Visual reproduction II		**104**	63	12	high average
Copying		**104**	99	12	High average
Visual reproduction - recognition		**48**	46	14	Superior
Elevator counting (auditory stimulus)	Attention	**7**	7	n/a	Normal
Elevator counting (with distraction)		**10**	10	12	High average
Map search 0-60 seconds		**n/a**	42	13	High average
Map search 60-120 seconds		**n/a**	32	n/a	
Map search total		**80**	74	15	Superior
Trail Making A		**n/a**	38	24th %ile	Low average
Trail Making B	Executive function	**n/a**	76	38th %ile	Average
Brixton spatial anticipation test		**54 (errors)**	11	7	High average

Table 4.4.vi demonstrates that Jon's level of performance across the neuropsychological assessment battery is largely above average, with impairment evident only for the digit span task.

4.4.2.iv: Steve

Memory

On STM picture pointing, Steve achieved an average score of 4.5. For assessment of STM letter pointing, his average score was 1.6, suggesting a marked impairment in Steve's ability to process letters compared with his ability to process pictorial input.

Steve scored 8 out of a possible 16 on the digit span forwards subtest, and 7 out of a possible 14 on the digit span backwards subtest. This total score gives Steve a scaled score of 8, which is classified as low average.

Steve reported that it was difficult for him to perform the recognition of faces subtests. He scored 31/48 on recognition of faces I but improved to 37 out of 48 on recognition of faces II. These give scaled score equivalents of 7 (low average) and 9 (average) respectively.

On the spatial span forwards subtest, Steve scored 8 out of a possible 16, which equates to a scaled score of 9, an 'average' performance. On the spatial span backwards subtest, Steve scored 7 out of a possible 16, which again equates to a scaled score of 9, indicating an average performance.

Steve reported enjoying the designs subsection, but this was not necessarily reflected in his performance. On visual reproduction I, Steve scored 54/104, a scaled score equivalent of 2 (impaired). His performance improved for visual reproduction II, with a score of 76/104, a scaled score equivalent 11 (average). Interestingly, Steve was below average on the copying subtest with a score of 92/104 (scaled score of 6, borderline) suggesting that his difficulties with this task could not be explained by impaired memory alone. This is further supported by his good performance on the recognition subtest, which requires no drawing output, in which Steve scored 47/48, a scaled score of 13 (high average).

Attention

On the elevator counting task, Steve scored 5/7, a score which is classified as abnormal.

Steve scored 5/10 on the elevator counting with distraction subtest, which equates to a scaled score of 6 (borderline).

In the first minute of the map search task, Steve found 19 symbols, giving a scaled score of 6 (borderline). In the second minute he found an additional 12 symbols, giving Steve a total of 31 symbols found out of a possible 80, equivalent to a scaled score of 3 (impaired).

Executive function

Steve completed part A of the Trail Making Test in 145 seconds, a score which is well below the 10th percentile for his age group (impaired/severely impaired). Steve showed determination in completing part B and succeeded in finishing the task, although he recorded a time of 440 seconds, again a score which is well below the 10th percentile for his age group (impaired/severely impaired).

Steve made 28/54 errors on the Brixton spatial anticipation test, which equates to a scaled score of 2 and is classified as abnormal.

Table 4.4.vii: Summary table of Steve's performance on tests of cognitive skills

Assessment	Cognitive domain	Maximum score	Steve's score	Scaled score	Classification
Picture span	Memory	**n/a**	4.5	n/a	
Letter span		**n/a**	1.6	n/a	
Digit span - forwards		**16**	8	n/a	
Digit span - backwards		**14**	7	n/a	
Digit span - total score		**30**	15	8	Low average
Faces I		**48**	31	7	low average
Faces II		**48**	37	9	Average
Spatial span - forwards		**16**	8	9	Average
Spatial span - backwards		**16**	7	9	Average
Spatial span - total score		**32**	15	8	Low average
Visual reproduction I		**104**	54	2	Impaired
Visual reproduction II		**104**	76	11	Average
Copying		**104**	92	6	Borderline
Visual reproduction – recognition		**48**	47	13	High average
Elevator counting (auditory stimulus)	Attention	**7**	5	n/a	abnormal
Elevator counting (with distraction)		**10**	5	6	Borderline
Map search 0-60 seconds		**n/a**	19	3	Impaired
Map search 60-120 seconds		**n/a**	12	n/a	
Map search total		**80**	31	<1	Severely impaired
Trail Making A		**n/a**	145	<10th %ile	Impaired/ severely impaired
Trail Making B	Executive function	**n/a**	440	<10th %ile	Impaired/ severely impaired
Brixton spatial anticipation test		**54 (errors)**	28	2	Abnormal

As Table 4.4.vii demonstrates, Steve showed a spread of scores on the memory tasks, but performed well below average on all measures of attention and executive function.

4.4.2.v: Ernie

Memory

Ernie's average number of items pointed to across 10 trials in the STM picture pointing task was 3.9. The average number of letters he pointed to in the STM letter pointing task was 3.5, suggesting a similar capacity for these two tasks.

On the digit span forwards subtest, Ernie scored 4 out of a possible maximum of 16, and on the digit span backwards subtest, he scored 3 out of a possible maximum of 14. Ernie's total score of 7 on these tasks is equivalent to a scaled score of 4 (impaired).

Ernie scored 37 out of 48 on the recognition of faces I subtest, and 30 minutes later on administration of recognition of faces II subtest, he scored 43/48. These scores are equivalent to scaled scores of 12 (high average) and 18 (very superior) respectively.

Ernie scored 6 on the spatial span forwards subtest, and 6 on the spatial span backwards subtest, both out of a possible maximum of 16. These are equivalent to scaled scores of 8 (low average) and 10 (average) respectively. Ernie's improved performance on this span task over the digit span task, suggests that the digit span task required additional processing and was not a pure measure of memory ability.

Ernie scored at, or above average on all the design subtests. In visual reproduction I, he scored 66/104 (scaled score 9, average), in visual reproduction II his score was 47/104 (scaled score 12, high average), on copying he scored 97/104 (scaled score 11, average) and finally on recognition he scored 46/48 (scaled score 15, superior).

His varied performance across the subtests on the memory section, suggest that these tasks are not all synonymous memory processing tasks but tap into different processes, either due to their different input mechanisms or due to their intrinsically different processing requirements.

Attention

On the elevator counting subtest, Ernie scored 7/7, which is considered to be normal.

On the more challenging elevator counting with distraction subtest, Ernie scored 4/10, which equates to a scaled score of 6 (borderline).

On the map search subtest, Ernie found 8 symbols in the first minute, which equates to a scaled score of 6 (borderline). In the second minute, he found a further 10 symbols, giving him a total of 18 symbols out of a possible 80, equivalent to a scaled score of 3 (impaired).

Ernie’s overall performance on the attention tasks suggests that he is impaired in this cognitive domain.

Executive function

Ernie completed part A of the Trail Making Test in 60 seconds, a score which is approximately equivalent to the 11^{th} percentile for his age group (low average). He completed part B in 190 seconds, which is below the 10^{th} percentile for his age group (impaired).

On the Brixton spatial anticipation test, Ernie made 27 errors out of a possible 54. This gives Ernie a scaled score of 2 which is classified by the test manual as abnormal.

Table 4.4.viii: Summary table of Ernie's performance on tests of cognitive skills

Assessment	Cognitive domain	Maximum score	Ernie's score	Scaled score	Classification
Picture span	Memory	**n/a**	3.9	n/a	
Letter span		**n/a**	3.5	n/a	
Digit span - forwards		**16**	4	n/a	
Digit span - backwards		**14**	3	n/a	
Digit span - total score		**30**	7	4	Impaired
Faces I		**48**	37	12	High average
Faces II		**48**	43	18	Very superior
Spatial span - forwards		**16**	6	8	Low average
Spatial span - backwards		**16**	6	10	Average
Spatial span - total score		**32**	12	9	Average
Visual reproduction I		**104**	66	9	Average
Visual reproduction II		**104**	47	12	high average
Copying		**104**	97	11	Average
Visual reproduction - recognition		**48**	46	15	Superior
Elevator counting (auditory stimulus)	Attention	**7**	7	n/a	Average
Elevator counting (with distraction)		**10**	4	6	Borderline
Map search 0-60 seconds		**n/a**	8	6	Borderline
Map search 60-120 seconds		**n/a**	10	n/a	
Map search total		**80**	18	3	Impaired
Trail Making A		**n/a**	60	11th %ile	Low average
Trail Making B	Executive function	**n/a**	190	<10th %ile	Impaired
Brixton spatial anticipation test		**54 (errors)**	27	2	Abnormal

Table 4.4.viii illustrates that Ernie strongest cognitive domain is that of memory, and his weakest is that of attention.

4.4.2.vi: Paul

Memory

On the test of STM picture pointing, Paul scored an average of 4.7, while STM letter pointing proved more difficult with his average score being 3.3.

On assessment of recalling numbers with the digit span forwards test, Paul scored 5 out of a possible 16. On the subtest, digit span backwards Paul scored 4 out of a possible 14. Paul's combined score on these tasks gives a scaled score of 6 (borderline).

On assessment of recognition of faces I, Paul scored 24/48 a score which suggests performance at a chance level, and converts to a scaled score of 5 (borderline). Administration of recognition of faces II, after a delay of 30 minutes resulted in an improved performance, 32/48, which is equivalent to a scaled score of 10 (average).

On the spatial span forwards subtest, Paul scored 7 out of a possible maximum of 16, which is equivalent to a scaled score of 10 (average). On the subtest spatial span backwards, Paul scored 9 out of a possible 16, indicating a better performance on this non-verbal subtest than the digit span backwards which requires a verbal response. This equates to a scaled score of 16 (very superior).

On the designs section, Paul had a mixed pattern of performance. His score of visual reproduction I was 58/104, which is equivalent to a scaled score of 8 (low average), while his score on visual reproduction II was 54/104, which is a scaled score of 14 (superior). His similar raw scores across the two tasks suggest that Paul retained most of the detail from the first administration to the delayed second administration. Paul's copying was scored as 83/104, which is a scaled score of 5 (borderline). This indicates that Paul's difficulties with these tasks were not purely related to memory impairment, but that there was a difficulty with the drawing output. On the final subtest from this section, designs recognition, Paul scored 35/48, a scaled score of 8 (low average).

Attention

Paul scored at ceiling on the test of elevator counting (7/7) which is considered to be normal.

Paul scored 7/10 on the subtest, elevator counting with distraction, which is equivalent to a scaled score of 8 (low average).

On searching for symbols on the map search subtest, Paul correctly identified 28 in the first minute, which equates to a scaled score of 10 (average). In the second minute, he identified a further 17, giving him total of 45 out of a possible 80, which is equivalent to a scaled score of 8 (low average).

Executive function

On the Trail Making Test, Paul completed part A in 75 seconds, a score equivalent to the 14th percentile for his age group (low average). He went on to complete part B in 160 seconds, which equates to the 22nd percentile (low average).

On the Brixton spatial anticipation test, Paul made 32 errors out of a possible 54. This gives Paul a scaled score of 1 which is classified as ‘impaired’ by the test manual.

Table 4.4.ix: Summary table of Paul's performance on tests of cognitive skills

Assessment	Cognitive domain	Maximum score	Paul's score	Scaled score	Classification
Picture span	Memory	**n/a**	4.7	n/a	
Letter span		**n/a**	3.3	n/a	
Digit span - forwards		**16**	5	n/a	
Digit span - backwards		**14**	4	n/a	
Digit span - total score		**30**	9	6	Borderline
Faces I		**48**	24	5	Borderline
Faces II		**48**	32	10	Average
Spatial span - forwards		**16**	7	10	average
Spatial span - backwards		**16**	9	16	Very superior
Spatial span - total score		**32**	16	14	Superior
Visual reproduction I		**104**	58	8	Low average
Visual reproduction II		**104**	54	14	Superior
Copying		**104**	83	5	Borderline
Visual reproduction – recognition		**48**	35	8	Low average
Elevator counting (auditory stimulus)	Attention	**7**	7	n/a	Average
Elevator counting (with distraction)		**10**	7	8	Low average
Map search 0-60 seconds		**n/a**	28	10	average
Map search 60-120 seconds		**n/a**	17	n/a	
Map search total		**80**	45	8	Low average
Trail Making A		**n/a**	75	14th %ile	Low average
Trail Making B	Executive function	**n/a**	160	22nd %ile	Low average
Brixton spatial anticipation test		**54 (errors)**	32	1	Impaired

Table 4.4.ix illustrates that Paul had a mixed pattern of performance across all cognitive domains.

4.4.2.vii: Tony

Memory

On assessment of STM through picture pointing, Tony's average score across the 10 items was 3.3. On testing STM through letter pointing Tony's average score was 1.5. Tony found this latter task difficult as in order to point to the letters following presentation by the therapist, he felt he needed to repeat the letters aloud, despite being informed that this was not required for the task. Unfortunately these were then subject to distortion as a result of his dyspraxia, which resulted in incorrect letters being selected.

On the digit span forwards subtest, Tony scored 4 while on the digit span backwards test he scored 2. His combined total score of 6 is equivalent to a scaled score of 4 (impaired). In order to rule out dyspraxia as being the reason for his difficulties with this task, he was provided with a number chart and encouraged to point to the digits to facilitate his responses, however this did not improve his performance.

On presentation of recognition of faces I, Tony scored 35/48, which is converted to a scaled score of 11 (average). On recognition of faces II Tony scored 38/45, showing an improvement, with a scaled score of 14 (superior).

On assessment of spatial span in a forwards direction, Tony scored 5 out of a possible total of 16. This scaled score of 7 classifies Tony as low average. On assessment of spatial span in a backwards direction, Tony scored 2 out of a possible 16, which is equivalent to a scaled score of 6 (borderline). Tony's poor performance on both the spatial span and digit span assessments indicates an impaired memory span, regardless of modality of access.

On administration of the designs section, Tony scored below average on all three tasks requiring drawing output. On visual reproduction I he scored 26/104 (scaled score of 3, impaired), on visual reproduction II he scored 7/104 (scaled score of 5, borderline) and on copying he scored 70/104 (scaled score of 2, impaired). Tony's performance improved for the recognition subtest on which he scored 37/48, equivalent to a scaled score of 9 (average).

Attention

Tony's simple attention skills as measured by elevator counting, are at normal levels with performance at ceiling (7/7).

Assessment of divided attention using the elevator counting with distraction task, Tony scored 9/10, equivalent to a scaled score of 11 (average).

In the first minute of the map search task, Tony correctly identified 16 symbols. This is equivalent to a scaled score of 8 (low average). In the second minute of the task he correctly identified a further 23 symbols, giving him a total of 39 out of a possible 80, equivalent to a scaled score of 7 (low average).

Executive function

In the Trail Making Test part A, Tony correctly completed the sequence in 80 seconds, a score which is below the 10th percentile and is therefore classified as impaired. Tony took 360 seconds to complete part B, a score which falls well below the 10th percentile for his age group (impaired/severely impaired). Participants who are completing the task as part of a battery are stopped after 5 minutes to prevent fatigue from impacting on further assessments. This was not done in Tony's case as he was not going on to carry out further assessments during that session.

On the Brixton spatial anticipation test, Tony made 33 errors, a performance which is equivalent to a scaled score of 1 (impaired in the test manual).

Table 4.4.x: Summary table of Tony's performance on tests of cognitive skills

Assessment	**Cognitive domain**	**Maximum score**	**Tony's score**	**Scale d score**	**Classification**
Picture span	**Memory**	**n/a**	3.3	n/a	
Letter span		**n/a**	1.5	n/a	
Digit span - forwards		**16**	4	n/a	
Digit span - backwards		**14**	2	n/a	
Digit span - total score		**30**	6	4	Impaired
Faces I		**48**	35	11	Average
Faces II		**48**	38	14	Superior
Spatial span - forwards		**16**	5	7	Low average
Spatial span - backwards		**16**	2	5	Borderline
Spatial span - total score		**32**	7	4	Impaired
Visual reproduction I		**104**	26	3	Impaired
Visual reproduction II		**104**	7	5	Borderline
Copying		**104**	70	2	Impaired
Visual reproduction - recognition		**48**	37	9	average
Elevator counting (auditory stimulus)	**Attention**	**7**	7	n/a	Average
Elevator counting (with distraction)		**10**	9	11	Average
Map search 0-60 seconds		**n/a**	16	8	Low average
Map search 60-120 seconds		**n/a**	23	n/a	
Map search total		**80**	39	7	Low average
Trail Making A		**n/a**	80	<10th %ile	Impaired
Trail Making B	**Executive function**	**n/a**	360	<10th %ile	Impaired/ severely impaired
Brixton spatial anticipation test		**54 (errors)**	33	1	Impaired

Tony's result Table 4.4.x reflects his tendency towards impairment across all three of the cognitive domains assessed. The only assessment on which he performed at an above average level was the subtest of recognition of faces II.

4.4.2.viii: Richard

Memory

On assessment with STM picture pointing, Richard scored an average of 2.3 across the 10 items. With the subtest, STM letter pointing, he scored an average of 2.1 across the 10 items representing a similar score across the two input modalities.

Richard scored 5 out of a possible 16 on the digit span forwards subtest, and 1 out of a possible 14 on the digit span backwards subtest, reflecting the great difficulty he had with this test. Richard stated that he was unable to hold the digits in his memory to be able to manipulate the information. His total score of 6 on these tasks is equivalent to a scaled score of 4 (impaired).

Richard reported finding is very difficult to recognise the faces in these subtests of the WMS-II. In recognition of faces I, Richard scored 29/48 and in recognition of faces II he scored 25/48. These scores are equivalent to scaled scores of 7 (low average) and 5 (borderline) respectively. His impaired performance on these tasks was surprising to Richard as he did not feel that he had any difficulty in recognising customers who came into his business, and he has spent his working life in roles that require good customer service.

On the spatial span forwards test, Richard scored 9 out of a possible 16 and he reported finding this easier than the digit span subtest. This is equivalent to a scaled score of 12 (high average). Richard scored 6 out of a possible maximum of 16 on the spatial span backwards subtest, equivalent to a scaled score of 9 (average).

On the designs section, Richard produced a varied performance. On visual reproduction I, he scored 70/104 (scaled score 7, low average) and on visual reproduction II he scored 51/104 (scaled score 10, average). On copying Richard's performance improved, and he scored 99/104 (scaled score 12, high average). His above average performance on this copying subsection suggests that his impaired performance on visual reproduction I cannot be ascribed to output difficulties. Finally, on the designs recognition subtest, Richard scored 42/48, a better performance than on the faces recognition subtests, and equivalent to a scaled score of 10 (average).

Attention

Testing of simple attention using the elevator counting subtest showed Richard to be at ceiling on this task (7/7). Richard needed to use his fingers to count for this task.

Richard found the elevator counting with distraction subtest to be extremely challenging and scored 1 out of a possible 10 on this task, equivalent to a scaled score of 4 (impaired).

On the map search task, Richard found 16 symbols in the first minute, which is equivalent to a scaled score of 7 (low average). In the second minute he correctly identified a further 24 symbols, giving him a total of 40 symbols found out of a possible 80, which equates to a scaled score of 5 (borderline).

Executive function

On the Trail Making Test, Richard completed part A in 41 seconds which corresponds to the 20th percentile for his age group (low average). However, Richard found part B much more challenging and took 252 seconds to complete this part, a time which equates to below the 10th percentile level for his age group (impaired/severely impaired).

Richard reported enjoying carrying out the Brixton spatial anticipation test, and made 14 errors out of a possible 54. This equates to a scaled score of 6 which is classified as 'average' in the test manual.

Table 4.4.xi: Summary table of Richard's performance on tests of cognitive skills

Assessment	Cognitive domain	Maximum score	Richard's score	Scaled score	Classification
Picture span	Memory	**n/a**	2.3	n/a	
Letter span		**n/a**	2.1	n/a	
Digit span - forwards		**16**	5	n/a	
Digit span - backwards		**14**	1	n/a	
Digit span - total score		**30**	6	4	Impaired
Faces I		**48**	29	7	low average
Faces II		**48**	25	5	Borderline
Spatial span - forwards		**16**	9	12	high average
Spatial span - backwards		**16**	6	9	Average
Spatial span - total score		**32**	15	11	Average
Visual reproduction I		**104**	70	7	Low average
Visual reproduction II		**104**	51	10	Average
Copying		**104**	99	12	High average
Visual reproduction - recognition		**48**	42	10	Average
Elevator counting (auditory stimulus)	Attention	**7**	7	n/a	Average
Elevator counting (with distraction)		**10**	1	4	Impaired
Map search 0-60 seconds		**n/a**	16	7	Low average
Map search 60-120 seconds		**n/a**	24	n/a	
Map search total		**80**	40	5	Borderline
Trail Making A		**n/a**	41	20th %ile	Low average
Trail Making B	Executive function	**n/a**	252	<10th % ile	Impaired/ severely impaired
Brixton spatial anticipation test		**54 (errors)**	14	6	Average

Richard's greatest strength was in the domain of memory, although he still performed below average for a number of these assessments. His overall pattern of processing was poor in the domain of attention, and on the executive function assessment of Trail Making part B. However, he was one of only two participants who scored at or above average on the Brixton spatial anticipation test demonstrating retained skills for the aspects of processing measured by this assessment.

See appendix 4 for a summary table of all participants' scores on the neuropsychological assessment battery.

4.4.2.ix: Summary of participants' performance on neuropsychological assessments

The following tables summarise the participants' performance according to cognitive domain: memory, attention and executive function.

Memory

Table 4.4.xii: Summary of memory assessment results for all participants (all scores are scaled scores, except those marked with an *)

Assessment	Participant							
	Anne	Derek	Jon	Steve	Ernie	Paul	Tony	Richard
Picture span*	3.1	3.1	4.1	4.5	3.9	4.7	3.3	2.3
Letter span*	2.9	3.1	3.5	1.6	3.5	3.3	1.5	2.1
Digit span – forwards*	6	4	2	8	4	5	4	5
Digit span – backwards*	2	3	2	7	3	4	2	1
Digit span - total score	5	5	3	8	4	6	4	4
Faces I	12	7	15	7	12	5	11	7
Faces II	14	14	17	9	18	10	14	5
Spatial span - forwards	10	7	14	9	8	10	7	12
Spatial span - backwards	8	11	17	9	10	16	5	9
Spatial span - total score	8	9	16	8	9	14	4	11
Visual reproduction I	10	11	14	2	9	8	3	7
Visual reproduction II	7	13	12	11	12	14	5	10
Copying	6	10	12	6	11	5	2	12
Visual reproduction - recognition	14	14	14	13	15	8	9	10

Table 4.4.xii illustrates a varied pattern of performance across assessments of memory by the participants with aphasia.

Table 4.4.xiii: Summary of attention assessment results for all participants (all scores are scaled scores)

Assessment	Participant							
	Anne	Derek	Jon	Steve	Ernie	Paul	Tony	Richard
Elevator counting (auditory stimulus)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Elevator counting (with distraction)	6	11	12	6	6	8	11	4
Map search 0-60 seconds	6	8	13	3	6	10	8	7
Map search 60-120 seconds	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Map search total	3	5	15	<1	3	8	7	5
Trail Making A	<10%ile	11^{th} %ile	24^{th} %ile	$<10^{th}$ %ile	11^{th} %ile	14^{th} %ile	$<10^{th}$ %ile	20^{th} %ile

Table 4.4.xiii reflects a greater tendency for performance by the participants on assessments of attention to be below average, with performance on Trail Making A being below average for all participants.

Table 4.4.xiv: Summary of executive function assessment results for all participants (all scores are scaled scores)

Assessment	Participant							
	Anne	Derek	Jon	Steve	Ernie	Paul	Tony	Richard
Trail Making B	n/a	16^{th} %ile	38^{th} %ile	$<10^{th}$ %ile	$<10^{th}$ %ile	22^{nd} %ile	$<10^{th}$ %ile	$<10^{th}$ %ile
Brixton spatial anticipation test	2	3	7	2	2	1	1	6

As Table 4.4.xiv shows, the majority of participants perform at a below average level on the two assessments of executive function used in the current study.

4.4.3: Neuropsychological assessments correlations

A series of correlations was carried out in order to test specific hypotheses about the neuropsychological assessment results. The results for relationships within each of the cognitive domains are reported: attention, memory, executive function and self-monitoring. Within each sub-process of the different cognitive domains, for example recognition memory with the domain of memory, it was hypothesised that a correlation would be found between the different assessments used to measure that process.

4.4.3.i: Attention

Sustained/simple attention

Two assessments of simple attention were used; elevator counting and Trail A from the Trail Making Test. The relationship between the two was investigated using Spearman's rank correlation and the two were found to be strongly and significantly correlated in a negative direction, *rho* = -0.76, $n = 8$, $p = 0.03$. The correlation was in the negative direction as predicted, as a longer, therefore higher, score on Trail A indicates a poorer performance, whereas a higher score on the elevator counting task indicates a better performance. This strong correlation suggests that the two measures are likely to be utilising the same attention process and furthermore that they are accessible by people with aphasia.

Selective/divided attention

Two measures of selective attention were included, both from the Test of Everyday Attention; elevator counting with distraction and map search. The relationship between the two was investigated using Spearman's rank correlation and the two were found to be strongly and significantly correlated in a positive direction, *rho* = 0.76, $n = 8$, $p = 0.03$. This strong correlation indicates that the two measures do indeed access the same attention process and again that they are accessible by people with aphasia.

4.4.3.ii: Memory

Short term memory

Three assessments of short term memory were used: picture pointing, letter pointing and digit span. The relationship between the three assessments was analysed using a Spearman's rank correlation. There was no correlation found between these assessments, and in fact the relationship between letter span and digit span was found to be in the negative direction, although this did not reach significance, *rho* = -0.51, *n* = 8, *p* =0.20. It is possible that participants' performance on digit span is markedly different from performance on letter span because of the variations in task requirements. Digit span requires spoken output whereas letter span requires a pointing response. For people with aphasia the spoken output requirement may result in performance reflecting language ability rather than short term memory. Alternatively, it may be that digit span taps into different memory processes than letter span. It has been proposed that digit span loads heavily on storage component of working memory rather than manipulation component (Connor et al., 2000).

Recognition memory

Three assessments of recognition memory were included: Faces I, Faces II and design visual recognition. Performance on Faces I and Faces II were strongly, positively and significantly correlated, *rho* = 0.77, *n* = 8, *p* =0.03, despite the former being administered immediately after exposure to the target items and the latter being administered after a delay.

The third measure of recognition memory, design visual recognition, was also found to be strongly correlated with Faces I and Faces II with p levels at, or approaching, significance (Faces I, *rho* = 0.68, *n* = 8, *p* =0.06, Faces II *rho* = 0.70, *n* = 8, *p* =0.05). These strong correlations suggest that the three assessments do tap into the same memory processes and again suggests that they are accessible by people with aphasia.

4.4.3.iii: Relationship between assessments of attention and assessments of memory

To ensure that the assessments tapping into attention processes were measuring different processes to assessments of memory, a correlation was carried out between the two sets of assessment results. It was hypothesised that a correlation would not be found between the two sets of assessments, reflecting their measurement of different processes.

The relationship between assessments of attention (as measured by the combined total score from the elevator counting with and without distraction and map search subtests of the Test of Everyday Attention) and assessments of memory (as measured by the combined total score from the STM picture span, STM letter span, STM digit span and the following subtests from the WMS: Faces I, Faces II, Visual Representation I, Visual Representation II, Copying, Visual Recognition, and Spatial Span Total Score) was investigated using Spearman's correlation coefficient. There was a small, positive correlation between the two variables *rho* = 0.32, n = 8, but this was not significant $p = 0.44$ (2-tailed). This finding supports the hypothesis that these assessments are indeed measuring different aspects of cognitive processing, even though there are some shared processes involved in successful completion of both sets of tasks. Furthermore, it supports the use of these assessments to measure different cognitive domains in people with aphasia.

4.4.3.iv: Executive function

Relationship between assessments of executive function

The relationship between assessments of executive function as used in the current study (as measured by time taken to complete the Trail Making part B and the number of items correct on the Brixton Spatial Anticipation Test) was investigated using Spearman's correlation coefficient. There was a small correlation between the two variables in the negative direction as predicted (due to longer times taken to complete Trail Making part B representing worse performance), *rho* = -0.27, n = 8, but this was not significant $p = 0.52$ (2-tailed).

While there was a small correlation between the two assessments of executive function, it is hypothesised that there was not a larger, or significant, correlation between these two variables due to a trend towards participants performing at, or near to, floor on the Brixton. As a result for all subsequent analyses, only the Trail Making part B is used when investigating relationships of executive function.

4.4.3.v: Relationship between assessments of executive function and assessments of attention

It was hypothesised that there would be a small correlation between assessments of executive function and assessments of attention, reflecting the reliance of effective executive functioning on attention processes.

The relationship between an assessment of executive function (as measured by time taken to complete the Trail Making part B) and assessments of attention (as measured by the combined total score from the elevator counting with and without distraction and map search subtests of the Test of Everyday Attention) was investigated using Spearman's correlation coefficient. There was a large correlation between the two variables in the negative direction as predicted (due to longer times taken to complete Trail Making part B representing worse performance), *rho* = -0.79, n = 8, which was significant $p < 0.05$ (2-tailed). This result may indicate that there is a co-dependency between the two cognitive domains, although the direction of the dependency is not clear from the data. It is possible that, as hypothesised, good attention is a prerequisite for successful execution of executive tasks. However, it is also possible that good attention skills require intact executive skills to effectively allocate resources. Alternatively, it may be that the assessment of executive function used in this thesis was heavily reliant on attention skills, and therefore utilised many of the same processes as measured by the assessments of attention and did not truly reflect participants' executive skills.

4.4.3.vi: Relationship between assessments of executive function and assessments of memory

It was hypothesised that there would be a small correlation between the results of assessments of executive function and the results of the assessments of memory, reflecting some shared processes between the two domains.

The relationship between an assessment of executive function (as measured by time taken to complete the Trail Making part B) and assessments of memory (as measured by the combined total score from the STM picture span, STM letter span, STM digit span and the following subtests from the WMS: Faces I, Faces II, Visual Representation I, Visual Representation II, Copying, Visual Recognition, and Spatial Span Total Score) was investigated using Spearman's correlation coefficient. There was a large correlation between the two variables in the negative direction as predicted (due to longer times taken to complete Trail Making part B representing worse performance), *rho* = -0.62, n = 8, but this was not significant p = 0.1 (2-tailed).

This non-significant finding between assessments of memory and assessments of executive function suggests that they are indeed independent.

Hence, memory and attention assessments were not found to be highly correlated with each other, but attention was correlated with executive function, suggesting that executive skills overlap with attention skills. This provides some support for the suggestion that cognitive skills do share some of the same processes but show sufficient individual characteristics to be classified as separate domains.

Self-Monitoring

4.4.3.vii: Relationship between self-monitoring ability and attention skills

It is hypothesised that in order to be successful at self- monitoring, good attention skills are a prerequisite so that responses can attended to. The relationship between attention (as measured by the total score on the subtests of the Test of Everyday Attention) and self-monitoring ability (as measured by the score on the naming self-judgement task) was investigated using Spearman's correlation coefficient. There was a small correlation between the two variables in the positive direction as predicted, *rho* = 0.10, n = 8, but this was not significant $p = 0.81$ (2-tailed).

While the data support the idea that attention skills may play a role in successful self-monitoring, the fact that only a small correlation was found suggests that these skills are not the most significant factor contributing to self-monitoring.

4.4.3.viii: Relationship between self-monitoring and memory skills

It is hypothesised that retained memory function plays an essential role in supporting self-monitoring allowing people to retain a trace of their production while comparing this to an internal lexical representation. The relationship between memory (as measured by the combined total score from the STM picture span, STM letter span, STM digit span and the following subtests from the WMS: Faces I, Faces II, Visual Representation I, Visual Representation II, Copying, Visual Recognition, and Spatial Span Total Score) and self-monitoring ability (as measured by the score on the naming self-judgement task) was investigated using Spearman's correlation coefficient. There was a large positive correlation between the two variables, *rho* = 0.62, n = 8, but this was not significant $p = 0.11$ (2-tailed).

This finding is unable to support the hypothesis that retained memory skills are related to successful self-monitoring. The use of the combined score for memory does not allow for investigation of whether certain aspects of memory are more involved in self-monitoring than others. However, it is hypothesised that for successful, online, self-monitoring to occur sub-processes of working memory must play a role, for example via the phonological loop to enable comparison between production and a stored model.

4.4.3.ix: Relationship between self-monitoring and executive function

It is hypothesised that self-monitoring may reflect an aspect of executive function, and therefore a correlation will be found between the two. The relationship between executive functioning (as measured by the Trail Making Test B) and self-monitoring ability (as measured by the score on the naming self-judgement task) was investigated using Spearman's correlation coefficient. There was a small, negative correlation between the two variables, *rho* = -0.23, n = 8, which was not significant *p* = 0.59 (2-tailed).

This finding of a small correlation suggests that there may be some common processes involved in carrying out self-monitoring and use of executive functions. However, as already noted, the assessment of executive function used in the current study may not adequately reflect the processing involved in successful utilisation of executive skills. It is therefore difficult to interpret the results with regard to the direction of the relationship and the degree of shared processing between these two cognitive functions.

The results from the neuropsychological correlations are summarised in Table 4.4.xv.

Table 4.4.xv: Summary table of neuropsychological correlations

Hypothesis: There is a relationship between...	Assessments used	Correlation value of rho	Significance (all 2 tailed)
Relationships within neuropsychological assessments			
Attention			
Simple attention	elevator counting and Trail A from the Trail Making Test	-0.76 Large	Significant p = 0.03
Divided attention	elevator counting with distraction and map search	0.76 large	Significant p = 0.03
Memory			
Short term memory	picture pointing, letter pointing and digit span	-0.51 Large	Non-significant p = 0.20
Recognition memory	Faces I and Faces II	0.77 Large	Significant p = 0.03
Recognition memory	Faces I and design recognition	0.68 Large	Non-significant p = 0.06
Recognition memory	Faces II and design recognition	0.70 Large	Significant p = 0.05
Memory and attention	Subtests of the TEA and all assessments of memory	0.32 medium	Non-significant p = 0.44
Executive function			
Relationships within assessments of executive function	Brixton and TMB (NB negative scoring)	-0.27 small	non-significant p=0.52

Table 4.4.xv: Summary table of neuropsychological correlations, cont.

executive function and attention	TMB (NB negative scoring) and subtests of the Test of Everyday Attention: elevator counting + elevator counting with distraction + map search	-0.79 large	significant $p<0.05$ (2 tailed)
executive function and memory	TMB (NB negative scoring) and STM letter span +STM digit span+ STM picture pointing span + subtests of the WMSIII: faces I + faces II + visual reproduction I + visual reproduction II + copying + visual recognition + SSTS	-0.62 large	non-significant $p=0.1$
Self-monitoring			
Self-monitoring and attention	score on the naming self-judgement task and subtests of TEA	0.10 Small	non-significant $p = 0.81$
Self-monitoring and memory	score on the naming self-judgement task and all assessments of memory	0.62 Large	non-significant $p = 0.11$
Self-monitoring and executive function	score on the naming self-judgement task and TMB	-0.23 Small	non-significant $p = 0.59$

4.5: Results: Language profiles and response to facilitation

4.5.1: Facilitation response by language impairment group

ANOVAs

As identified in the analyses of facilitation using combined S tests, emerging patterns of differences in response to different facilitation cues are evident between individuals identified as having a primary locus of impairment in either the phonological or semantic system. To explore this relationship further, one-way between-groups analysis of variance (ANOVA) were conducted to explore the impact of type of language impairment on response to each facilitation cue. Participants were divided into three groups according to their type of language impairment: group 1 - phonological impairment, group 2- semantic impairment, and group 3 - mixed impairment.

4.5.1.i: Phonological cue and language impairment group

Ho: there is no significant difference between language groups in their response to facilitation with a phonological cue.

It is hypothesised that participants with a primary phonological locus of impairment would benefit most from provision of a phonological cue, as this cue could provide sufficient information to access, or boost the activation of, the target word form.

The results from the ANOVA fail to reject the null hypothesis, with no statistically significant difference in delayed naming scores following facilitation with a phonological cue for the three groups: phonological impairment, M = 10.67, SD = 2.89, semantic group, M = 3.33, SD = 3.51, mixed impairment, M = 6.88, SD = 4.39, F (2, 5) = 3.76, p = .10. However, as can be seen from the mean scores for each group, numerically the group with a primary phonological impairment do show most benefit from the phonological cue. Thus, while the mean scores support the notion that people with aphasia whose primary lesion is phonological show the most benefit from cues aimed at improving access to this area of processing, this was not confirmed with statistical analysis.

4.5.1.ii: Repetition and language impairment group

Ho: there is no significant difference between language groups in their response to facilitation with repetition.

It is anticipated that the semantic group may show the most benefit of repetition due to the activation of both semantic information from the provision of the picture, and the link to the phonological form from the presentation of the whole word.

The null hypothesis failed to be rejected, with no statistically significant difference in naming scores for the three groups: phonological impairment, M = 13.00, SD = 4.00, semantic group, M = 9.33, SD = 4.51, mixed impairment, M = 6.50, SD = 7.78, F (2, 5) = 0.99, p = .43.

The combined S test result found that the three individuals with a primary impairment in the semantic system; Derek, Steve and Tony, had a significant benefit to delayed naming from repetition over phonological cues. The results here compare the response to repetition with extra time, and find that the individuals with a primary impairment in the semantic system do not benefit more than individuals with other loci of impairment. The finding here that all three language impairment groups benefit from repetition cues, supports Howard's hypothesis that intervention in which both the picture and the word form is provided can benefit a range of underlying impairments, by strengthening the pathway from semantics through to phonological output.

4.5.1.iii: Increasing cue and language impairment

Ho: there is no significant difference between language groups in their response to facilitation with increasing cues.

It is anticipated that the group with primary locus of impairment in access to, or within, phonological processing will benefit most from an increasing cueing hierarchy due to the provision of extra phonological information.

The null hypothesis failed to be rejected with no statistically significant difference in naming scores for the three groups: phonological impairment, M = 13.67, SD = 5.69, semantic group, M = 6.00, SD = 2.65, mixed impairment, M = 8.50, SD = 4.95, F (2, 5) = 2.20, p = .21.

4.5.1.iv: Decreasing cue and language impairment group

Ho: there is no significant difference between language groups in their response to facilitation with decreasing cues.

It is hypothesised that the semantic group may show the greatest benefit of decreasing cues, by strengthening the connection from semantics to phonology from the first cue in the hierarchy.

The null hypothesis failed to be rejected with no statistically significant difference in naming scores for the three groups: phonological impairment, M = 15.33, SD = 1.15, semantic group, M = 6.67, SD = 3.79, mixed impairment, M = 7.00, SD = 5.66, F (2, 5) = 5.40, p = .06. The lack of statistical evidence for the alternative hypothesis again suggests that when a picture is presented along with the whole target word form, people with different loci of impairment can benefit. It is likely that the benefit arises from strengthening the mapping between semantics and phonology.

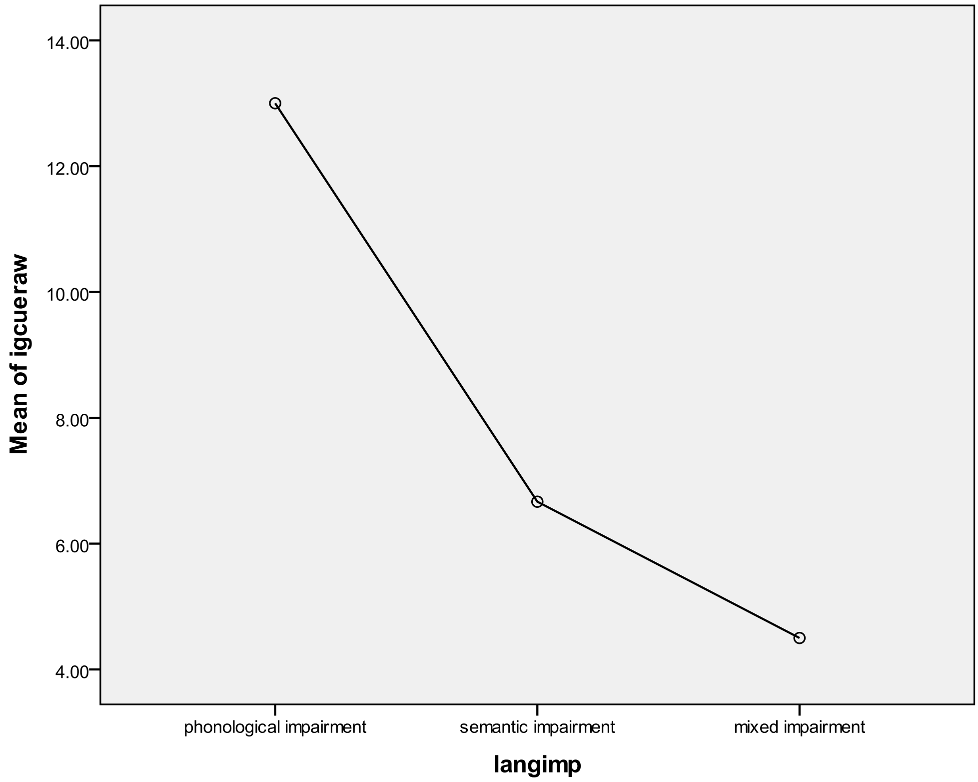
4.5.1.v: Initial grapheme and language impairment group

Ho: there is no significant difference between language groups in their response to facilitation with initial graphemes.

It is hypothesised that the mixed impairment group will show the most improvement to delayed naming following facilitation with initial graphemes, as the additional information provided in this different modality may overcome the presence of impairment in both the semantic and phonological system.

There was a statistically significant difference in naming scores for the three groups: phonological impairment, $M = 13$, $SD = 1.73$, semantic group, $M = 6.67$, $SD = 1.53$, mixed impairment, $M = 4.50$, $SD = 2.12$, $F\ (2, 5) = 16.95$, $p = .01$. The effect size, calculated using eta squared, was 0.87, indicating a large difference between the groups. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for the phonological group was statistically significantly higher than the mean score for the semantic and the mixed impairment groups, see Figure 7.

Figure 7: means plot showing the mean naming score for each language impairment group, following facilitation with an initial grapheme cue (igcueraw)



Therefore, while the null hypothesis was rejected, the direction of difference did not follow the expected pattern, with the phonological group showing the greatest benefit to naming following facilitation with initial graphemes. This finding corroborates the work of Lorenz and Nickels (2007) who found that three participants, each with an identified post-semantic deficit in accessing lexical entries, benefitted from facilitation with an initial grapheme. Their participants similarly showed impairment in sounding out letters and reading aloud non-words (Anne: 13/14 and 2/26; Jon: 12/14 and 12/26; Ernie: 14/14 and 4/26 respectively) but were still able to benefit from facilitation with an initial grapheme. Lorenz and Nickels hypothesised that the initial grapheme may be operating at a lexical level given the identified impairments at the sub-lexical level.

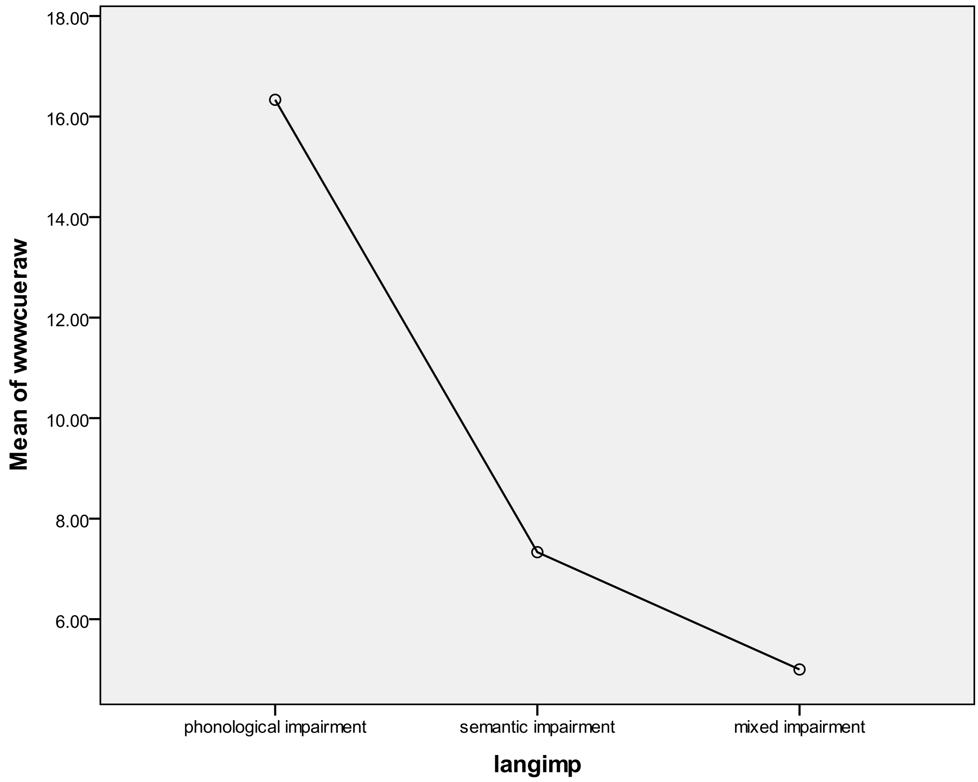
4.5.1.vi: Whole written word and language impairment group

Ho: there is no significant difference between language groups in their response to facilitation with the whole written word.

Provision of the whole written word could work at both the semantic and phonological level and it is therefore hypothesised that the phonological and semantic groups will benefit most from facilitation with the whole written word.

There was a statistically significant difference in naming scores for the three groups: phonological impairment, $M = 16.33$, $SD = 2.31$, semantic group, $M = 7.33$, $SD = 3.21$, mixed impairment, $M = 5.00$, $SD = 5.66$, $F(2, 5) = 7.56$, $p = .03$. The effect size, calculated using eta squared, was 0.75, indicating a large difference between the groups. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for the phonological group was higher than the mean score for the mixed impairment group, but the semantic group did not differ significantly from either the phonological or the mixed impairment group, see Figure 8.
The finding that the phonological group's naming benefitted significantly more than the mixed group supports the alternative hypothesis, however, the semantic group did not benefit significantly more than the mixed group. On language assessment measures of reading words, the mean score for the phonological group showed a numerical advantage over the semantic and mixed group (39, 34 and 19 respectively) suggesting that in contrast with the initial grapheme, facilitation with the whole written word optimally benefits people with more intact single word reading skills.

Figure 8: means plot showing the mean naming score for each language impairment group, following facilitation with a whole written word (wwwcueraw)



4.5.1.vii: Clinician-delivered feedback following an incorrect response and language impairment group

Ho: there is no significant difference between language groups in their response to feedback from a clinician following an incorrect response.

It is hypothesised that the phonological group will show the greatest benefit from clinician-delivered feedback due to the provision of the spoken word form within the feedback process.

The null hypothesis was rejected with a statistically significant difference in naming scores for the three groups: phonological impairment, $M = 13.33$, $SD = 2.08$, semantic group, $M = 5.00$, $SD = 3.61$, mixed impairment, $M = 3.50$, $SD = 4.95$, F (2, 5) = 6.44, $p = .04$. The effect size, calculated using eta squared, was 0.72, indicating a large difference between the groups. Post-hoc comparisons using the Tukey HSD test show that while the mean score for the phonological group was higher than the mean score for the semantic and mixed impairment groups, this did not reach significance over either group (p = 0.07 and p = 0.06 respectively). This is due to the more stringent significance levels set by the post-hoc tests in order to reduce the risk of a type 1 error.

While the results support the alternative hypothesis in suggesting that people with a primary impairment in the phonological system may show an advantage for naming following clinician delivered feedback, the combined S test showed that clinician delivered feedback for responses incorrect at immediate naming significantly improved naming at a delay over extra time for the group as a whole. This along with the findings from the ANOVA implies that clinician delivered feedback is beneficial to naming for all patterns of impairment in aphasia.

4.5.1.viii: Self-feedback following an incorrect response and language impairment group

Ho: there is no significant difference between language groups in their response to self-feedback following an incorrect response.
It is hypothesised that participants with a primary impairment in the semantic system may be able to benefit most from self-feedback. Successful self-feedback is hypothesised to require maintenance of the spoken word production and comparison with the target form in the phonological output lexicon and these processes may be affected in people with a primary phonological impairment.

There was a statistically significant difference in naming scores for the three groups, but not in the direction hypothesised: phonological impairment, M = 12.33, SD = 4.04, semantic group, M = 3.00, SD = 1.00, mixed impairment, M = 2.50, SD = 0.71, F (2, 5) = 12.14, p = .01. The effect size, calculated using eta squared, was 0.83, indicating a large difference between the groups. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for the phonological group was higher than that of both the semantic and mixed impairment groups (p = 0.02 and p = 0.02 respectively), see Figure 9. The semantic and mixed impairment groups did not differ significantly from each other.

This implies that encouraging people with aphasia to reflect on their production through self-feedback is only of benefit when the primary locus of impairment is phonological in nature. This has important implications for how self-feedback may be occurring, suggesting that people with a primary impairment in phonology are able to use self-feedback to modify their subsequent naming response, perhaps utilising feedback mechanisms between phonological output and the phonological output lexicon, as depicted in Figure 1.

Figure 9: means plot showing the mean naming score for each language impairment group, following facilitation with self-feedback (selffbincorrraw).

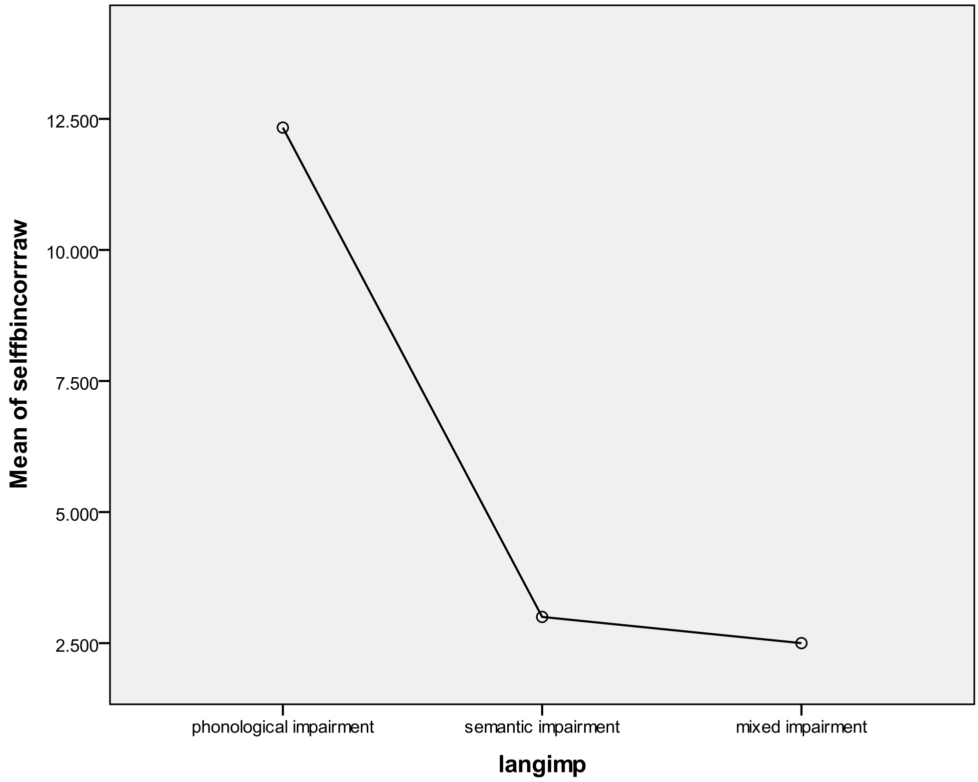


Table 4.5.i: ANOVA summary table of language impairment and response to facilitation

Hypothesis: There is a significant difference between...	**ANOVA *F* value**	**Significance**
language impairment groups in response to facilitation with a phonological cue	F (2,5) = 3.76	non-significant p=0.10
language impairment groups in response to facilitation with repetition	F (2,5) = 0.99	non-significant p=0.43
language impairment groups in response to facilitation with increasing cues	F (2,5) = 2.20	non-significant p=0.21
language impairment groups in response to facilitation with decreasing cues	F (2,5) = 5.40	approaching significance p=0.06
language impairment groups in response to facilitation with an initial grapheme	F (2,5) = 16.95 eta squared = 0.87	significant p=0.01 group 1> group 2 and group 3
language impairment groups in response to facilitation with the whole written word	F (2,5) = 7.56 eta squared = 0.75	significant p=0.03 group 1> group 3
language impairment groups in response to facilitation therapist delivered feedback following an incorrect response	F (2,5) = 6.44 eta squared = 0.72	significant p=0.04
language impairment groups in response to facilitation with self-feedback following an incorrect response	F (2,5) = 12.14 eta squared = 0.83	significant p=0.01 group 1> group 2 and group 3

4.5.2: Relationships between assessments of language processing and individual facilitation cues

Correlations

4.5.2.i: Relationship between reading and naming following orthographic facilitation

It is hypothesised that relatively intact reading skills are necessary to be able to benefit from orthographic facilitation, and therefore it was anticipated that the performance across the two would be correlated.

The relationship between reading ability (as measured by the combined correct score for reading aloud words and non-words) and orthographic facilitation (as measured by naming at a delay following facilitation with the whole written word) was investigated using Spearman's correlation coefficient. There was a small positive correlation, between the two variables, *rho* = 0.22, n = 8, but this was not significant, *p* = 0.61 (2-tailed).

A subsequent Spearman's correlation coefficient was carried out to identify whether there was a relationship between response to orthographic facilitation with the whole written word and ability to read aloud the initial grapheme from non-words, cf. Best et al. (2002). However, in this study there was no correlation between the two variables, *rho* = -0.06, n = 8, *p* = 0.89 (2-tailed).

While the results from this study were unable to support previous findings, the outcome may reflect differences in methodology. In the current study, participants' naming following facilitation with the whole written word was compared with ability to read aloud the initial grapheme from non-words. This contrasts with Best et al. (2002) in which the combined results from provision of written CV cues in a single and choice of cue paradigm were compared to ability to read aloud non-words. The ability to benefit from the provision of written CV cues may be more closely aligned with ability to read aloud the initial grapheme from non-words.

4.5.2.ii: Relationship between repetition and repetition facilitation

It is hypothesised that relatively intact repetition skills are necessary to be able to benefit from repetition facilitation, and therefore it was anticipated that the performance across the two would be correlated.

The relationship between repetition ability (as measured by the combined correct score for repeating aloud words and non-words) and repetition facilitation (as measured by naming at a delay following facilitation with the spoken word for repetition) was investigated using Spearman's correlation coefficient. There was no correlation between the two variables, *rho* = -0.04, n = 8, *p* = 0.93 (2-tailed).

The above two analyses, for reading and repetition skills, indicate that poor performance in a particular language skill does not prevent people with aphasia from being able to benefit from cues which utilise that skill. While intuition would lead us to conclude that strength in such skills would enable greater improvements in naming following cues employing them, the current data do not support that notion. This is clinically relevant as it may help clinicians consider approaches for anomia which had previously been dismissed as a result of clients performing poorly in assessment of a particular skill.

4.5.3: Relationships between assessments of language processing and combined facilitation response

The delayed naming scores from all facilitation studies in which a linguistic cue was provided were combined to provide an overall indication of response to intervention (phonological cue, repetition, increasing cue, decreasing cue, initial grapheme and whole written word). This combined facilitation response score was used to analyse the relationship between response to intervention and general language skills. It is worth noting that Fillingham et al. found no language measure which correlated with response to therapy.

4.5.3.i: Relationship between combined facilitation response and language comprehension

The relationship between combined facilitation response and language comprehension (as measured by total score from spoken word to picture matching and spoken sentence to picture matching) was investigated using Spearman's correlation coefficient. There was a medium correlation, between the two variables, *rho* = 0.43, n = 8, but this was not significant *p* = 0.28 (2-tailed). This suggests that facilitating word retrieval with cues can be used as a technique even with people with poor language comprehension.

4.5.3.ii: Relationship between combined facilitation response and language expression

The relationship between combined facilitation response and language expression (as measured by total score from naming, repetition and reading of words) was investigated using Spearman's correlation coefficient. There was a large correlation, between the two variables, *rho* = 0.79, n = 8, which was significant *p* = 0.02 (2-tailed). This suggests that clients with better language expression are more likely to see improvements in word retrieval following facilitation. However it does not preclude people with greater impairments in expressive language skills from participating in cueing therapy for anomia, as the relationship is not straight-forward, and as has already been demonstrated by other authors depends on other neuropsychological factors. This relationship is considered further in the discussion, page 218.

Table 4.5.ii: Summary table of correlation analyses for language assessments and response to facilitation

Hypothesis: There is a relationship between...	Assessments used	Correlation value of rho	Significance (all 2 tailed)
Language assessments and facilitation			
reading and orthographic facilitation	word reading and delayed naming following facilitation with the whole written word	0.26 Small	non-significant p=0.61
Reading initial graphemes and orthographic faciliation	Number of initial graphemes read correctly from non-words and delayed naming following facilitation with the whole written word	-0.06 None	non-significant p=0.89
repetition and repetition facilitation	word + non-word repetition and delayed naming following facilitation with repetition	-0.04 None	non-significant p=0.93
Combined facilitation response and language abilities			
response to combined facilitation and language comprehension	combined delayed naming score following facilitation and SWPM+SSentPM	0.43 Medium	p = 0.28
response to combined facilitation and language expression	combined delayed naming score following facilitation and naming+reading+repetition	0.79 Large	p = 0.02

4.6: Results: Language and Neuropsychological assessment results

4.6.1: Correlations between language and neuropsychology assessment findings

4.6.1.i: Relationship between working memory and language comprehension

Following the neuropsychological literature review (see page 64) it is predicted that working memory capacity is related to performance on language comprehension tasks. The null hypothesis is that there is no relationship between working memory and language comprehension.

It is hypothesised that working memory is more likely to be correlated with auditory comprehension as there is only one exposure to the information (as opposed to written comprehension in which the information remains in view). Therefore, spoken word to picture matching (SWPM) and spoken sentence to picture matching (SSent PM) are used as a measure of language comprehension. Spatial span is categorised as an assessment of working memory which does not require any phonological encoding and is used to represent this cognitive skill (spatial span total score (SSTS)).

The relationship between working memory and language comprehension was investigated using Spearman's correlation coefficient. There was a large positive correlation between the two variables, *rho* = 0.74, n = 8, $p < 0.05$ (2-tailed), with high scores on working memory assessments associated with high scores on language comprehension.

The results from this test allow for rejection of the null hypothesis, and support the view that there is a correlation between working memory and language comprehension. While the data do not enable full interpretation of the direction of the dependency, Ernie's result provides some evidence to support the position that intact working memory is not a prerequisite for language comprehension to occur successfully as his ceiling performance on the test of spoken sentence to picture matching suggests that language comprehension can proceed even when working memory is impaired.

4.6.1.ii: Relationship between letter span and non-word reading

Letter span is an assessment of short term memory ability which utilises the phonological loop in working memory to retain and rehearse the letter sequence. It is considered that successful non-word reading also requires use of the phonological loop as there is no corresponding lexical form that can be accessed, so letter sequence must be retained to sound out the novel words. Therefore, these two assessments were hypothesised to be positively related due to shared underlying processing.

Spearman's correlation coefficient was used to investigate the relationship between letter span (as measured by the short term memory letter span assessment) and non-word reading (as measured by number correct on the assessment of reading non-words aloud).There was a large, positive correlation between the two variables, *rho* = 0.81, n = 8, $p < 0.05$ (2-tailed), with high scores on STM letter span associated with high scores on non-word reading. This suggests that the two assessments involve shared underlying processes, and that these may utilise both language and neuropsychological skills. However, at this early stage results must be interpreted with caution, as one participant, Ernie, performed well compared to the group on assessment of letter span, but less well on assessment of non-word reading.

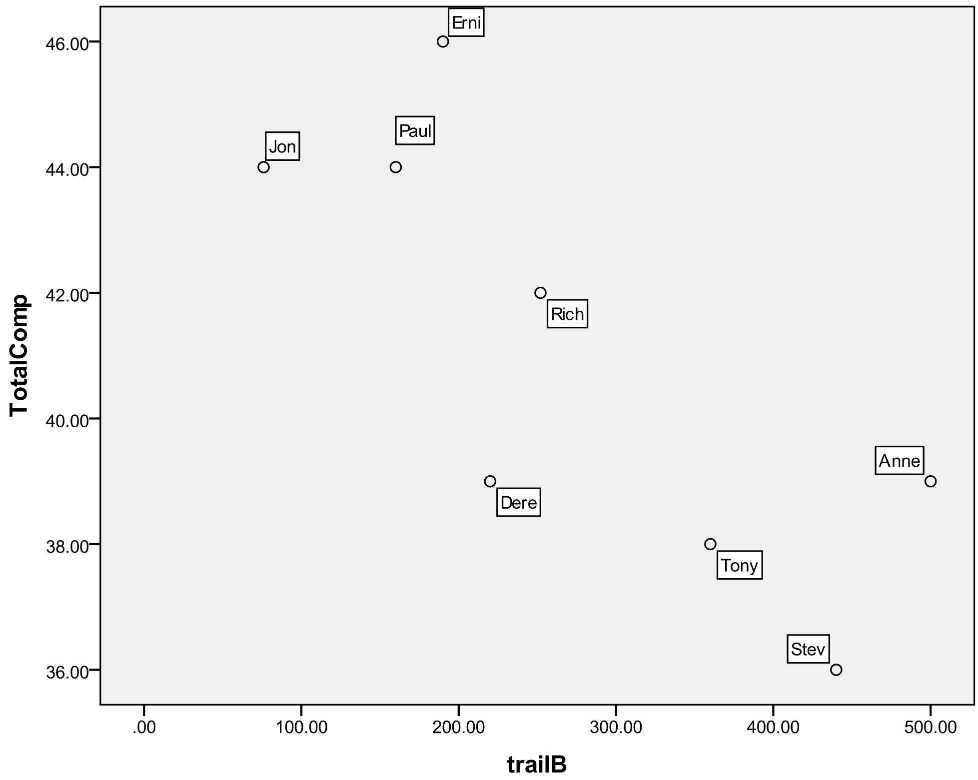
The results from the current study are not sufficient to guide clinicians about interpretation of results from these assessments with regards to shared underlying processes. However, with further research to enable greater understanding of the underlying language and neuropsychological processes involved, it is possible that administration of either of these assessments could be carried out to provide information about working memory abilities as well as language skills.

4.6.1.iii: Relationship between executive function skills and language comprehension

It is hypothesised that due to the complex and novel nature of assessments of executive function, relatively intact language comprehension is required to process the demands of the task.

The relationship between executive function skills (as measured by the Trail Making part B) and language comprehension (as measured by spoken word to picture matching and spoken sentence to picture matching) was investigated using Spearman's correlation coefficient. There was a large, negative correlation between the two variables, *rho* = -0.78, n = 8, $p < 0.05$ (2-tailed), with fast completion times on Trail Making B associated with high scores on language comprehension (see Figure 10). This large, significant correlation suggests that there are some shared underlying processes engaged in successful completion of these tasks, or that there is a dependency between the tasks. Such a dependency could work in either direction, with relatively intact language comprehension required to be able to understand and complete the task requirements of assessments of executive function, or executive skills being required to effectively allocate resources for successful language comprehension. In order to explore these hypotheses, further studies would need to be carried out in which additional assessments of executive function are used to analyse this relationship and with a larger number of participants.

Figure 10: The relationship between participants' performance on language comprehension and executive function



4.6.1.iv: Relationship between executive function skills and language expression

It is hypothesised that executive skills are correlated with expressive language skills with both requiring formation of goals and planning. As identified in the neuropsychological literature review (page 76), Coehlo, Liles and Duffy (1995) and Frankel, Penn and Ormond-Brown (2005), among others identified correlations between measures of executive function and aspects of connected speech in story retelling and conversation respectively. The current study did not use any measures of connected speech, therefore the relationship between executive abilities and language expression at the single word level is analysed.

The relationship between executive function skills (as measured by the Trail Making part B) and language expression (as measured by the combined total of naming, reading and repetition of words) was investigated using Spearman's correlation coefficient. The relationship was anticipated to be in the negative direction with longer durations on Trail Making B being associated with lower scores on the combined measures of language expression. There was a medium negative correlation between the two variables, *rho* = -0.45, n = 8, but this did not reach statistical significance *p* = 0.26 (2-tailed).

This finding does not corroborate the work of other researchers who have found relationships between executive abilities and measures of expressive language. However as already mentioned, previous investigations have largely used measures of connected speech. The lack of a stronger relationship between this measure of expressive language and executive skills suggests that executive processing is not crucial for successful single word production.

4.6.1.v: Correlation between executive function skills and non-word reading

For successful reading aloud of non-words participants must be able to self monitor and apply strategies, skills which overlap with executive processing. It is therefore hypothesised that these two skills are related.

The relationship between executive function skills (as measured by the Trail Making part B) and non-word reading (as measured by number correct on the assessment of reading non-words aloud) was investigated using Spearman's correlation coefficient. There was a large, negative, significant correlation between the two variables, *rho* = -0.71, n = 8, *p* = 0.05 (2-tailed), in which a fast time on Trail Making B was associated with a high score on non-word reading.

The large relationship identified suggests that the two tasks are related. Clinically this could be useful as, with further investigation, it may prove possible to administer an assessment of non-reading reading to provide information about a client's executive functioning, in addition to information about specific components of language processing.

4.6.1.vi: Relationship between span tasks and repetition

Repetition may make use of the phonological loop in working memory, a process which is also recruited in successful completion of span tasks. Therefore, it is hypothesised that there is a relationship between these two tasks.

The relationship between repetition (as measured by repetition of words) and short term memory span tasks (as measured by the combined total score on the test of STM letter span, STM digit span and STM picture pointing span) was investigated using Spearman's correlation coefficient. Contrary to expectations, there was a medium correlation, in the *negative* direction, between the two variables, *rho* = -0.48, n = 8, but this did not reach significance, *p* = 0.23 (2-tailed).

A task in which delayed repetition is required may be found to correlate with these span tasks, as such a task would necessarily recruit sub-vocal rehearsal process.

See Table 4.6.i for a summary of the correlations performed for language and neuropsychological assessments.

Table 4.6.i: Summary table of correlation analyses between language and neuropsychological assessments

Hypothesis: There is a relationship between...	Assessments used	Correlation value of rho	Significance (all 2 tailed)
Language and Neuropsychological assessments			
working memory and language comprehension	SSTS and SSentPM	0.74 large	significant $p<0.05$
letter span and non-word reading	STM letter span and non-word reading	0.81 large	significant $p<0.05$
executive function and language comprehension	TMB (NB negative scoring) and SWPM+SSentPM	-0.78 large	significant $p<0.05$
executive function and language expression	TMB (NB negative scoring) and naming+reading+repetition	-0.45 medium	non-significant $p=0.26$
executive function and non-word reading	TMB (NB negative scoring) and non-word reading	-0.71 large	significant $p<0.05$
span tasks and repetition	STM letter span+STM digit span+ STM picture pointing span and repetition	-0.48 medium	non-significant $p=0.23$

4.7: Results: Neuropsychological assessment and facilitation results

The relationship between response to intervention, as measured by delayed naming following facilitation, was analysed alongside participants' performance on neuropsychological assessments. The first set of results reported here are for individual facilitation studies, followed by results for the response to combined facilitation.

4.7.1: Relationships between individual facilitation tasks and neuropsychological processing

4.7.1.i: Relationship between repetition facilitation and span tasks

It was hypothesised that delayed naming performance for items facilitated with repetition would be correlated with span tasks.

The relationship between repetition facilitation (as measured by delayed naming following facilitation with repetition) and short term memory span tasks (as measured by the combined total score on the test of STM letter span, STM digit span and STM picture pointing span) was investigated using Spearman's correlation coefficient. There was a small non-significant correlation between the two variables but contrary to expectation this was in the *negative* direction, *rho* = -0.11, n = 8, *p* = 0.80 (2-tailed).

The results do not allow for rejection of the null hypothesis, and imply that word retrieval can benefit from facilitation with repetition even for people with identified short term memory impairments. Clinically, this is useful information to consider when planning therapy, as it suggests that cueing with repetition can be a successful approach for anomia to use with people with memory impairments who may find other, more complex cueing therapies difficult to engage with.

4.7.1.ii: Relationship between increasing cue facilitation and executive function

It is hypothesised that in order to benefit from increasing cues, executive processes are required to allocate resources between attention to provision of different levels of cues and word retrieval processes.

The relationship between increasing cue facilitation (as measured by naming at a delay following facilitation with increasing cues) and executive function (as measured by the time taken to complete Trail Making B, where longer durations relate to poorer performance) was investigated using Spearman's correlation coefficient. There was a medium correlation, in the negative direction, between the two variables, *rho* = -0.35, n = 8, but this did not reach significance, *p* = 0.39 (2-tailed).

4.7.1.iii: Relationship between phonological cue facilitation and letter span

It is hypothesised that successful naming following cueing with an initial phoneme requires utilisation of the phonological loop sub-process of working memory to keep the phoneme active while attempting to access the phonological form. Therefore, it is hypothesised that there is a relationship between delayed naming following facilitation with an initial phoneme and ability to retain a series of letters.

The relationship between phonological cue facilitation (as measured by naming at a delay following facilitation with an initial phoneme) and letter span (as measured by STM letter span task) was investigated using Spearman's correlation coefficient. There was a large positive correlation, between the two variables, *rho* = 0.61, n = 8, but this did not reach significance, *p* = 0.11 (2-tailed). Although not significant, the trend was towards longer letter span being associated with better naming scores following facilitation with a phonological cue.

Clinically it may prove useful to assess clients' letter span when considering whether phonological cueing therapy would be an optimal approach to use for individuals with anomia. However, further research is required before being able to recommend such analysis.

4.7.2: Relationships between combined facilitation response and neuropsychological processing

Delayed naming scores from all linguistic facilitation studies were combined to provide an overall indication of response to intervention (phonological cue, repetition, increasing cue, decreasing cue, initial grapheme and whole written word). This combined facilitation response score was used to analyse the relationship between response to intervention and different neuropsychological domains. Fillingham et al. identified key domains of neuropsychological function to be related to response to intervention: recognition memory and executive function. It is anticipated that these findings may be replicated in the current study.

4.7.2.i: Relationship between combined facilitation response and assessments of attention

The relationship between combined facilitation response and attention (as measured by the total score on the subtests of the Test of Everyday Attention) was investigated using

Spearman’s correlation coefficient. There was a small, positive correlation, between the two variables, *rho* = 0.22, n = 8, which did not reach significance, *p* = 0.61 (2-tailed).

As only a small correlation was found, it is indicative that this cognitive skill and successful response to this intervention do not share underlying processes nor is there is a dependency in either direction. This reflects the findings from Fillingham et al.’s errorless learning literature in which attention was not found to be related to therapy response.

4.7.2.ii: Relationship between combined facilitation response and assessments of memory

The relationship between combined facilitation response and assessments of memory (as measured by the total score from all memory assessments) was investigated using Spearman’s correlation coefficient. There was a large positive correlation, between the two variables, *rho* = 0.52, n = 8, which approached significance, *p* = 0.14 (2-tailed). As this analysis used the combined memory score, an additional correlation was carried out to analyse the relationship between combined response to facilitation and recognition memory. To measure recognition memory the combined score from the following assessments was used: Faces I, Faces II and design visual recognition. Using a Spearman’s correlation coefficient to analyse the relationship, a large, positive correlation was found between the two variables, *rho* = 0.76, n = 8, which was significant, *p* = 0.03 (2-tailed). This finding is important as it supports the finding from Fillingham et al., in which participants with aphasia who had better recognition memory made greatest improvements in both immediate and long term naming. Not only does this advocate the clinical use of a test of recognition memory for people with aphasia, but it is indicative that successful response to facilitation requires the same set of cognitive abilities as successful response to therapy, thereby supporting the use of facilitation as a probe tool.

4.7.2.iii: Relationship between combined facilitation response and assessment of executive function

The relationship between combined facilitation response and assessment of executive function (as measured by the time taken to complete Trail Making part B) was investigated using Spearman’s correlation coefficient. There was a small, negative correlation, between the two variables, *rho* = -0.29, n = 8, which was not significant, *p* = 0.49 (2-tailed). The lack of a more convincing relationship between response to facilitation and this measure of executive function, suggests that the processes measured by the Trail Making Test are not related to the processes involved in successful word retrieval following facilitation.

4.7.2.iv: Relationship between self-monitoring and overall response to facilitation

In view of Fillingham et al.'s finding that better response to therapy was correlated with better ability to self-monitor, it is hypothesised that participants' overall response to facilitation will be correlated with self-monitoring ability.

The relationship between naming response for combined facilitation cues (as measured by the combined delayed naming score following facilitation with: phonological cues, repetition, increasing cues, decreasing cues, initial grapheme cues and the whole written word) and self-monitoring ability (as measured by the score on the naming self-judgement task) was investigated using Spearman's correlation coefficient. There was a large, positive significant correlation found between the two variables, *rho* = 0.84, n = 8, p = .009. This finding supports the work of Fillingham et al. in finding that self-monitoring ability is an important factor to consider when identifying appropriate naming therapy for people with aphasia.

Table 4.7.i provides a summary of the correlations between facilitation, individual and combined, and neuropsychological assessments.

Table 4.7.i: Summary table of correlation analyses for facilitation and response to neuropsychological assessments

Hypothesis: There is a relationship between...	Assessments used	Correlation value of rho	Significance (all 2 tailed)
Facilitation and neuropsychological assessments			
repetition facilitation and span tasks	delayed naming following facilitation with repetition and STM letter span+STM digit span+ STM picture pointing span	-0.11 small	non-significant p=0.80
increasing cue facilitation and executive function	delayed naming following facilitation with increasing cues and TMB (NB negative scoring)	-0.35 medium	non-significant p=0.39
phonological cue facilitation and STM letter span	delayed naming following facilitation with a phonological cue and STM letter span score	0.61 large	non-significant p=0.11

Combined facilitation response and neuropsychological assessments			
Combined facilitation and attention	Combined delayed naming score following facilitation and subtests of TEA	0.22 Small	non-significant p = 0.61
Combined facilitation and memory	Combined delayed naming score following facilitation and all assessments of memory	0.52 Large	non-significant p = 0.14
Combined facilitation and recognition memory	Combined delayed naming score following facilitation and Faces I, Faces II + design recognition	0.76 Large	significant p = 0.03
Combined facilitation and executive function	Combined delayed naming score following facilitation and TMB	-0.29 small	non-significant p = 0.49
Self-monitoring and combined response to facilitation	score on the naming self-judgement task and combined delayed naming score following facilitation	0.84 large	significant p = 0.009

4.8: Results: Feedback

4.8.1: Relationships between feedback and domains of neuropsychological processing

Naming performance at delayed naming following clinician-delivered feedback was used to analyse the relationship between response to feedback and different domains of neuropsychological processing.

4.8.1.i: Relationship between response to clinician-delivered feedback and attention

It is hypothesised that in order to benefit from clinician-delivered feedback participants must have good attention skills to attend to the information being presented. Therefore, the relationship between response to clinician-delivered feedback and assessment of attention (as measured by the total score on the subtests from the Test of Everyday Attention) was investigated using Spearman's correlation coefficient. No correlation was found between the two variables, *rho* = 0.04, n = 8, *p* = 0.93 (2-tailed). The results suggest that attention skills are not related to ability to benefit from clinician-delivered feedback. It is possible that the repetitive, structured framework of the feedback delivered in the current study minimised demands on attention processing, with only utilisation of simple attention skills required.

4.8.1.ii: Relationship between response to clinician-delivered feedback and memory

In a Hebbian model of learning, intact memory processes are postulated to be recruited during the process of feedback, with people storing the stimulus while associating it with the response fed-back to them. It is therefore hypothesised that there is a relationship between response to feedback and performance on assessments of memory.

The relationship between response to clinician-delivered feedback and assessment of memory (as measured by the total score on all assessments of memory) was investigated using Spearman's correlation coefficient. A medium, positive correlation was found between the two variables, *rho* = 0.43, n = 8, which did not reach significance *p* = 0.29 (2-tailed). Therefore, the data from this thesis does not support the idea that intact memory processes are an essential prerequisite for people to be able to benefit from feedback.

4.8.1.iii: Relationship between response to clinician-delivered feedback and executive skills

It is hypothesised that executive processes are recruited during feedback in order to allocate the resources to attend to, maintain and modify subsequent responses following feedback. It is therefore hypothesised that there is a relationship between response to feedback and executive processes.

The relationship between delayed naming response to clinician-delivered feedback and assessment of executive function (as measured by the time taken to complete Trail Making B) was investigated using Spearman's correlation coefficient. No correlation was found between the two variables, *rho* = -0.03, n = 8, *p* = 0.96 (2-tailed), suggesting that executive processing as measured by this assessment, does not recruit the same processes as those involved in modifying naming response following feedback. As already discussed, the assessment of executive function used in the current study may not reflect more general executive processes, and further investigation may reveal a relationship between feedback and this domain as measured by different assessments.

4.8.1.iv: Relationship between response to clinician-delivered feedback and self-monitoring ability

It is hypothesised that in order to optimally benefit from externally delivered feedback, ability to self-monitor is necessary so that productions can be compared with responses provided by clinicians. The relationship between delayed naming response to clinician-delivered feedback and assessment of self-monitoring (as measured by PALPA naming self-judgement task) was investigated using Spearman's correlation coefficient. A large, positive correlation was found between the two variables, *rho* = 0.88, n = 8, which was highly significant, *p* = 0.004 (2-tailed).

This supports the hypothesis and indicates that assessment of self-monitoring ability could have potential as an informative measure to administer when planning the use of feedback in anomia therapy.

The correlations between delayed naming response following feedback and neuropsychological assessments, shows that the only neuropsychological factor related to ability to benefit from feedback is the ability to self-monitor. The correlation may reflect utilisation of shared underlying processes involved in both tasks. Alternatively, as hypothesised, the relationship may reflect a co-dependency with ability to self-monitor spoken word productions, and comparing these productions with external feedback, being an essential part in the process of modifying a response to improve accuracy.

4.8.2: Relationship between feedback and overall language skills

It was considered that language processing skills may show a relationship with ability to benefit from clinician-delivered feedback, due to the requirement to comprehend the feedback being given and subsequently utilise this in production.

4.8.2.i: Relationship between response to clinician-delivered feedback and language comprehension

The relationship between response to feedback and language comprehension (as measured by total score from spoken word to picture matching and spoken sentence to picture matching) was investigated using Spearman's correlation coefficient. There was a small, positive correlation between the two variables, *rho* = 0.25, n = 8, but this was not significant *p* = 0.55 (2-tailed). This suggests that intact language comprehension is not a crucial component in the processes involved in benefitting from clinician-delivered feedback as implemented in the current study.

The current study deliberately used a repetitive, simple framework for delivering feedback, in order to reduce language processing demands. It is therefore possible that other, more complex feedback frameworks would show a relationship with language comprehension abilities.

4.8.2.ii: Relationship between response to clinician-delivered feedback and language expression

The relationship between response to clinician-delivered feedback and language expression (as measured by total score from naming, repetition and reading of words) was investigated using Spearman's correlation coefficient. There was a large, positive correlation between the two variables, *rho* = 0.74, n = 8, which was significant *p* = 0.04 (2-tailed).

Better expressive language skills were found to be related to optimal benefit from feedback, perhaps because people with better expressive language skills are able to more accurately reproduce the model provided in feedback by the clinician.

4.8.3: Relationship between clinician-delivered feedback and combined facilitation response

It is hypothesised that there are overlapping skills required in being able to benefit from feedback and being able to benefit from facilitation, as both require ability to attend to a cue/response provided by a clinician and then use his at a later point in time to aid word retrieval. Therefore the relationship between response to feedback and combined facilitation response was investigated using Spearman's correlation coefficient. There was a large, positive correlation between the two variables, *rho* = 0.95, n = 8, which was highly significant $p = 0.000$ (2-tailed). This supports the hypothesis and indicates that by measuring response to feedback, clinicians may be better able to predict which clients' with aphasia are more likely to benefit from a cueing approach to anomia therapy.

See Table 4.8.i for a summary of the correlations performed for feedback and language and neuropsychological assessments.

Table 4.8.i: Summary table of correlation analyses for feedback and language and neuropsychological assessments

Hypothesis: There is a relationship between...	Assessments used	Correlation value of rho	Significance (all 2 tailed)
Clinician-delivered feedback and neuropsychological assessment			
Clinician-delivered feedback and attention	Delayed naming score for items initially incorrect following facilitation with clinician-delivered feedback and subtests of TEA	0.04 None	non-significant p = 0.93
Clinician-delivered feedback and memory	Delayed naming score for items initially incorrect following facilitation with clinician-delivered feedback and all assessments of memory	0.43 Medium	non-significant p = 0.29
Clinician-delivered feedback and executive function	Delayed naming score for items initially incorrect following facilitation with clinician-delivered feedback and TMB	-0.03 None	non-significant p = 0.96
Clinician-delivered feedback and self-monitoring	Delayed naming score for items initially incorrect following facilitation with clinician-delivered feedback and self-monitoring assessment	0.88 large	significant p = 0.004
Clinician-delivered feedback and language assessment			
Clinician-delivered feedback and language comprehension	Delayed naming score for items initially incorrect following facilitation with clinician-delivered feedback and SWPM + SSentPM	0.25 Small	non-significant p = 0.55
Clinician-delivered feedback and language expression	Delayed naming score for items initially incorrect following facilitation with clinician-delivered feedback and naming+reading+repetition	0.74 large	significant p = 0.04
Clinician-delivered feedback and response to combined facilitation	Delayed naming score for items initially incorrect following facilitation with clinician-delivered feedback and combined delayed naming score following facilitation	0.95 large	significant p = 0.000

See appendix 5 for a correlation matrix providing a summary of the main language, neuropsychological, facilitation, feedback and self-monitoring findings for combined results.

5: Discussion

The results presented in the previous chapters are discussed here in the same order: language assessments, individual results and subsequent grouping into primary impairment types; facilitation, group response to the different cues and validity as a technique; neuropsychological assessments, individual results and relationships between outcomes of assessments of the same and different cognitive domains; relationships between language assessments and response to facilitation; relationships between language assessments and neuropsychological assessments; relationships between neuropsychological assessments and response to facilitation; and feedback, relationships with language assessments, neuropsychological assessments and response to facilitation. The key points from the results are considered within each section, with reference to the original aims of the thesis:

- To identify a group of neuropsychological assessments, from a larger battery, that can be administered to people with aphasia, without language impairment confounding the interpretation of results
- To establish whether people with aphasia show similar patterns of neuropsychological processing, for example is executive function universally affected in people with aphasia cf Helm-Estabrooks (2002)?
- To investigate the relationship between underlying language and neuropsychological processing and response to facilitation
- To investigate the effectiveness of different cues on naming at a delay following facilitation
- To establish the reliability of facilitation as a probe tool
- To manipulate feedback and analyse its effect on delayed word retrieval.

The discussion ends by drawing conclusions from the research along with limitations of the current study. Finally, the implications of the results are considered with reference to future research and clinical practice.

5.1: Language skills

One of the aims of this thesis was to provide a detailed account of the language profiles of people with aphasia, and to investigate how these profiles relate to neuropsychological processing and response to facilitation. In this section the language profiles of the participants in the study are discussed.

5.1.1: Language assessment results

This thesis used a range of published and unpublished assessments, aimed at assessing language processing primarily at a single word level. The group of assessments was largely based on those used in previous research studies carried out by Best et al., for example Best, Greenwood, Grassly and Hickin (2008) and Hickin, Best, Herbert, Howard and Osborne (2002). Assessments were selected to provide information on both input and output processing, at peripheral and central levels.

Participants' performance across the range of assessments showed variation in both pattern and severity of aphasia, as anticipated. The assessments were largely felt to provide a true reflection of participants' functional language abilities. For example, Richard had reported difficulties with reading information affecting both business and pleasure pursuits and this was reflected in his poor performance on assessments of reading in which he scored 1/26 on non-words and 5/52 on reading real words.

5.1.2: Language impairment groupings

The assessments allowed for patterns of processing to be identified across participants, with participants varying in their degree of semantic and phonological level impairments. In order to reflect this, assessment results and error performance were used to calculate z scores, which divided participants into above and below the mean score for the group on each task. This method of assigning primary levels of impairment was based on that originally used by Howard et al. (2006) and was felt to accurately categorise participants according to their, profiles of language processing, both anecdotal and assessed. However, as acknowledged, most participants present with a degree of impairment at both levels of processing (semantic and phonological), and use of a binary categorisation system alone, albeit with additional inclusion of a mixed category, does not provide an accurate profile of the patterns of deficits. Therefore, while this technique was felt to provide useful information for carrying out analysis with regard to response to different cues, it is not suggested that it is used independently from detailed individual patterns of performance.

5.2: Facilitation

5.2.1: Response to facilitation

5.2.1.i: Phonological cues and repetition

The phonological cues used in this study were the initial phoneme of the target word combined with a schwa, while repetition provided the whole word form. It was anticipated that there would be at least an immediate effect on naming (cf. Howard et al., 1985) and potentially an effect on naming at a delay (cf. Best et al., 2002).

While numerically there was a small advantage for immediate naming of items that had been cued with a phonological cue over items which had received extra time, this was not the case at delayed naming, where there was a small numerical advantage for items which had received extra time over items which had been cued with the initial phoneme. It appears that for some participants the provision of the initial phoneme plus schwa actually served to distract from their own word retrieval process. This was an unexpected finding which may be explained by the precise nature of the limited information provided by the phonological cue used. In other studies where a phonological cue has been used, it has usually provided more information than just the initial phoneme, for example Best et al. (2002) used CV and VC cues. The only other study known by the author, in which just the initial phoneme was provided, also found that two out of three participants did not benefit from the initial phoneme cue, while the third did not benefit from the initial phoneme until after several replications of the facilitation sessions (Lorenz and Nickels, 2007).

In contrast, the other type of phonological cue, repetition of the whole form, was found to show significant benefit for delayed naming over extra time. Thus in order for phonological cues to be effective in facilitation, there appears to be a minimum amount of information that needs to be provided.

5.2.1.ii: Increasing and decreasing cues

Both increasing and decreasing cues were found to benefit delayed naming significantly, with a greater significance for decreasing cues over increasing cues. This contrasts with the findings of Abel et al. (2005) who found significant improvement in both conditions, but better naming following increasing cues than decreasing cues. However, there are fundamental differences between this study and the previous research. First, Abel et al. used a combination of phonological and semantic cues with increasing cues starting with semantic information and decreasing cues starting with phonological information.

Therefore, the advantage for increasing cues in their study reflects the differences in the content of the cue rather than reflecting the differences between an increasing and decreasing hierarchy consisting of the same content. Additionally, decreasing cues were applied in an increasing fashion if an error was made, hence becoming a mixture of increasing and decreasing cues.

The current study was designed to avoid these complications, and interestingly found that utilising purely phonological content resulted in better naming following facilitation with a decreasing hierarchy than an increasing hierarchy. Abel et al. hypothesised that people with aphasia who have poor self-monitoring may benefit most from a decreasing cueing hierarchy. However, this was not found to be the case in the current study in which good self monitoring ability was significantly correlated with most benefit from decreasing cues. As discussed in more detail below, it may be that good self-monitoring ability is in fact an essential skill in order to benefit from a cueing therapy approach. This finding provides some support for the application of this type of error reduced learning system in which clients are afforded limited opportunities to make errors.

5.2.1.iii: Initial grapheme and whole written word

Of the cues used in this facilitation study, initial grapheme and whole written word cues were found to be the most beneficial for spoken naming for the group, even though the phonological form was not provided. This corroborates the findings of Lorenz and Nickels (2007) who found that the naming of all three of their participants benefitted from the provision of the initial grapheme even though all had some degree of impaired sounding out of single letters and reading non-words. While no assessment of sounding out letters was used in the current study, an analysis of the relationship between response to initial grapheme cues and reading aloud non-words showed no correlation; that is, impairment in sub-lexical grapheme to phoneme conversion as measured by reading aloud non-words did not prevent participants benefitting from the initial grapheme. In their case series examining the effects of phonological and orthographic facilitation on word-retrieval, Best, Herbert, Hickin, Osborne and Howard (2002) found that there was a relationship between response to orthographic facilitation and ability to read aloud the initial grapheme from non-words. Therefore an additional correlation was carried out in which the participants' ability to read aloud the initial grapheme from non-words was compared to response to facilitation with the whole written word. Again, in the current data there was not a significant correlation between the two variables. While the results from this study were unable to support previous findings, the outcome may reflect differences in methodology.

In the Best et al. study, response to orthographic facilitation was measured for naming following facilitation with a written CV cue, rather than either the initial grapheme or the whole written word as used in the current study. Additionally, Best et al. used immediate naming response to measure effectiveness of facilitation in this case, whereas the current study only examines the effect on delayed naming.

The findings in this study seem to support the idea proposed by Lorenz and Nickels (2007), that initial grapheme cues may work by accessing the lexical system, rather than operating at a sub-lexical level, which would require intact orthographic to phonological conversion.

Research with more participants may be necessary to demonstrate the clinical potential of orthographic cues, and to confirm that ability to convert graphemes to phonemes is not a prerequisite in order to be able to benefit from such cues, as shown by Anne, Jon and Ernie who performed poorly on reading aloud non-words (2/26, 12/26 and 4/26 respectively) yet showed greatest benefit from orthographic cues.

5.2.2: Validity/robustness of facilitation as an assessment tool

Facilitation was selected as a tool for assessing different effects of cues due to its:

- ability to act as a probe tool in identifying whether a task would be successful in therapy (see Best et al., 2002)
- cost effectiveness for economic, social and psychological reasons (Nickels, Bachmann, Makin, McDonald, Moses and Taylor, 2011)
- reduced administration time allowing a number of different cues to be investigated.

As previously noted, since the current study was undertaken, Nickels, Bachmann, Makin, McDonald, Moses and Taylor (2011) raised questions from their own data about the reliability of facilitation. In repeating administration of the same repetition facilitation, Nickels et al. found significant differences in participants' responses to the cue over two presentations, with only two of their fifteen participants showing significant benefits following both presentations.

It was not possible to repeat the administration of any of the facilitation tasks in the current study; therefore, as described, the data were divided in two to look at stability of performance across cued items 1-10 compared with cued items 11-20. In this study no significant difference was found in naming between items 1-10 and items 11-20, with a strong significant correlation found between the two sets of items.

The difference between these results and those found by Nickels et al. may be explained by the difference in design of the facilitation studies. The items given facilitation in their work are pre-chosen for inability to name, whereas in the current study facilitation is given to items that participants are unable to name at that moment in time. As naming ability is known to vary, it is possible that Nickels et al.' results reflect at least in part variation in naming due to regression to the mean, rather than in response to facilitation.

Although the findings from the current facilitation studies were not extended into a therapy study, the stability of the results across the two divided sets are encouraging in supporting the notion that facilitation can be used as a reliable probe tool to identify appropriate therapy techniques.

5.3: Neuropsychological Processing

5.3.1: Neuropsychological assessment battery

For the thesis, neuropsychological assessments were combined in a novel way to assess abilities across different cognitive domains in people with aphasia. Assessments were selected primarily on the basis of requiring limited overt language processing, and included subtests from published, standardised assessments commonly used by clinical psychologists. Of interest to the current study were the questions of whether the participants would be able to carry out the tasks required for each assessment and whether there would be similar patterns of performance across participants.

The main recruitment criterion for the current study was presence of aphasia, with no prior information available regarding participants' cognitive abilities. In the research literature to date, hypotheses have been made about the co-morbidity of language and cognitive impairments. For example, Helm-Estabrooks (2002) found that, while clinically it is not possible to predict the relative integrity of other domains of cognition on the basis of language deficits, second to language, executive functions are the cognitive skills most vulnerable to the effects of brain damage associated with aphasia. However, research into this field is still at a relatively early stage. Therefore, detailed patterns of performance from people with different types of aphasia need to be described, in order to understand fully the relationship between language and cognitive skills. As Luria (1973, page 41) stated 'careful neuropsychological analysis of the syndrome and observations of the 'double dissociation' which arises in local brain lesions can make a major contribution to the structural analysis of psychological processes themselves and can pick out the factors involved in one group of mental processes but not in others'.

Participants' results across the range of neuropsychological assessments are summarised in Tables 4.4.xii - 4.4.xiv, see pages 166-167. At a glance, it can be seen that the greatest range of scores occurs across the assessments of memory, followed by attention assessments. However, performance across assessments of executive function is generally more impaired with participants largely performing below average. While this suggests that participants in the current study follow the suggestion of Helm-Estabrooks' (2002) pattern of processing abilities in people with aphasia, the complexity of assessments used to measure executive function must be considered with regards to the degree of language processing demands required.

5.3.1.i: Memory

Table 4.4.xii, page 166, illustrates a varied pattern of performance across assessments of memory by the participants with aphasia. The variation in profile across these assessments leads to two suggestions: the presence of aphasia does not preclude ability to participate in the assessments of memory used in the thesis; and presence of aphasia does not predict memory function as measured by these assessments.

However, it is still possible that the presence of aphasia does affect performance on *some* of the measures of memory used. For example, all participants in the current study performed below average for digit span, total score. One of the prerequisites for inclusion of neuropsychological assessments in the current study was the need for minimal language processing, but the digit span task was an exception in that stimuli were presented auditorily and a spoken response was expected. Two of the participants, Jon and Tony, were provided with an Arabic numeral scale to aid responses, as they showed greatest difficulty with providing a spoken numerical response. However, neither participant's performance improved as a result of having a number scale. This suggests that the requirement for a spoken response was not the sole cause for the participants universally scoring below average.

One of the aims of administering this battery was to identify assessments that can be carried out by people with aphasia while remaining sensitive to the domain being measured. With the exception of the digit span task, the memory assessments used in the current study reflect a range of patterns of processing in this domain and are therefore considered to appropriate assessments to administer to people with aphasia.

5.3.1.ii: Attention

Table 4.4.xiii, page 167, reflects a greater tendency for performance by the participants on assessments of attention to be below average, with performance on Trail Making A being below average for all participants. It is not possible to determine whether poor performance across the participants arose as a result of impaired language ability, or as a result of co-morbidity between language and attention impairment. Performance on elevator counting with distraction, and to a lesser degree, map search, did show patterns of variation across participants, suggesting that these assessments may have potential as clinical tools in providing measures of attention. However, it is necessary to carry out these, and other, assessments of attention with more participants with aphasia before they can be suggested as reliable measures of this domain.

5.3.1.iii: Executive Function

As Table 4.4.xiv, page 167, shows, the majority of participants perform at a below average level on the two assessments of executive function used in the current study. Six of the eight participants were classified as below average on the Brixton spatial anticipation test. While a greater spread of results, as measured by durations, was achieved on Trail Making B, when these scores were converted to their equivalent percentiles, seven out of the eight participants were classified as being below average. Jon was the only participant to score at, or above, average on both assessments.

It is not clear from the data whether the language demands of these assessments are such that the participants were unable to show their intact executive function ability on the tasks, or whether, in line with Helm-Estabrooks' (2002) hypothesis that second to language impairment, people with aphasia are most likely to show impairments in executive skills.

5.3.2: Relationships within assessments of neuropsychological processing

While theoretical models can be useful in aiding our understanding of a disrupted system, the development of models is a two-way process, with models providing a framework for interpreting results, and results informing and improving our knowledge of processing. Clinically, this is of importance as, for example executive function testing may provide not only an explanatory basis for communication symptoms but also with reference to appropriate models, a framework for focusing therapy (Frankel et al., 2007).

For each of the domains, attention, memory and executive function, a number of different assessments was selected and the relationships within and between these assessments were analysed. It was hypothesised that assessments within specific areas of each cognitive domain would show strong, positive correlations if measuring the same, or overlapping, processes.

5.3.2.i: Memory

Short term memory

Three assessments of short term memory were used: picture pointing, letter pointing and digit span. Using a Spearman's rank correlation to analyse the relationship between these assessments, no correlation was found. It is hypothesised that the lack of a relationship is due to the differing task demands, most notably the difference in output requirements. While picture span and letter span both require a pointing response, as already discussed digit span was the only assessment requiring a verbal response, which may have resulted in language impairment confounding measurement of short term memory with this task. An alternative hypothesis for the lack of correlation between the assessments is that digit span taps into different memory processes than letter span. Connor et al. (2000) proposed that digit span loads heavily on the storage component of working memory rather than the manipulation component, which may be implicated in the other short term memory tasks. Until further research is carried out with these assessments with a larger number of participants, the results from the current thesis do not support the use of digit span as a reliable measure of short term memory for people with aphasia.

Recognition memory

Three assessments of recognition memory were included: Faces I, Faces II and design visual recognition. There were large, positive correlations identified between the three assessments, which were significant for Faces I and Faces II, and approaching significance between these assessments and design visual recognition.

Demonstrating parity of performance across these assessments with a group of people with aphasia suggests that these assessments do tap the same memory process. If these assessments are proved to be robust and reliable measures of recognition memory in people with aphasia through further research, future studies could implement just one of these tasks as part of a neuropsychological battery. Fillingham et al. (2006) found that participants with aphasia who had better recognition memory, made greatest improvements in both immediate and long term naming. This, combined with the findings from the current study, suggests it is important to include one recognition memory task in future intervention studies and that such a task may be useful clinically when considering appropriate therapy approaches.

5.3.2.ii: Attention

Sustained/simple attention

Two assessments of simple attention were used: elevator counting and Trail Making A. There was a large, significant relationship found between the two assessments, suggesting that both measures tap into the same underlying processes. The range in performance levels across participants suggests that language impairment does not prevent people with aphasia from being able to carry out these tasks. This encouraging finding is useful for clinicians, as a test such as the Trail Making A is quick to administer and could provide valuable information about a client's attention skills. Such knowledge could help contribute to an overall profile of a client's ability, informing decision-making about optimal therapy approaches.

Selective/divided attention

Two measures of selective attention were included, both from the Test of Everyday Attention; elevator counting with distraction and map search. A large, positive and significant relationship was found between the two assessments, suggesting that the two assessments do provide a measure of the underlying processes involved in divided attention. As participants in the current study produced a range of performance across these assessments, it is suggested that presence of aphasia does not prevent assessment of this domain using these measures. Use of one of these assessments could usefully contribute to a clinician's battery of measures taken to provide information about a client's overall pattern of processing.

5.3.2.iii: Executive function

The relationship between the two assessments of executive function, Trail Making B and Brixton spatial anticipation test, was investigated using Spearman's rank correlation. A small correlation was found in the negative direction but this did not reach significance. The direction of the relationship was anticipated to be negative given that higher scores on Trail Making B indicate a poorer performance, whereas higher scores on the Brixton spatial anticipation test indicate a better performance. The absence of a stronger correlation between these two assessments, leads to three possible suggestions: the assessments were not measuring the same process; one, or both, of the assessments was not sensitive to the underlying processes encapsulated by executive function; or language processing affected the participants' ability to participate in the assessments.

It is acknowledged that in the case of the assessments for executive function, the raw data were inputted for Trail Making B while the converted standardised scores were inputted for the Brixton spatial anticipation assessment. The reason for this is that the standardised scores provided for Trail Making B are given as approximate percentiles, and are not sensitive to the differences between participants' scores. However, carrying out the above analysis using the raw scores for both assessments yields a similar small, non-significant relationship.

For the purpose of this thesis, only Trail Making B was used as an indicator of executive function for analysing relationships with other processes and response to facilitation. The reasons for this were that participants demonstrated greater understanding of the task requirements for Trail Making B than for the Brixton spatial anticipation test, even though not all were able to complete the task successfully. This resulted in greater sensitivity to the variations in executive function across the participants, and subsequently produced a greater spread of scores across the group.

At present, there is not an accepted assessment of executive function that seems to be consistently accessible to people with aphasia, without presenting a high possibility for misunderstanding task instructions (cf. Keil and Kaszniak, 2002). The widely used Wisconsin Card Sorting Test was not included in the current thesis due to acknowledgement by several authors that elderly people without aphasia, and people with aphasia are unable to access this task (for example Bhutani et al., 1992, and Purdy, 2002, respectively). While research is ongoing in finding measures of executive function that are not confounded by impaired language processing in people with aphasia, it should be considered that executive function is a multifaceted process and it is perhaps unrealistic to expect one or two assessments to reflect an individual's ability in this domain.

5.3.2.iv: Self monitoring task

The self-monitoring assessment used in this study was based on that used by Fillingham et al. (2006), with the modality and number of choices of response modified. The inclusion of the additional scoring category of close/not sure, was based on feedback from participants with aphasia who could not relate to scoring themselves as having produced a 'wrong' response when they knew what the target was but were unable to produce the word accurately. Prior to the inclusion of this category, participants indicated that they would score themselves as 'correct' if they knew the target word and produced a phonologically or semantically related response, as they did not feel that a 'wrong' score reflected their ability. Therefore, the inclusion of this extra category removed the potential for misunderstanding participants' ability to self-monitor.

As this was the only assessment of self-monitoring used in the current study, it was not possible to compare outcomes with other assessments of self-monitoring. The assessment from the researcher's perspective provided a good measure of participants' ability to self-monitor, and relationships established with response to intervention and feedback, as discussed in later sections, seem to support this view.

5.3.3: Challenges of using neuropsychological assessments with people with aphasia

In order to progress our understanding into the nature of the interaction between linguistic skills and cognitive skills, performance of participants with varying profiles of aphasia could provide valuable insight (cf. Keil and Kaszniak, 2002).

While stability of measures of attention and recognition memory has been established above for the participants with aphasia in the current study, the generally below average performance on other measures of neuropsychological skills illustrates the difficulties in selecting reliable assessments for people with aphasia. There are a number of issues which affect the use of published assessments with people with aphasia which need to be considered by researchers and clinicians prior to incorporation of any neuropsychological measures into assessment batteries. Some of the key complications are:

i. limited agreement about which areas of cognition are measured by each of the assessments.

Cognitive skills employed in carrying out neuropsychological tasks often overlap, with successful completion of tasks often requiring a degree of processing by each of the cognitive domains of memory, attention and executive function. With such overlap it is perhaps not surprising that there has been some difficulty in forming agreement about which skills are measured by each of the assessments. For example, as previously highlighted, most authors consider digit span tasks to be a measure of working memory, but Hodges (2007) believes digit span is better described as an assessment of the efficacy of phonological and attentional processes than what is commonly thought of as memory. Interpretation of results is thus complicated while such necessary debate is ongoing.

ii. limited evidence to suggest whether non-verbally mediated assessments measure the same skills as verbally mediated assessments of cognitive domains.

This is an important question for research with people with aphasia, with the answer potentially having implications for interpretation of results. Whilst it is not appropriate to carry out both verbally and non-verbally mediated tasks with people with aphasia, the author is not aware of any current research which allows comparison and correlation between such tasks with a non-language impaired population. Such a comparison would help examine whether using different modalities of access do provide a measure of the same skill. The only example within the current study was the use of digit span as a measure of short term memory, which, as already discussed, resulted in below average performance for all the participants. While it has been speculated that this was a result of impaired language processing affecting performance, it is possible that the poor performance, compared to performance on other measures of short term memory used, arose due to other causes, for example as a result of deficits in number processing (dyscalculia). To address the issue, further research needs to be carried out in which verbally and non-verbally mediated assessments are administered with a non-language impaired population.

iii. limited convergence in the research of assessments and study designs, reducing the ability to compare across cases.

While this area of research is still in its infancy, every aspect is under debate including selection of assessments, skills measured by different assessments, interpretation of results and accuracy of processing models. It is therefore perhaps not surprising that there is limited consistency across studies. As researchers pursue different avenues of investigation with divergent assessments and materials, comparison across studies is limited resulting in an emerging database which is broad but disparate. In the current study relationships have been studied between assessments measuring the same aspect of different cognitive skills, and parity of performance has been established for assessments of attention and recognition memory. This suggests that the measures used for these domains could be reliable tools with which to carry out further research.

iv. the necessity of assessments of executive function to include novel tasks, with few if any practice items.

The requirements of measures of executive function mean that assessments are often introduced with a verbal explanation (for example the Brixton Spatial Anticipation Test), and with no practice items (for example the Wechsler Memory Scale III). Consequently, comprehension has to be sufficient to understand complex, often abstract task requirements from auditory input alone. People with impaired language comprehension skills will naturally be at a disadvantage for successful completion of such tasks, which in turn impedes interpretation of results.

For progress to be made, researchers need to engage in debate about which models most closely describe the neuropsychological processes observed in people with and without aphasia, which, in turn, will enable increased agreement about cognitive skills being measured by different assessments. Subsequently, through administration of a set of reliable assessments to a large number of people with aphasia, a database should emerge informing clinicians about which assessments can be accessed by people with aphasia, and which most closely correspond to the skills they purport to measure.

Finally, in developing and modifying assessments for people with aphasia and ensuring that impaired language processing is not obscuring ability in other cognitive domains, a sufficient number of practice items needs to be included to ensure comprehension of task requirements, providing that such practice items can be demonstrated not to disproportionately inflate performance.

5.4: Relationships between language processing and response to facilitation

5.4.1: Response to facilitation by language impairment groups

Based on language profiles, participants were divided into one of three groups; semantic, phonological or mixed impairment, and the relationship between these groups and response to facilitation was investigated. If the findings of Abel, Willmes and Huber (2007) were to be replicated it would be anticipated that cues directly targeting participants' impairment would be most effective. However, analysis of response to initial phoneme and repetition cues showed that there was no significant difference between the language impairment groups for either type of phonological cue. The reason that the initial phoneme was not found to operate in a significantly different way between the groups may be explained by its general lack of effectiveness in this study. Repetition may have had an effect at both a semantic and a phonological level, given that the phonological form was provided in the presence of a picture. This is in line with other researchers who have found that cues that operate at both semantic and phonological levels can be beneficial for all people with aphasia (for example, Wambaugh et al., 2001).

Despite having a significant effect on naming at a delay for the group as a whole, increasing and decreasing cues did not show a different pattern of advantage across the language impairment groups. This again may have been related to the fact that the whole word was provided in the presence of a picture for both types of cue which were therefore of benefit for all the participants regardless of their underlying language profile.

Response to cueing with the initial grapheme did differ across the language impairment groups with the naming of the phonological group benefitting significantly more than either the semantic or the mixed group, although participants in *all* three groups benefitted from this type of cue. The participants in the phonological group, who showed the greatest benefit, had poor grapheme to phoneme conversion as measured by non-word reading ability, yet were still able to benefit from orthography. This is clinically important as it supports the use of orthographic cues even for people with poor grapheme to phoneme conversion. The possible locus of effect is that the provision of the initial grapheme provided sufficient information for the correct phonological form to be selected by the participants with a primary phonological deficit by enabling access to the phonological output lexicon, as suggested by Lorenz and Nickels (2007).

Facilitation with a whole written word was also found to be of most benefit to those participants with a primary phonological impairment, with a significant advantage over the mixed group but not over the semantic group. However, participants in all three groups again showed benefit from this type of orthographic cueing. It is likely that the whole written word worked at different levels for different profiles of language impairment but essentially functioned by reinforcing the link between semantics and phonology. As there was only a small, non-significant correlation between ability to read aloud and benefit from the whole written word, ability to convert orthography to phonology again cannot be taken as a prerequisite skill needed to benefit from orthographic cues in facilitation.

5.4.2: Relationship between language skills and response to combined facilitation

The data indicate that there is a significant relationship between participants who benefit most from facilitation and participants who have better expressive language skills.

The relationship between severity of language impairment and response to intervention for anomia has been investigated in previous studies, and findings have been mixed. For example Snell, Sage and Lambon Ralph (2010) found that severity, as measured by naming performance on the Boston Naming Test, affects and predicts the number of items learned in naming therapy, whereas Fillingham et al. (2006) found language profiles not to be predictive of response to therapy.

The relationship identified in the current study may be interpreted as evidence that improved naming is simply related to severity of aphasia, with participants with greater severity benefitting less from facilitation. However, there are two of pieces of evidence which suggest that this relationship is not so straightforward. First, it is not possible, or appropriate, to capture severity of aphasia by measures of expressive language alone. Analysis of the relationship between response to facilitation and language comprehension was not found to be significant. Therefore, aphasia severity alone cannot account for improved naming following facilitation.

Second, there is not a straightforward one-to-one relationship between response to facilitation and expressive language skills (severity of anomia) for each participant in the study. Table 5.4.i classifies each of the participants as having better or worse expressive language and better or worse response to facilitation, based on z scores, which divided participants into above and below the mean score for the group on each task.

Table 5.4.i: Groups of participants according to better or worse expressive language skills and better or worse response to facilitation based on z scores.

<table>
<tr><th rowspan="2">Response to facilitation</th><th colspan="2">Language expression</th></tr>
<tr><th>Better</th><th>Worse</th></tr>
<tr><td>Better</td><td>Jon
Ernie
Tony</td><td>Anne</td></tr>
<tr><td>Worse</td><td>Paul</td><td>Steve
Derek
Richard</td></tr>
</table>

As can be seen in Table 5.4.i, Anne and Paul do not have corresponding better language expression and response to facilitation. Anne's improvement in naming demonstrated that she was amenable to facilitation, but she fell into the lower half of the group for expressive language skills.

Paul showed the opposite pattern in which his expressive language skills put him into the top half of the group, but his naming improvement following facilitation left him in the lower half of the group.

Whilst the data reflect some degree of relationship between severity of expressive language skills and naming improvement following intervention, the pattern is not straight forward and could not be used in isolation when identifying appropriate therapy for people with aphasia. This supports the findings from Fillingham and colleagues (2006) and Simmons-Mackie et al. (1999) in suggesting that while profiles of language skills may be used to guide selection of therapy approaches, the link is not always straight-forward and interventions need to be trialled to look at an individual response.

5.5: Relationship between language assessments and neuropsychological assessments

5.5.1: Relationships between overall language skills and neuropsychological assessments

5.5.1.i: Relationship between language comprehension and working memory

Just and Carpenter's (1992) theory of language comprehension proposes that working memory capacity should predict performance on language comprehension tasks. Indeed, Miyake et al. (1994) took this view further by proposing that syntactic comprehension impairments occur in people with aphasia because of reduced working memory capacity. Consequently, Miyake et al. suggest that clinical interventions which limit the load on working memory, such as slowing speech rate and reducing the number of concurrent tasks, should improve comprehension in people with aphasia.

However, Butterworth, Campbell and Howard (1986) found that for participant RE, phonologically mediated short term list recall was not related to performance on comprehension tasks leading them to hypothesise that a single short term store underpinning these two tasks could not be plausible. Furthermore, Waters and Caplan (1996) cite examples of patients who have impaired working memory but preserved ability to manipulate complex sentence structures.

Since the turn of the century, there has been a growing body of evidence to suggest that impairments in working memory *can* contribute to impaired language comprehension observed in people with aphasia (for example, Wright and Shisler, 2005; Friedmann and Gvion, 2003). While the relationship between the two is not transparent, Connor et al.

(2000) acknowledge the different positions but find a commonality in which both hypotheses share the assertion that working memory represents a pool of resources which allows the temporary storage and manipulation of activated information.

In this thesis, Spatial Span total score (SSTS) was used to measure working memory capacity, which is a non-phonologically mediated task, while performance on spoken word to picture matching combined with spoken sentence to picture matching was used to measure language comprehension. It was hypothesised that should there be no correlation between the two measures, that there is no relationship between working memory and language comprehension.

In fact, a strong, significant correlation was found between working memory and language comprehension supporting the idea that the two factors are related and dependent. However, the data do not provide convincing evidence to support the direction of the dependency and there are exceptions in the group for whom the relationship does not fit the usual pattern. For example, Ernie scored at ceiling on the test of spoken sentence to picture matching, but based on his z score, he fell into the lower half of the group for performance on spatial span (total score). Such variations in the general pattern must be interpreted with caution. As Dell and Schwartz (2011) note, exceptional observations in cognitive neuropsychology fall on a continuum with regard to how much a theory can be changed in response to an observation. However, Ernie's pattern of performance supports the view of Butterworth and Howard (1986) and Waters and Caplan (1996) that intact working memory is not a prerequisite for language comprehension, as measured in these particular tasks, to occur successfully.

5.5.1.ii: Relationship between language comprehension and executive function

Using Trail Making B as a measure of executive function, and the combined score of spoken word to picture matching and spoken sentence to picture matching as a measure of language comprehension, a significant correlation was identified. The data do not allow a definitive analysis of whether there is a unilateral or mutual dependency. As can be seen in Figure 10 (results page 189) all participants conformed to this pattern of relationship, with faster times to complete Trail Making B being associated with better scores on language comprehension.

As already identified, participants in the current study generally performed below average on the Trail Making B with only Jon performing within an average time limit for his age group. Assessments of executive function are required to be complex and novel, and therefore it may be postulated that participants who were better able to comprehend the task requirements performed better on this assessment of executive function and that this may account for the overall poor performance level. However, it is also possible that participants were able to comprehend the task requirements, but that language processing is employed in carrying out the task itself, resulting in the presence of aphasia restricting the ability to carry out tasks of executive function.

The identified relationship between language comprehension and ability to carry out tasks requiring executive function contradicts the findings of Van Mourik, Verschaeve, Boon, Paquiers and Van Harskamp (1992) who found that people with global aphasia were able to carry out the tasks from their Global Aphasia Neuropsychological Battery (GANBA), even when auditory comprehension was found to be impaired. This anomaly may arise from the different tests of executive function used, with Van Mourik et al. acknowledging that their battery does not measure cognitive function per se, but rather measures cognitive skills as required for communication.

It is likely that variation in the relationships reported in the research data to date arise at least in part from the inconsistency in assessments used to measure the highly complex skills of executive functioning. While significant correlations may be identified with some measures of executive function, others may have subtle variations in task requirements which make different processing demands. It is possible that there are indeed robust correlations between certain language skills and aspects of executive function, but until our understanding increases of the nature of executive function, correlations may have to be considered on an assessment by assessment basis rather than considered to reflect executive function as a whole.

5.5.2: Relationships between individual language skills and neuropsychological assessments

Based on theoretically motivated hypotheses, analyses were performed to investigate the relationship between neuropsychological and language processing, and the outcomes are reported in the results chapter (page 187). Of the results, one in particular is likely to have clinical implications. It was hypothesised that short term memory letter span and non-word reading both require access to the phonological loop in working memory in order for the individual to be able to retain sequences of novel letters, and therefore that a correlation would be found between the two tasks. The hypothesis was supported with the finding of a significant correlation, with high scores on STM letter span associated with high scores on non-word reading. The finding suggests that the two assessments may recruit shared underlying processes, which involve both language and neuropsychological skills. The clinical implication from this finding is that assessment of non-word reading could be administered as part of a battery, with interpretation of results used to contribute to understanding of working memory abilities as well as language skills.

5.6: Relationship between neuropsychological skills and response to facilitation

5.6.1: Relationships between assessments of neuropsychological processing and individual facilitation tasks

Hypotheses were formed about relationships in the data between response to specific facilitation cues and performance on assessments of neuropsychological processing. The outcomes of these hypotheses are reported in the results section (page 192). One of these relationships has particular clinical implications as considered here.

Contrary to expectations, repetition facilitation and short term memory span tasks were not found to be correlated. While this finding was not as anticipated, it has useful clinical implications as it suggests that repetition can be beneficial as a naming therapy approach to use with people with identified memory impairments, who may find other approaches to load too heavily on memory abilities.

5.6.2: Relationships between assessments of neuropsychological processing and combined facilitation tasks

One of the aims of investigating the relationship between neuropsychological profiles and response to language intervention in people with aphasia is to try to gain an improved insight into how neuropsychological skills influence both response to intervention and functional communication skills.

Fillingham et al. (2006) identified a relationship between response to therapy and key domains of neuropsychological function: recognition memory and executive function. It was anticipated that these findings would be replicated in the current study.

Response to facilitation, combined, was not found to correlate significantly with memory, attention or executive function. While the lack of a correlation between response to facilitation and attention skills was anticipated in the light of errorless learning literature

(Fillingham et al., 2005), it was anticipated that a relationship may have been found between memory and executive skills and response to facilitation. As mentioned above, the diversity of skills considered to be part of executive processing and the lack of consistency of assessments used across studies, may help explain why the current thesis did not find executive function to be related to improved naming following facilitation.

It was hypothesised that the lack of a significant correlation between assessments of memory and response to facilitation may have resulted from using a combined score for memory from assessments measuring different components of this domain. Therefore, a further analysis was carried out in which only the assessments of recognition memory were used to investigate the relationship with response to facilitation. Using the subtests of Faces I, Faces II and design visual recognition, a significant correlation was found between the two variables.

This finding is important as it supports the work of Fillingham et al. (2006), which found that participants with aphasia who had better recognition memory made greatest improvements in both immediate and long term naming. Not only does this advocate the clinical use of a test of recognition memory for people with aphasia, but it is indicative that successful response to facilitation requires the same set of cognitive abilities as successful response to therapy, thereby supporting the use of facilitation as a probe tool.

The relationship between self-monitoring and overall response to facilitation was examined. Fillingham, Sage and Lambon Ralph (2006) found that their test of self-rating was strongly correlated with immediate therapy effect. A large, significant correlation in the positive direction was also found in this study between ability to self-monitor and overall response to facilitation. The wider rehabilitation literature has already reported the importance of self-awareness of deficits in the process of recovery with people with other neurological deficits (Robertson and Murre, 1999). The current findings support the notion that the same is true for people with aphasia.

5.7: Clinician-delivered Feedback

The aim of including feedback in the current study was to add to the extremely limited evidence base examining the effect of manipulating feedback for people with aphasia. As there is little research in this area, the study investigated feedback commonly employed by experienced clinicians to serve the roles of 'encouraging and boosting confidence' and 'modifying and maintaining a target behaviour' (cf. Simmons-Mackie et al., 1999, page 224). Therefore, the feedback used was orally delivered by the clinician and informed the participant whether their response was correct or incorrect, followed by a model of the target word, regardless of whether the participants' responses had been correct or incorrect. This model of delivery reduced the potential for the confounding factor of participant involvement in this feedback paradigm. Interestingly, in their study of feedback behaviours, Simmons-Mackie et al. did not find many occurrences of negative feedback, with clinicians observed to use less direct and less transparent methods when an incorrect response had been produced. Therefore while the inclusion of clear feedback for incorrect responses may not reflect clinical practice, it was felt to be important to examine this to identify whether such feedback can improve naming after an incorrect response.

Although feedback was given alongside a 'no feedback', extra time condition, the study design did not allow for analysis of paralinguistic feedback delivered unknowingly. It is acknowledged that in both the feedback and no-feedback conditions additional, unintentional, paralinguistic feedback may have been provided. However, as the same clinician delivered facilitation in both conditions, it is very likely that similar levels of paralinguistic feedback were given across the two conditions.

5.7.1: Relationship between clinician-delivered feedback and language assessments

The feedback used in the current study was orally relayed by the clinician, with no visual support such as a tick or a cross as used in some studies. The feedback was designed to be simple and repetitive in structure so as to avoid excess language processing by participants.

The relationship between ability to respond to clinician-delivered feedback and language comprehension was not found to be significant and therefore it was considered that the structure of the feedback provided had met its aim of being clear while avoiding over-complication through excessive language processing requirements.

To demonstrate beneficial effects of clinician-delivered feedback, participants were required to successfully name an item for which they had previously experienced a word finding difficulty in the delayed naming condition. It was hypothesised that participants who responded better to feedback may have better expressive language skills which would enable greater accuracy in reproducing the model provided in feedback by the clinician. This hypothesis was confirmed with a significant correlation found between the two variables. As already discussed, the data do show individual variation, therefore it is not suggested that feedback is only provided to clients with better expressive language skills. Furthermore, the current study does not allow for analysis of the effect of providing feedback over a course of therapy, in which case clients with poorer expressive language skills may show similar benefits due to repeated exposure (cf. Lorenz and Nickels who found repeated exposure to be beneficial for some people who do not benefit initially).

5.7.2: Relationship between clinician delivered feedback and neuropsychological processing

Comparison of delayed naming responses for items that were assigned to the feedback condition compared to the no-feedback, extra time condition showed a significant difference between the two for the group with feedback showing most benefit. One possibility is that during the period of no-feedback, participants were carrying out internal self-feedback which may have served to reinforce incorrect associations, as hypothesised in the Hebbian model of learning. This in turn would have resulted in incorrect naming responses at delayed naming, therefore the absence of feedback may have negatively impacted not through the absence of the content, but rather as a result of enabling reinforcement of negative associations.

As discussed in the literature review (see page 48), Fillingham et al. (2003) proposed three aspects of processing that must be intact in order for feedback modulation of the learning system to occur according to a Hebbian model. Each of these is reconsidered here in the light of the results from the thesis.

i. 'Before feedback modulation initiation participants must be able to monitor accuracy of their response' (page 345). This was examined by analysing the relationship between participants' ability to benefit from feedback and their ability to self-monitor their responses accurately. The two variables were found to have a significant correlation which supports the hypothesis that self-monitoring ability is an important prerequisite for being able to benefit from externally provided feedback.

ii. 'Feedback modulation necessitates the temporary storage or prolonged activation of the original stimulus and the association response while the underlying mechanisms are adjusted by the learning mechanism' (page 345). This implies that in order to benefit optimally from feedback, memory processes must be intact. The data from this thesis show a non-significant correlation between the total memory score and response to feedback, suggesting that memory function is not necessarily a critical factor in order to benefit from feedback.

iii. ‘It is very likely that feedback modulation requires efficient verification and regulation of behaviour and perhaps deliberate manipulation of representations’ (page 345). These skills would relate to processes performed by the executive system. However, the data collected for this theses shows no relationship between ability to benefit from feedback and executive function ability.

These findings indicate that the only critical factor in being able to benefit from feedback, as suggested by Fillingham et al., is the ability to self-monitor. This perhaps reflects the need to be able to compare production with the feedback given as being an essential step along the way to modifying a response to increase accuracy.

5.7.3: Relationship between clinician delivered feedback and facilitation

The provision of cues used in facilitation may be considered to be use of covert feedback, in which participants know that they have made an incorrect response due to the provision of the next cue in a hierarchy. It was hypothesised that participants with most benefit to delayed naming from this covert use of feedback may also show the most benefit to naming at a delay following overt, clinician-delivered feedback. Indeed a significant correlation was identified between combined facilitation response and clinician-delivered feedback. The strength of this relationship suggests that by providing feedback during language intervention, clinicians can help clients’ naming to a similar degree as if providing a cue, hence provision of feedback may optimise clients’ ability to benefit from naming cues.

5.7.4: Clinician-delivered feedback summary

In summary there is a strong correlation between ability to self monitor, response to feedback and improved naming following facilitation. The indication is that ability to self-monitor and ability to benefit from feedback are important prerequisites in order to optimally benefit from therapy language intervention. Furthermore, these skills may be related to functional communication ability; Purdy (2002) recognised executive function skills are required to monitor communicative attempts, understand feedback from a communication partner and implement cognitive flexibility to switch between communication modalities in conversations.

The current study has not investigated how these findings might relate to functional communication ability. It is hypothesised, in line with Purdy, that people with aphasia who demonstrate ability to benefit from feedback are more likely to have better functional communication ability as they respond to a communication partner's implicit and explicit feedback. Further investigation would allow the relationship between response to feedback and functional communication ability to be explored. As previous studies have found language impairment measures not to reliably correlate with response to therapy (Fillingham et al., 2006) or functional communication ability (Fridriksson et al., 2006), research needs to turn to other skills such as executive function and response to feedback to help understand the processes involved in optimising response to therapy.

5.8: Self feedback

In this study self-feedback was encouraged for correct and incorrect responses. The clinician did not provide any overt, external feedback, orally or with the presentation of further cues, in either condition. Self-feedback was found to have a different effect depending on whether participants' produced a correct or an incorrect response.

5.8.1: Self-feedback following an incorrect response

When participants made an incorrect response encouraging self-feedback was not found to have a beneficial effect on naming at a delay above that of extra time. It is hypothesised that the lack of benefit of self-feedback following an incorrect response may have actually arisen from the absence of externally provided feedback. This could have negatively affected word retrieval at a delay in one of several ways. The absence of externally provided feedback resulted in participants not having their behaviour modified, and therefore they were not exposed to the content of the feedback that would have allowed them to change their naming response at a delay. Additionally, the requirement for participants to provide their own feedback was novel and changed the dynamics of the session, with there being no distinct markers to parse the discourse. Participants who were aware that they had produced an incorrect response may have been more sensitive to this change in role.

As discussed in the literature review (page 49), Nickels (1992) identified two theories which account for how self-feedback may occur. The first is the editor theory, in which a monitor is hypothesised to be located outside the language production system, and an internal feedback loop passes information back through the language comprehension system for review. Marshall et al. (1998) found evidence to suggest that auditory comprehension cannot be the major means of monitoring speech. The data from this thesis provide support for Marshall et al., as there was not a significant correlation between language comprehension and self-feedback. While this result must be interpreted with caution due to the limited impact of self-feedback, it is suggestive that language comprehension cannot be solely responsible for enabling effective self-feedback.

The alternative hypothesis identified by Nickels (1992) is based on connectionist theory in which monitoring ability is located within the language production system itself and occurs in a bottom up fashion. The thesis is unable to support this theory directly, but in view of finding evidence against the editor theory, it is accepted that a monitoring system located within the language production system may at least in part explain the mechanism for self-feedback. This could be investigated by exploring the relationship between self-feedback and the nature of naming errors, to see if participants who use self-feedback, by employing a process internal to the language system, are found to produce lexical errors.

Maher et al. (1994) found that self-feedback improved when the response to be analysed was given in an off-line condition compared to an on-line condition. They concluded that this was consistent with the idea of limited resources affecting ability to provide self-feedback. The design of the current study did not allow for comparison of on-line and off-line feedback ability. However, Maher et al. concluded that some people with aphasia, especially those with jargon aphasia, may be more receptive to feedback when it is provided by an external source as this does not place extra demands on potentially limited resources. The current study found that the individuals with aphasia that benefitted optimally from feedback were those who had a primary phonological impairment although through post-hoc testing this did not reach significance over the other two groups (semantic or mixed). Therefore, there is insufficient evidence to support the notion that feedback only benefits people with particular language impairment profiles.

5.8.2: Self-feedback following a correct response

While self-feedback was not found to be beneficial to delayed naming following an incorrect response, it is interesting to note that there was a significant effect of self-feedback over extra time following correct responses at initial naming. This is an important distinction as it suggests that encouraging clients to reflect on their production through self-feedback following a correct response, could help to strengthen the association between a stimulus and its target leading to greater success at subsequent word retrieval attempts.

5.8.3: Summary of feedback

The findings from the current study support the use of feedback in facilitating word retrieval for people with aphasia. This contradicts the findings of Breitenstein et al. (2004) who suggest that feedback is not essential to word re-learning in aphasia and that economising on feedback may serve to reduce clients' continuous confrontation with their deficits. However the feedback used in their study was provided by a visual display and only fulfilled the role of modifying and maintaining the target communication behaviour. This finding considered alongside the discussion of the lack of effect of self-feedback, implies that for feedback to be effective, it must fulfil more than this one function. The feedback used in the current study was consistent across correct and incorrect responses, providing clear information to participants about the accuracy of their responses and modifying naming by providing a model response. Clinically, this is an important finding to ensure that naming therapy is carried out with feedback in order to provide optimal outcomes. While Simmons-Mackie et al. (1999) found that feedback for incorrect responses tends to be less direct, the current study found that direct feedback for incorrect responses yielded positive effects on naming at a delay.

6: Conclusions

6.1: Summary of Findings

The current study used a case series design to investigate the relationships between language skills, neuropsychological profiles and response to facilitation. The differences in profiles enabled significant theoretically-motivated correlations to be identified between a number of aspects of processing.

The complex relationship between language skills and response to intervention as measured by facilitation confirms the results of other researchers in finding that language skills alone cannot be used to predict therapy outcome nor guide selection of therapy approach.

Facilitation was found to be a robust and valid tool, with consistency in outcome across two sets of data. This supports the use of facilitation as a probe tool, providing clinicians with a cost and time effective means of investigating the impact of different cues.

Neuropsychological assessments have been found to be sensitive to specific domains of cognition in people with aphasia, with participants able to carry out assessments without being impeded by their language impairment. This is especially true for assessments in the domain of memory and attention. However, researchers need to exercise caution in their interpretation of assessments as, for example, the current study does not support the use of digit span as a reliable measure of short term memory for people with aphasia.

Executive function is a complex, multi-faceted domain which requires shared processing with other domains of cognition. While there are many published assessments of executive function, the requirement of novel and complex tasks to be used as a measure means that covert or overt language processing is often involved, thereby reducing accessibility to people with aphasia. Assessments of executive function should be considered on an individual basis in terms of the specific skills they measure and how those skills correlate with response to therapy.

Self-monitoring ability has been found to correlate strongly with both ability to respond to feedback and naming improvements following facilitation. The indication is that ability to self-monitor and ability to benefit from feedback are important prerequisites in order to benefit optimally from language intervention.

Finally, use of clear and structured feedback has been shown to improve delayed naming significantly and therefore needs to be considered as an important part of the therapy process.

6.2: Limitations and future research

The current study demonstrated a strong correlation between ability to self-monitor, ability to benefit from feedback and improvement in naming following cueing. However it was not possible within the scope of this study to explore how these skills related to functional communication ability. There is a small but growing body of evidence suggesting that other extra-linguistic processes, in particular executive function skills, could be related to functional communication ability and ability to use alternative and augmentative communication systems. One of the limitations of the current study is that it did not allow for investigation of these relationships, but future research could helpfully be carried out in this area with a view to guiding clinician and client choices about optimally appropriate and effective therapy approaches. These extra-linguistic cognitive processes have great potential for further investigation, especially as presently research has not found language skills to be predictive of functional communication abilities.

The findings from this thesis support the use of neuropsychological assessments as part of a routine battery administered by Speech and Language Therapy clinicians. Although our understanding of these assessments is at an early stage, there is a growing evidence base to suggest that these skills are related to key aspects of therapy. Developing a database of clearly specified and understood assessments of neuropsychological processing for people with aphasia would benefit clinicians' understanding of clients' overall patterns of processing, and ultimately enable more successful predictions about optimal therapy approaches. While the current study identified several assessments of neuropsychological processing as having potential for forming part of a battery, further research is needed to analyse the validity and accuracy of these assessments. For example, the current study did not incorporate control groups into the design, and it is suggested that further research should include a brain-damaged, linguistically-unimpaired, control group to help tease apart the impact of impaired language processing from brain damage. Furthermore, routine analysis of scan data could help researchers identify whether lesion size is related to performance on neuropsychological assessments.

Since embarking on this study, several assessments have come to light which could have been useful to include as part of the neuropsychological assessment battery. For example, Murray (2011) reported using the Ruff figural fluency test as a reliable measure of executive function with people with aphasia. Replication of the neuropsychological battery with such additional measures of each of the cognitive domains will help to further inform our understanding of the interaction between language and cognitive ability.

The findings from the current study are based on the results of eight people with aphasia, with language and neuropsychological profiles analysed in relation to response to facilitation. While facilitation was demonstrated to be a robust probe tool, replication of the results in therapy studies, with more people with aphasia, would be beneficial. For example, a study could be carried out with the aim of replicating the effectiveness of clinician-delivered feedback following incorrect responses over repeated exposures in a therapy protocol.

6.3: Clinical Implications

6.3.1: Cues for naming therapy

In using phonological cues it appears that there is a minimum amount of information that is required to be given for the cue to be effective, with repetition of the whole word form shown to be significantly more effective than initial phoneme cues. Repetition has been shown to be effective regardless of underlying primary location of impairment, and therefore may have an effect at both a semantic and phonological level. Participants who perform poorly on assessments of repetition and memory can still benefit from repetition cues.

Primary source of language impairment does not appear to predict outcome for increasing or decreasing cues, but participants with better executive function ability were able to benefit more from an increasing cueing hierarchy than those participants who performed more poorly on the assessments of executive function used.

Initial grapheme and whole written word cues are currently underused in clinical practice. The current study found these cues to be effective for all participants, with those participants with a primary impairment at the level of phonology showing greatest benefit. The finding that grapheme-to-phoneme conversion is not a prerequisite skill in order to benefit from orthographic cues, supports the wide use of orthography in anomia therapy.

6.3.2: Assessment batteries

The findings from the current study support the use of neuropsychological assessments by Speech and Language Therapy clinicians as an essential component of a screening battery, helping guide selection of appropriate therapy methods.

The current study has identified a number of specific assessments which would usefully form the basis of such a neuropsychological assessment for people with aphasia, as listed below:

- assessment of recognition memory, which has been demonstrated by the current study and Fillingham et al. (2006), to be related to immediate and long-term naming improvements following intervention.
- assessment of simple/sustained attention, such as the Trail Making part A, which is quick to administer and could provide valuable information about clients' attention abilities.
- assessment of selective/divided attention which could provide information about a client's overall pattern of processing.
- assessment of self-monitoring which has been shown to relate to response to intervention and ability to benefit from feedback.
- assessment of letter span which is hypothesised to reflect the phonological loop sub-process in working memory, and ability to respond to cueing with an initial phoneme.
- assessment of non-word reading which could inform clinicians about working memory abilities as well as language skills.

At present, measures of executive function should be considered on an assessment by assessment basis with different aspects of this multi-faceted process reflected by different tasks. Until there is greater understanding of executive function, it is not realistic to expect one or two assessments to truly reflect clients' skills in this particular domain.

6.3.3: Feedback

Use of clear, structured clinician delivered-feedback has been found to positively influence the naming abilities of people with aphasia, and should be incorporated as a planned device within the therapy process. The results from the current study do not suggest that feedback should only be used with people with particular language profiles, but do suggest that optimal benefit from feedback will be gained by people with better self-monitoring skills.

The results suggest that clinicians could encourage clients to reflect and provide self-feedback following a correct response, but that this should not be encouraged following an incorrect response as this can negatively impact on long-term naming. While replication with a larger number of participants would be beneficial, this finding has potentially very significant implications for clinical practice in anomia therapy, and could also be explored in relation to wider language therapy and beyond.

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Appendix 1: Participant Information Sheet

Please note, identifying information has been removed.

USE OF FEEDBACK AND COMPUTER DELIVERED THERAPY IN WORKING WITH PEOPLE WITH APHASIA

I would like to invite you to take part in a research project. It will look at how helpful Speech and Language Therapy is for word finding problems. It will help to answer questions about aphasia. Aphasia is the word for language difficulties after a stroke.

? ?
? APHASIA ?
? ?

First I will do some tests of your language skills. I will ask you about the difficulties you have in day to day life. Then I will give you a naming test.

We will meet once a week to practice saying words by naming pictures. If you get stuck on a word then I will give you help. The type of help I give you will be different each week.

None of the studies should be uncomfortable or embarrassing. But you won't be able to have any other Speech and Language therapy while you are doing the research. You may find that the treatment does not help you. The research is to help us understand aphasia better.

The results of the study may be described in research papers or in talks. You will be kept anonymous. I will store the audio-tapes as confidential records.

You do not have to take part in this study if you do not want to.

If you decide to take part you may withdraw at any time without having to give a reason. Your decision whether to take part or not will not affect your care and management in any way.

If you want to know more about the research, please ask. You can contact me by telephone, or writing to the address at the start of this sheet.

A research project as part of an MPhil / PhD.

Supervisor: Dr Wendy Best, Speech and Language Therapist, Dept of Human Communication Science, University College London, Remax House - 31/32 Alfred Place - London - WC1E 7DP
Tel: 0207 679 4257

All proposals for research using human subjects are reviewed by an ethics committee before they can proceed. This protocol was reviewed by Local Research Ethics Committee.

Appendix 2: Participant details summary

Participant	Age	Sex	Time since onset	Diagnosis	Aphasia	Handedness	Social circumstance
Anne	69	F	6 years	Left hemisphere CVA	Non-fluent	Right	Retired administrator. Lives alone.
Derek	81	M	2 years	Left hemisphere CVA	Fluent	Right	Retired pilot and chartered surveyor. Lives with his wife.
Jon	56	M	1 year	Left hemisphere CVA	Fluent	Right	Had to sell business when had stroke. Hoping to get back into employment. Lives with his wife and son.
Steve	25	M	6 years	Head injury	Non-fluent	Right	Works at a garage with support. Moving into independent accommodation.
Ernie	73	M	5 years	Left hemisphere CVA	Fluent	Right	Retired builder. Lives with his wife.
Paul	76	M	4 years	Left hemisphere CVA	Fluent	Right	Retired businessman from building trade. Lives alone during the week and with his wife at weekends.
Tony	72	M	4 years	Left hemisphere CVA	Fluent	Right	Retired from farming business. Lives with his wife.
Richard	58	M	3 years	Left hemisphere CVA	Fluent	Right	Has own computing business, returning to work there. Lives with his wife.

Appendix 3: Language assessment results summary table

Assessment	Max.	Anne	Derek	Jon	Steve	Ernie	Paul	Tony	Richard
Sound to letter matching	**14**	13	12	12	8	14	14	9	14
Pyramids and Palmtrees	**52**	51	49	52	44	50	48	51	47
Spoken word to picture matching	**30**	28	27	30	25	30	29	27	30
Written word to picture matching	**30**	27	28	30	25	30	28	29	29
Spoken sentence to picture matching	**16**	11	12	14	11	16	16	11	12
Non-word repetition	**26**	5	1	14	16	4	4	10	14
Non-word reading	**26**	2	15	12	ab.	4	6	0	1
Repetition	**52**	11	15	42	43	40	41	45	44
phonological errors		0.98	0.81	1.00	1.00	1.00	0.91	1.00	0.88
semantic errors		0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
no response		0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other errors		0.00	0.16	0.00	0.00	0.00	0.09	0.00	0.12
Word reading	**52**	21	42	46	11	50	29	49	5
phonological errors		0.94	1.00	1.00	0.15	1.00	0.87	0.67	0.55
semantic errors		0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.04
no response		0.06	0.00	0.00	0.59	0.00	0.13	0.00	0.38
other errors		0.00	0.00	0.00	0.10	0.00	0.00	0.33	0.02
Naming	**200**	104	68	151	72	181	115	121	12
phonological errors		0.43	0.11	0.45	0.07	0.32	0.32	0.05	0.26
semantic errors		0.28	0.33	0.14	0.49	0.42	0.39	0.47	0.05
no response		0.16	0.50	0.20	0.35	0.26	0.19	0.46	0.31
other errors		0.13	0.07	0.20	0.09	0.00	0.10	0.04	0.38
Variables		Oper; AoA	Img; F&F; AoA	AoA	F&F	F&F	F&F	Img	-

Language assessment results summary table cont.

Written naming	**40**	15	8	35	ab.	19	4	5	10
initial grapheme	**40**	29	16	38	2	40	19	19	29
orthographic errors		0.56	0.19	0.00	0.67	1.00	0.58	0.46	0.60
semantic errors		0.28	0.19	0.80	0.00	0.00	0.06	0.06	0.03
no response		0.16	0.59	0.00	0.16	0.00	0.31	0.40	0.23
other errors		0.00	0.03	0.20	0.16	0.00	0.05	0.09	0.13

Key
ab.=test abandoned; Oper=Operativity; AoA=Age of acquisition; Img=Imageability; F&F=Familiarity and Frequency.

Appendix 4: Neuropsychological assessments results summary table

Assessment	Max. score	Anne	Anne ss	Derek	Derek ss	Jon	Jon ss	Steve	Steve ss	Ernie	Ernie ss	Paul	Paul ss	Tony	Tony ss	Richard	Richard ss
Picture span	n/a	3.1	n/a	3.1	n/a	4.1	n/a	4.5	n/a	3.9	n/a	4.7	n/a	3.3	n/a	2.3	n/a
Letter span	n/a	2.9	n/a	3.1	n/a	3.5	n/a	1.6	n/a	3.5	n/a	3.3	n/a	1.5	n/a	2.1	n/a
Digit span - forwards	16	6	n/a	4	n/a	2	n/a	8	n/a	4	n/a	5	n/a	4	n/a	5	n/a
Digit span - backwards	14	2	n/a	3	n/a	2	n/a	7	n/a	3	n/a	4	n/a	2	n/a	1	n/a
Digit span - total score	30	8	5	7	5	4	3	15	8	7	4	9	6	6	4	6	4
Faces I	48	38	12	28	7	42	15	31	7	37	12	24	5	35	11	29	7
Faces II	48	40	14	35	14	43	17	37	9	43	18	32	10	38	14	25	5
Spatial span - forwards	16	7	10	5	7	10	14	8	9	6	8	7	10	5	7	9	12
Spatial span - backwards	16	5	8	6	11	11	17	7	9	6	10	9	16	2	5	6	9
Spatial span - total score	32	12	8	11	9	21	16	15	8	12	9	16	14	7	4	15	11
Visual reproduction I	104	70	10	69	11	95	14	54	2	66	9	58	8	26	3	70	7
Visual reproduction II	104	16	7	48	13	63	12	76	11	47	12	54	14	7	5	51	10

Neuropsychological assessments results summary table cont.

Copying	104	90	6	93	10	99	12	92	6	97	11	83	5	70	2	99	12
Visual reproduction - recognition	48	44	14	43	14	46	14	47	13	46	15	35	8	37	9	42	10
Elevator counting (auditory stimulus)	7	5	abnormal	7	normal	7	normal	5	abnormal	7	normal	7	normal	7	normal	7	normal
Elevator counting (with distraction)	10	4	6	9	11	10	12	5	6	4	6	7	8	9	11	1	4
Map search 0-60 seconds	n/a	10	6	16	8	42	13	19	3	8	6	28	10	16	8	16	7
Map search 60-120 seconds	n/a	10		14		32		12		10		17		23		24	
Map search total	80	20	3	30	5	74	15	31	<1	18	3	45	8	39	7	40	5
Trail Making A (secs)	n/a	165	<10th %ile	90	11th %ile	38	24th %ile	145	<10th %ile	60	11th %ile	75	14th %ile	80	<10 %ile	41	20th %ile
Trail Making B (secs)	n/a	abandoned	n/a	220	16th %ile	76	38th %ile	440	<10th %ile	190	<10th %ile	160	22nd %ile	360	<10th %ile	252	<10th %ile
Brixton spatial anticipation test	Errors	26	2	25	3	11	7	28	2	27	2	32	1	33	1	14	6

Appendix 5: Correlation matrix: summary of main language, neuropsychological, facilitation, feedback and self-monitoring findings for combined results

			executive function (TMB)	Attention (totalTEA)	Memory (totalMem)	Combined facilitation	Language expression	Language comprehension	Clinician feedback	Self monitoring
Spearman's rho	executive function (TMB)	Correlation Coefficient		-.790*	-.619	-.286	-.452	-.783*	-.024	-.229
		Sig. (2-tailed)	.	.020	.102	.493	.260	.022	.955	.586
		N		8	8	8	8		8	8
	Attention (totalTEA)	Correlation Coefficient	-.790*		.323	.216			.036	.103
		Sig. (2-tailed)	.020	.	.435	.608			.933	.808
		N	8		8	8			8	8
	Memory (totalMem)	Correlation Coefficient	-.619	.323		.571			.429	.615
		Sig. (2-tailed)	.102	.435	.	.139			.289	.105
		N	8	8		8			8	8
	Combined facilitation	Correlation Coefficient	-.286	.216	.571		.786*	.434	.952**	.843**
		Sig. (2-tailed)	.493	.608	.139	.	.021	.283	.000	.009
		N	8	8	8		8	8	8	8

		executive function (TMB)	Attention (totalTEA)	Memory (totalMem)	Combined facilitation	Language expression	Language comprehension	Clinician feedback	Self monitoring
Correlation matrix cont.									
Language expression	Correlation Coefficient	-.452			.786*			.738*	.843**
	Sig. (2-tailed)	.260			.021	.		.037	.009
	N	8			8			8	8
Language comprehension	Correlation Coefficient	-.783*			.434			.253	.463
	Sig. (2-tailed)	.022			.283		.	.545	.247
	N	8			8			8	8
Clinician feedback	Correlation Coefficient	-.024	.036	.429	.952**	.738*	.253		.880**
	Sig. (2-tailed)	.955	.933	.289	.000	.037	.545	.	.004
	N	8	8	8	8	8	8		8
Self monitoring	Correlation Coefficient	-.229	.103	.615	.843**	.843**	.463	.880**	
	Sig. (2-tailed)	.586	.808	.105	.009	.009	.247	.004	.
	N	8	8	8	8	8	8	8	

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).