Patterns of word and non-word production in jargon aphasia

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Abstract

This study investigates the spoken word and non-word production of two individuals, RS and TK, who both presented with neologistic jargon aphasia (a form of fluent aphasia characterised by the presence of non-words). Trials of naming, reading and repetition of sets of nouns and verbs were carried out over a year, and different features of their production were investigated in further detail.

For both participants, naming was severely impaired, while reading and repetition appeared to benefit from non-semantic sources of activation. Evidence was found that word errors were genuine lexical retrievals and that there was a continuum of target relatedness in word and non-word errors. In both cases, a relationship was found between perseverative responses within individual trials and over-represented phonemes across different trials and tasks. These are argued to be default phonemes, readily available as gap-fills in the event of reduced activation at the phonemic level. The constant availability of a limited pool of phonemic material to help form the basis of an error phoneme string could explain lengthy intervals between perseverative responses. The perseveration of whole words or non-words is argued to arise from the phonemic level, with strings of phonemes which happen to correspond to words being reinforced by feedback to the lexical level and therefore more likely to recur than non-word strings.

TK demonstrated an inverse frequency effect in repetition. This is hypothesised to arise from the use of relatively unimpaired sub-lexical processing for low frequency words. A similar explanation is invoked for his superior performance on verbs over nouns in repetition.

RS also demonstrated interesting word class effects, with a superior performance on verbs over nouns in naming, argued to be due to additional syntactic activation. Meanwhile, he demonstrated an *inferior* performance on verbs in reading and repetition, argued to be due to a difficulty with processing the inflectional affix on the verb stimuli.

Finally, a longitudinal study of TK revealed an improved performance in terms of correct responses, as well as changes in the error patterns.

It is argued that these features can be accommodated within a model with feedback from the phonemic to the lexical level. Future investigations are also discussed.

Chapter 1: Introduction to jargon aphasia and models of spoken word production

This is an investigation of the patterns of spoken word and non-word production of two individuals with jargon aphasia, RS and TK. It evaluates aspects of their data against different cognitive neuropsychological models. Because each aspect involves its own body of theory, a single literature review will not be attempted. Instead, each section will be introduced by its own discussion of the relevant literature. However, a fundamental theoretical question links the various aspects under investigation: how can the derailment of the normal processing system generate the patterns of impairment and integrity demonstrated by these individuals, and which of the main models of spoken word production best accommodates these patterns? Before RS and TK are introduced, an overview of jargon aphasia and a brief review of these models are presented below.

1.1: Jargon aphasia

The phenomenon of jargon aphasia has long fascinated and bewildered researchers. Its strangeness may arise from the fact that whereas aphasia generally entails a loss or limitation of language, this disorder involves copious streams of expression, consisting of bizarre and incongruous units of speech. The earliest known report of jargon was by a Dr Osborne who in 1833 described a young man whose stroke left him with speech that "caused him to be treated as a foreigner" (in Perecman & Brown 1981; Robson 1997). Other reports have highlighted the reactions of others to people with jargon aphasia: Peuser and Temp (1981) discuss Mr W, who was brought to hospital by people who thought he was a foreign spy. Lecours, Osborn, Travis, Rouillon and LaVallee-Huynh (1981) describe Mr K, whose expression "suddenly became grossly abnormal. This occurred to such an extent that his next of kin thought he had been struck by sudden madness and decided, somewhat hastily, to have him interned in a lunatic asylum. Mr K understood the meaning of this decision and resented it; indeed, he never forgot nor forgave although he later agreed that his verbal protests could hardly have helped".

Alajouanine and his colleagues were the first to use the term jargon aphasia to describe a distinct type of aphasia and to classify its sub-types as paraphasic jargon, asemantic jargon and undifferentiated jargon (Alajounine et al. 1952, Alajounine 1956, both reported in Perecman & Brown 1985). Brown (1972) used the terms *semantic* jargon for paraphasic jargon, neologistic jargon for asemantic jargon and *phonemic* jargon for undifferentiated jargon, terms generally adopted by later authors (also in Perecman & Brown 1985). These categories are described in more detail below. They are not clear-cut: there may be some overlap, or one form may evolve into another (Butterworth 1985).

Semantic jargon consists of phrase structures in which content words are replaced by real words used incongruously. For example, Kinsbourne and Warrington (1963) report on EF, whose response to the question "What does "strike while the iron is hot" mean?" was "Better to be good and to post office and to pillar box and to distribution to mail and survey and headmaster. Southern Railways very good and London and Scotland". Weinstein (1981) describes Dr J, who when asked to give a homonym for the word "fire" said "it's the hamburger of urgency and expectancy". Marshall, Pring, Chiat and Robson (2001) discuss JP, who named the Isle of Wight as "Blank Harbour of the Differentiate".

Neologistic jargon consists of phrase structures, with content words replaced by non-words, or neologisms. For example "We used to /nɪʃ/. I used to /nɪʃ/. I used to /fɪp/ in a fed batter on flesh island. I always /'fɛʃɪst/ in broad England" (Buckingham, Avakian-Whitaker & Whitaker 1978). A further example is taken from Butterworth (1979). His participant, KC, was asked to name a telephone: "Oo, that, that sir. I can show you then what is a /'zæprɪks/ for the /'ɛlɛnkɒm/ the /'ɛlɛnkɒm/ with the /'pɪdlənd/ thing to th… and then each of the /'pɪdləmz/ has an /'aɪjɪn/- one, two, three and so on. And the /'ædrʌm/ can be correct to /sus/ taken. But it's a- a thing of document."

Phonemic jargon consists of a stream of phonological material almost entirely devoid of any real words. For example, Robson reports on RMM, who when asked about a trip to an art exhibition replied /'bʌtə gɪd ɔ maɪn aɪ dɔt 'ɪgədəmənɪ 'nɔtaɪ wʌn 'gʌdəmɪni 'midi də'mʌnaɪt/ (in Robson 1997).

In traditional classifications of aphasia, jargon aphasia is classically associated with Wernicke's Aphasia (e.g. Buckingham et al. 1978; Ellis, Miller & Sin 1983, Butterworth 1985; Miller & Ellis 1987), although it may also be produced by people said to have conduction aphasia (e.g. Lecours et al. 1981; Lecours 1982; Christman & Buckingham

1989; Blanken 1993). Indeed, Kertesz (1981) argues that there is a continuum between conduction and Wernicke's aphasia. Jargon aphasia is also closely associated with comprehension deficits of varying degrees (Butterworth 1985; Miller & Ellis 1987; Cohen, Verstichel & Dehaene 1997; Marshall, Robson, Pring & Chiat 1998; Marshall 2001) and with poor awareness of the disordered output (Weinstein, Lyerly, Cole & Ozer 1966; Peuser & Temp 1981; Cohen et al. 1997, Marshall et al. 1998), which can lead to frustration and irritation when the speaker cannot make him or herself understood (Marshall et al. 1998). However, some people with jargon aphasia present with relatively good receptive skills (Kinsbourne & Warrington 1963; Weinstein et al. 1966; Lecours et al. 1981; Butterworth & Howard 1987) or some awareness of their difficulties (Peuser & Temp 1981; Marshall et al. 1998).

Jargon aphasia tends to be associated with damage to the left temporo-parietal region of the cortex (e.g. Marshall et al. 1998; Goldmann, Schwartz & Wilshire 2001), particularly Wernicke's area, the posterior superior temporal gyrus (e.g. Kohn, Smith & Alexander 1996). Several cases have been reported in which the individual with jargon aphasia had bilateral damage (e.g. Hanlon & Edmondson 1996; Cohen et al. 1997; Robson 1997; Robson, Pring, Marshall & Chiat 2003). At the very least, jargon aphasia seems to involve more extensive lesions than other types of aphasia (Weinstein 1981). It has also been suggested that it is more likely to be found in older individuals (Robson 1997), possibly because there is an increased chance of bilateral damage following repeated infarction.

One of the conundrums of jargon aphasia is that despite such profound processing problems, there is much that is intact. Thus it has been said that it is a *negative* condition which allows *positive* symptoms to occur (Head 1926, in Butterworth 1985). Several authors have noted that non-word content tends to obey the phonotactic constraints of the speaker's language (e.g. Buckingham 1981; Lecours 1982; Butterworth 1985; Miller & Ellis 1987; Christman & Buckingham 1989). Semantic and neologistic forms of jargon aphasia also tend to show evidence of some intact syntactic processing (Kertesz & Benson 1970; Perecman & Brown 1985; Christman & Buckingham 1989). Lecours (1982) comments that non-words are often perceived as belonging to a particular grammatical class. This is due in part to the presence of inflectional affixes on non-words (Buckingham 1981; Butterworth 1985; Butterworth & Howard 1987; Christman & Buckingham 1989). However, it has also been observed that sentences and phrases are not always well-formed, and grammatical structure may be limited (Buckingham 1981; Butterworth 1985; Christman & Buckingham 1989; Bastiaanse, Edwards & Kiss 1996). For example, Kinsbourne & Warrington (1963) report on EF, whose speech, although fluent, consisted mostly of nouns and conjunctions.

Another well-known observation about jargon aphasia is its intact prosody (e.g. Kertesz & Benson 1970; Butterworth 1985; Perecman & Brown 1985; Hanlon & Edmondson 1996). As Marshall (in press) comments, a person with jargon aphasia can use this to great effect communicatively: they can show surprise, anger, empathy, humour, and they can question or rebuke. Marshall (2001) reports on BC, who performed poorly on the most basic language tasks but with whom he could enjoy conversations about the Boston Red Sox.

Furthermore, all forms of jargon aphasia may involve the use of segments which resemble each other (Perecman & Brown 1981). This perseveration (or assonance, in the terminology of Buckingham et al. 1978) may occur within a single speech act, or stereotypical elements may be apparent across different contexts (Kinsbourne & Warrington 1963; Perecman & Brown 1981; Blanken 1993; Marshall et al. 2001).

There are numerous theories as to why and how jargon aphasia occurs. These can be divided into two types: linguistic and non-linguistic (Robson 1997; Marshall *in press*). The former will be examined later in this chapter following a discussion of models of spoken word production. Non-linguistic theories explain jargon aphasia as being due to a cognitive disorder or as an adaptive strategy, possibly linked to pre-morbid personality traits. For example, it has been considered to be an attentional deficit (Kussmoul 1877 and Pick 1931, both in Perecman & Brown 1985); a thought disorder (Goldstein 1948 and Brain 1961, also in Perecman & Brown 1985) or a state of pathological arousal and lack of control (Rochford 1974, in Robson 1997). It has also been described as "an amnesiac syndrome embedded in the language disorder" (Perecman & Brown 1985), and "a distortion of consciousness and social interaction" (Weinstein 1981).

Several authors have highlighted anosognosic elements in jargon aphasia (e.g. Kinsbourne & Warrington 1963; Weinstein, Cole, Mitchell & Lyerly 1964; Prigatano & Weinstein 1996). In fact Critchley (1964) referred to it as "anosognosic aphasia" (in Weinstein & Puig-Antich 1974). Anosognosia is more clearly observed in *right* hemisphere brain injuries, for example involving denial or reduced awareness of hemiplegia or visual deficits

(Prigatano 2003), and has been associated with damage to the right temporo-parietal region (Starkstein, Federoff, Price, Leiguarda & Robinson 1992; Prigatano & Weinstein 1996). This agrees with reports of jargon aphasia involving bilateral damage (see above).

Anosognosic behaviour in aphasia has been attributed to an adaptation to stress (Kinsbourne & Warrington 1963; Weinstein et al. 1966). Indeed, cases have been reported when jargon appears specifically when the speaker is discussing their brain injury or the resulting disabilities. For example, Weinstein (1981) discusses a woman whose production was mostly accurate, but when asked about her language problem, responded that she had a "fressary of my mouthpiece". Weinstein also argues that denial of difficulties is often accompanied by ludic behaviour, such as a sing-song or imitatory voice, or playing on words. He reports on Dr J, who when asked what his main trouble was, replied "It's a rose of another kind which really shouldn't swell as sweet" (ibid.). Weinstein and Lyerly (1976) compared 20 people with jargon aphasia with 20 people with non-jargon forms of aphasia, and found that those with jargon aphasia exhibited certain pre-morbid personality traits such as compulsiveness, perfectionism and illness-denial (see also Weinstein 1981). It is argued by these authors that such traits pre-dispose these individuals to the anosognostic behaviour of jargon aphasia.

Semantic jargon in particular has been described as "high sounding language" or "officialese" (Weinstein et al. 1966; Weinstein & Puig-Antich 1974; Weinstein & Lyerly 1976) or "pretentious-sounding" (Kinsbourne & Warrington 1963). Weinstein and Puig-Antich (1974) report on a lawyer with jargon aphasia who, in response to the observation that it took a long time for him to express himself said: "Naturally, because I am in the necessity of saying things in a manner that will not lead to contrary implications". Kinsbourne and Warrington (1963) argue that fluency, with continuity aided by the use of abstract words, non-words and stereotypical elements, gives the illusion of "verbal abilities of a high order". Similarly Weinstein (1981) states that people with jargon aphasia "seek to give the impression of being erudite", with alliteration and assonance being used to give a "poetic quality". He later summarises with the statement that jargon aphasia "is an attempt to imitate normal- even elegant- speech in order to avoid depression and preserve a sense of identity and social relatedness" (ibid.).

It is acknowledged that the references above are somewhat historic. Although there have been more recent reports on semantic jargon (e.g. Marshall, Pring, Chiat & Robson 1996a; 2001; Marshall, Chiat & Robson & Pring 1996b), attempts to link jargon to pre-morbid personality traits seem to have fallen out of favour, perhaps because they were largely anecdotal and difficult to substantiate. Non-linguistic theories have attempted to explain *why* some aphasic individuals use jargon of one form or another. They have remained largely silent on *how* such individuals construct their disordered output. This question is examined by various linguistic theories of jargon aphasia, which are each set within a specific model of spoken word production. Therefore, before they can be discussed, these models are briefly described

1.2: Models of spoken word production and theories of non-words

In the last few decades, different models of spoken word production have been proposed. For the sake of brevity, the salient points of the most well-known models, the serial model and the interactive activation account, will be outlined. This will be followed by a discussion of their relative merits and problems.

The review will also examine how the various models account for one of the features of jargon aphasia that has proved most fascinating to authors, the production of non-words, or neologisms (Christman & Buckingham 1989; Robson et al. 2003). Before discussing different hypotheses on this, the terminology needs clarification. Some authors state that the word "neologism" implies only the "innovative quality" of the item (Buckingham 1981), and could be applied to any word that does not appear in a dictionary of the native language (Lecours 1982). However, distinctions have been made between two types: those which are clearly related to the target and those which are not, which may be called *abstruse* neologisms (e.g. Blanken 1993; Kohn, Smith & Alexander 1996). Some authors argue that the term *neologism* should only be applied to the abstruse variety, target related items being *phonemic paraphasias* (e.g Lecours et al. 1981; Buckingham 1977; 1987; Schwartz, Wilshire, Gagnon & Polansky 2004). Buckingham (1977) states that a neologism is a "phonological form, isolatable in a stream of speech, from which it is impossible to recover, with any reasonable degree of certainty, some single item or items in the lexicon of the subject's language". To avoid making a priori assumptions about the relatedness of such items, this work will follow Robson et al. (2003): all errors which do not appear in the dictionary will be termed “non-words”, regardless of their phonological relationship with their target.

1.2.1: Serial models of word production

Serial (or modular) models are those in which processing proceeds from one stage to the next in a discrete or modular fashion. One stage must be complete before the next can commence, and only a single selected representation from each stage can pass its information to the next stage. There is no overlap between the stages and no feedback from a lower to a higher stage (Nickels 2002). Early versions of the serial model, with a single post-semantic stage of word production, will be described first, followed by the two-stage models which were derived from it.

1.2.1.1: One-stage models

The classic one-stage model discussed in the literature is Morton’s logogen theory (1969 & 1979, in Levelt 1989, 1992; Nickels 1997). This was developed to explain written word input, but was then adapted to explain auditory input and spoken output. Lexical representations are envisaged as logogens, devices in the mental lexicon which each accumulate their own relevant information from the previous processing level (the conceptual level in the case of picture naming). This involves parallel processing, as all logogens simultaneously collect the information pertaining to them. Each logogen has a threshold, and when enough information has been gathered to reach threshold, the logogen is activated, or "fires". It sends a phonological code to the response buffer, leading to the spoken response.

Nickels (1997) discusses some problems with the logogen model: firstly, difficulties with access to the lexicon should always lead to *semantic* errors, when logogens for semantic neighbours reach threshold before the target. Phonological errors can therefore only be explained as post-lexical corruptions and not as lexical level selection errors. Secondly, the firing of logogens is "all-or-nothing". The theory does not allow for the partial retrieval of information. This makes "tip of the tongue" states (in which the speaker is unable to retrieve a word but expresses some knowledge of the word form) problematic to explain. Furthermore, some studies into slips of the tongue have found that semantic and syntactic factors affect *word* exchanges, whereas phonological factors affect *segment* exchanges, suggesting that there are two separate stages, one in which semantic/syntactic information is processed, the other in which phonological information is processed (Caramazza & Miozzo 1997).

The problems with one-stage models led to the development of models with two stages of lexical access, currently favoured by most theorists, whether adopting a modular or a connectionist approach (although Lambon Ralph, Moriarty and Sage (2002) argue that the patterns of impairment they examined in twenty out of the twenty one cases of aphasia could be explained by a model with only a conceptual level and a phonological level). Two influential variations on the serial two-stage model, Butterworth's Semantic Lexicon model (1979, 1989) and the theory of lexical access developed by Levelt and his colleagues (e.g.

Levelt 1989; Levelt, Schriefers, Vorberg, Meyer, Pechmann & Havinga 1991; Levelt, Roelofs & Meyer 1999), are described below.

1.2.1.2: Two-stage models

Butterworth (1979, 1989) describes a strictly top-down serial model with a stage between the conceptual level (which consists of a network of semantic features) and the word-form level (or phonological lexicon). He titles this intermediary level the semantic lexicon, which he describes as a "transcoding device" which takes a semantic code as its input and converts it into a "phonological address" which is its output. This phonological address then retrieves the word form from the phonological lexicon, another transcoding device whose output is the phonetic form to be spoken.

Butterworth's model explains semantic errors as being due to difficulties within the conceptual level itself or to failures to match semantic information to the correct representation in the semantic lexicon. Phonological errors may occur when there is a failure to match the phonological address to the form in the phonological lexicon or when there is only a partially available phonological code, in which case the nearest possible match may be retrieved from the lexicon. The possibility of having partially available phonological information can also explain tip of the tongue states: the correct representation is retrieved from the semantic lexicon, but only *some* information about the word form (e.g. the initial letter or the length of the word) is available.

Over the years, Levelt and his colleagues have developed a two stage model. A key difference between this and the Butterworth model described above is that instead of the semantic lexicon, the intermediate stage in the Levelt model is the lemma level. This will be described in more detail in Chapter 8 but briefly, a lemma is a modality-independent abstract representation. In Levelt's 1989 model, the lemma encodes semantic and syntactic information, but in Levelt and colleagues' 1999 version, it does not encode either type of information, but is connected to both, and makes syntactic information available (Nickels 2001). Several lemmas can be activated by their semantic representations, but only a single activated lemma is selected. This then activates its phonological representation, or lexeme. Individual phonemes are assembled in a further stage of phonological encoding, as described below.

1.2.1.3: Phonological encoding

Phonological encoding involves the creation of the fully specified phonological form. It starts with the retrieval of a stored word form and ends with a phonetic representation that is the input to articulatory processes (Meyer 1992). A "slot-and-filler" model explains how discrete lexical representations are mapped onto continuous phonetic programmes (or "syllabified") for connected speech (Levelt 1992). The process involves the separation of segmental information (the "fillers") from metrical information (the "slots" in a frame) and then their recombining (Nickels 1997). Perhaps the most well-known example is Shattuck-Hufnagel's Scan-Copier (1979, 1983 and 1987, in Shattuck-Hufnagel 1992), in which the set of available segments is scanned and the most appropriate segment copied into each slot. Two monitors, a "check-off" monitor and an error monitor, prevent the re-use of segments and their incorrect placement.

Most models adopt a slot and filler approach (Nickels 1997). For example, Levelt and his colleagues describe the process as consisting of segmental spell-out, in which the retrieved representation is broken down into segments, and metrical spell-out, in which the frame is constructed on the basis of the number and stress pattern of its syllables. Syllabification crosses lexical word boundaries, forming "phonological words" (e.g. "demand it" → "demandit" → "de + man + dit"). Spelled-out segments are then associated with the slots in the frame in a sequential left-to-right fashion. Articulation subsequently proceeds as programmes are generated from the phonological specifications or retrieved from the "mental syllabary", a store of programmes for frequently used syllables (Levelt et al 1991; Levelt 1992; Levelt & Wheeldon 1994).

1.2.1.4: Reading and repetition in serial models

Reading and repetition may be accomplished via the semantic route: a semantic representation is accessed via visual or auditory input lexicons, then a lexical representation is retrieved from the speech output lexicon in the same way as for picture naming (e.g. Hillis & Caramazza 1995). In addition, reading and repetition each have at least one non-semantic route. In reading, the sub- (or non-) lexical route maps visual (orthographic) input onto phonological output. Its existence can be demonstrated by the ability to read non-words or unfamiliar words (i.e. items which are not stored in the lexicon) and also by individuals who regularise irregular words when reading, following rule-based conversion procedures (ibid.). A similar sub-lexical route is assumed to exist for repetition, mapping auditory input onto phonological output without lexical mediation. In this way, non-words can be repeated (Ellis &Young 1996).

There may also be a direct lexical route for each process, whereby the orthographic or auditory input lexicons are directly connected to the speech output lexicon so that a word can be processed lexically but not via semantics. Support for this in reading has been found from people with dementia who have poor semantic skills but retain skills in reading aloud (e.g. McCarthy & Warrington 1983). The fact that both regular and irregular words are read aloud demonstrates lexical involvement, because the sub-lexical route can only process regular words. This has also been reported in people with aphasia (e.g. Howard & Franklin 1987). The discovery of individuals who *repeat* words (but not non-words) without understanding them would provide support for the existence of a direct lexical route in repetition (Ellis & Young 1996).

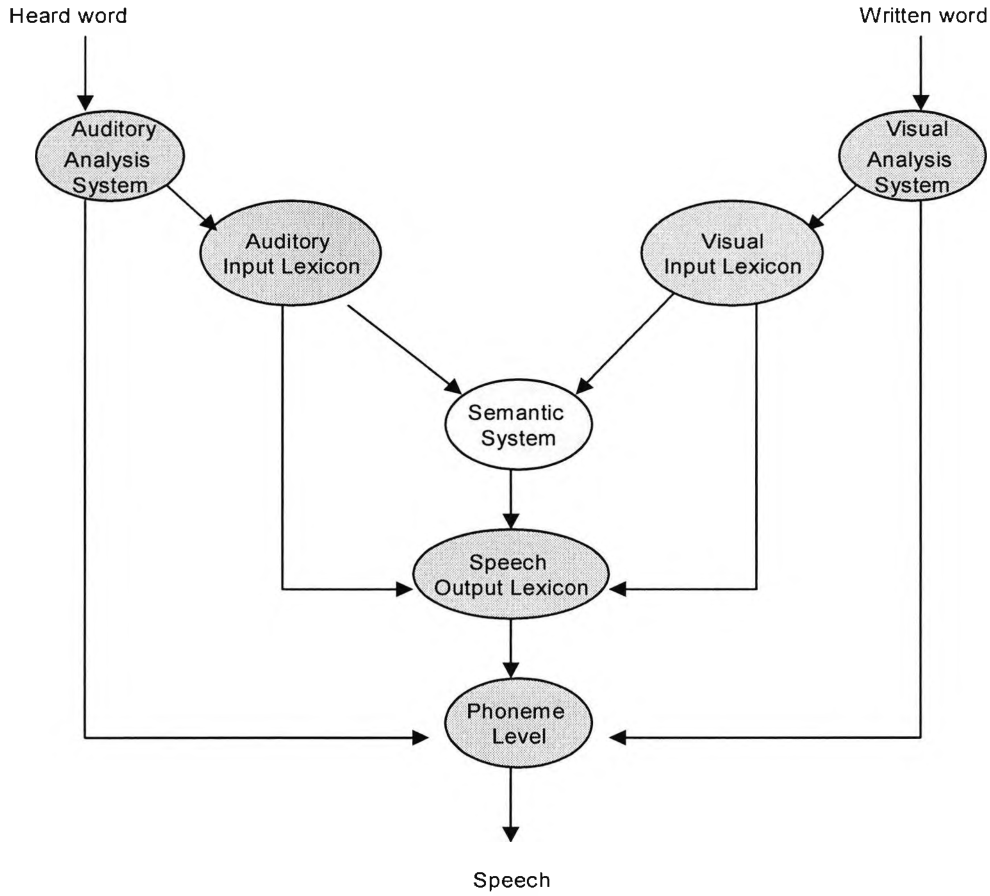
It has been proposed that in reading, the summation of activation may be an alternative to the direct lexical route (Hillis & Caramazza 1991, 1992; Miceli, Giustolisi, Caramazza 1991; Miceli, Capasso & Caramazza 1994; Miceli, Amitrano, Capasso, Caramazza 1996). Semantic information and sub-lexical information both feed into the speech output lexicon, and sub-lexical information also feeds directly into a subsequent post-lexical level. It is not specified in these reports whether a similar process is envisaged to occur in repetition.

1.2.1.5: Summary of two-stage serial models of spoken word production for naming, reading and repetition

The figure below (Figure 1.1) illustrates the basic architecture of a generic two-stage serial model, based on Ellis and Young's (1996) model. Like Ellis and Young's model, only a *speech* output lexicon is included here, because only spoken output is discussed within this work. It is acknowledged that in other accounts, there may be a *modality-independent* lexical level (e.g. Levelt et al's (1999) lemma level), in which abstract representations for both speech and writing are stored, as discussed by Goldrick & Rapp (2002).

This model shows the naming route, from the semantic system to the speech output lexicon and then to the phoneme level. It also shows the three possible reading and repetition routes discussed above. In the first, the semantic route, there is input from the visual (orthographic) or auditory system to the semantic system. Processing then continues in the same way as naming. The second route is the sub-lexical route, from the visual or auditory analysis system directly to the phoneme level, thus by-passing the lexicons and semantic system. This is achieved through grapheme to phoneme matching in the case of reading, and phoneme to phoneme mapping in the case of repetition. The third route is the direct lexical route, from the visual or auditory input lexicon to the speech output lexicon, thus by-passing the semantic system. As discussed above (section 1.2.1.4), this route is the most controversial, with scant evidence for its existence in repetition (Ellis & Young 1996), and the alternative hypothesis of summated activation in reading (e.g. Hillis & Caramazza 1991).

Figure 1.1: Two-stage serial model of spoken word production for naming, reading and repetition (adapted from Ellis & Young 1996)



1.2.1.6: Non-word production within a serial model

There are several classic theories of non-word production which relate to the serial model: anomia theories, partial lexical retrieval theories, conduction theories and dual impairment theories. These are described below.

1.2.1.6.1: Anomia theories

The general premise of these theories is that following the failure of lexical retrieval, a non-word is created by non-lexical means. Probably the most well-known account is Butterworth's 1979 study. He argues that there are two types of non-word: those which are clearly related to their targets, and those which bear no discernible resemblance to their targets. Butterworth attributes the former to partial lexical retrieval (see below). Furthermore, he found that non-words occurred after a pause, with unrelated non-words occurring after longer pauses than related non-word errors. These unrelated non-words he attributes to a "random phoneme generating device", creating strings of phonemes. The string slowly decays, during which time its elements remain available for reuse in the event of a further lexical retrieval failure, thus explaining the tendency of successive sequences of non-words to resemble each other. Butterworth also found abnormal phoneme frequency distributions, which he takes to indicate a reliance of a limited number of available segments. Anomia theories also predict a lexical frequency effect, with low frequency words in the language being more difficult to retrieve from the speech output lexicon than higher frequency words.

The major criticism of Butterworth's theory is that in proposing a random generating device, he is advocating the creation of a novel mechanism following brain damage. Defenders of the theory have pointed out that it need not be a novel mechanism: we all have the capacity to create non-words, and certain phenomena other than language impairment involve non-word production, for example the glossolalia which may be observed in charismatic religion or in schizophrenia (Lecours et al. 1981; Lecours 1982). Buckingham (1990) describes this ability as a "normal albeit suppressed capacity". He suggests that instead of stringing together individual *phonemes*, the mechanism involves the stringing together of *syllables*. This would explain the adherence to phonotactic constraints generally observed in non-words (e.g. Butterworth 1979, Buckingham 1990). A further variation on the theme was described by Kohn, Smith and Alexander (1996) in their theory of phonological reconstruction. This involves the creation of a phoneme string from phonemic material at what the authors call the "phonemic planning" stage. It echoes Butterworth's 1992 version of random generation, which is considered to be a default mechanism occurring during the phonological encoding stage (Nickels 1997). Anomia theories predict that non-words generated by such a mechanism should not bear any phonological resemblance to the target beyond chance. Patterns of recovery predicted by this and other theories of non-word production are discussed in Chapter 9.

1.2.1.6.2: Partial lexical retrieval theory

In this theory, mapping difficulties between the lexical and phonological levels result in the partial retrieval of phonological information (Butterworth 1985; Kohn & Smith 1994b). Missing information is gap-filled from phonemic material available because of factors such as recency of use or frequency in the language. This theory predicts differing degrees of target-relatedness, depending on how much phonological information is available (Robson 1997). Like anomia theories, partial lexical retrieval theories predict a lexical frequency effect (Kohn & Smith 1994b). There should also be a normal phoneme frequency distribution because non-words are derived from lexical representations, assumed to have normal frequency distributions (ibid.).

1.2.1.6.3: Conduction theory

This theory suggests that target lexical representations are successfully retrieved but are then subject to distortion at later post-lexical stages of processing, such as phonological encoding (Kertesz & Brown 1970). It predicts target-relatedness beyond chance (Buckingham 1990, Robson 1997). Serial position effects are also predicted because the chances of an error occurring within a word increase as encoding progresses, so errors are more likely to occur later in a word (Kohn & Smith 1994a, 1995; Schwartz et al. 2004). Length effects should also be apparent because the longer the string of phonemes to be encoded is, the more chance there is of an error occurring (Kohn & Smith 1994a; Schwartz et al. 2004). A lexical frequency effect is not predicted, because frequency is a lexical property, and lexical retrieval should have been fully accomplished (Schwartz et al. 2004). A normal phoneme frequency distribution is predicted, because non-words are derived from lexical items.

1.2.1.6.4: Dual impairment theory

This theory, as proposed by authors such as Luria (1970), Lecours and Lhermitte (1972) and Brown (1972; 1977) (all reported in Buckingham 1990), suggests that non-words result from a two-stage process. Firstly, a lexical selection error occurs and a semantic neighbour is selected. Secondly, this erroneous item becomes distorted by post-lexical processes (e.g. phonological encoding), as described above in the conduction theory. The dual impairment theory does not predict any target relatedness beyond chance, as non-words do not arise from the target lexical representation. It does however allow for a normal phoneme frequency distribution, again because non-words are derived from lexical items.

Robson and colleagues (2003) argue that these theories are by no means exclusive. It is possible for an individual to make use of different mechanisms (e.g. a random generating device, partial lexical retrieval, post-lexical distortion) depending on the availability of phonological information. For example, as discussed above, Butterworth (1979) identified his distinct types of non-words in the production of the same speaker, the former when some phonological information is available and the latter when no target information is available.

1.2.2: Interactive activation accounts of word production

Interactive activation accounts of spoken word production are connectionist models, consisting of complex networks of connections through which activation spreads, or cascades. This spread is controlled by the strength or *weight* of the connections (Harley 1993a; Nickels 1997). The account discussed here is based mostly on the theories of Dell and his colleagues (e.g. Dell & Reich 1981; Dell 1986; 1988; Dell & O'Seaghdha 1991; Dell, Schwartz, Saffran & Gagnon 1997). Reference will also be made to another influential model, that of Stemberger (1985), on which versions such as Harley and

MacAndrew's (1992) account were based. In common with other connectionist models, interactive activation accounts are based on computer simulations of lexical networks, in which variables can be adjusted or portions lesioned in order to model different experimental data, such as error patterns in people with aphasia.

Instead of stages, processing in connectionist models proceeds through levels or layers of *units* or *nodes,* which receive and transmit activation (Stemberger 1985). As soon as a unit or node is activated, it can pass on its activation to nodes in the next level. Because of this *cascading* activation, processing occurs in all levels of the system more-or-less simultaneously, instead of one stage needing to be completed before the next can commence (Nickels 1997). Furthermore *all* activated representations in one level can pass their activation on. Semantic competitors, even if not selected at the lexical level (the equivalent of the speech output lexicon in the serial model), will still have their constituent segments activated in the phoneme level (Goldrick & Rapp 2002). Activation can flow forwards and backwards: for example, phoneme nodes can pass their activation back to all lexical nodes to which they are connected. Levels are thus said to interact (Nickels 2002). In fully interactive models, all connections are bi-directional.

The connections between layers of nodes through which activation passes can be inhibitory or excitatory in Stemberger's (1985) account. They tend to be inhibitory *within* levels, so that the most highly activated unit can more effectively dampen the activation of its competitors. Connections *between* levels tend to be excitatory, but have variable strengths. However, in Dell's account (1986, 1988), all connections are excitatory and have equal strength. Interactive activation accounts of word production, like most current serial models, propose two post-semantic stages of lexical access: from the semantic to the lexical level, and from the lexical level to the phoneme level. Unlike Levelt's serial model, in which lemma retrieval leads to the retrieval of a single phonological representation which in turn retrieves the necessary phonemes, in Dell's model, lexical activation connects directly to individual phoneme nodes. A pattern of activation across these corresponds to a phonological representation (Nickels 1997).

Dell (1988) details the processing assumptions of this model. Activation spreads by time-step, and when it reaches a node, it is summed with that node's resting level of activation. At the lexical level, resting levels of activation are dependent on the word's frequency (high frequency words being assumed to have high resting levels of activation). At the semantic and phoneme levels, resting levels of activation are set to zero. Activation at each node decays with each time-step, but at the same time, bidirectional connections cause a reverberation of activation between connected nodes. After a certain number of time-steps (determined by the speech rate), the most highly activated node is selected. Its activation is immediately reduced to zero, in order to prevent its reselection, but is soon boosted again by reverberation.

A further point to be noted at this stage is that feedback from the phoneme to the lexical level means that a pattern of activation across phonemes which corresponds to a word is said to be stable because it feeds back to a lexical node and is thus reinforced. A pattern which does not correspond to a word does not have a lexical node to feed back to and is therefore unstable and liable to alter until it does correspond to a word (Nickels 1997). This encourages a lexical bias in normal production, as discussed in further detail below in section 1.3.1.

Phonological encoding in interactive activation accounts, like that of serial models, is generally assumed to involve a slot and filler model. Dell (1986, 1988) proposes two connected networks: a lexical network (the fillers), and a word-shape network (the frame of slots). Selected lexical items and phoneme segments are slotted into the frame in the word-shape network. Wilshire (2002) argues that in an interactive activation account, phonological encoding for a single word actually takes place within the lexical-phonological stage, as phonemes are fully specified and ordered directly as they are selected following activation from their lexical node. This contrasts with the serial model account, in which phonological encoding is regarded to occur in a post-lexical stage.

1.2.2.1: Reading and repetition in interactive activation accounts

Interactive activation accounts of reading and repetition are broadly similar to serial accounts, in that they assume the availability of processing routes additional to the semantic route. For example, Martin and Saffran (2002) explain repetition with a model in which a single phonological network is shared by input and output processes, or in which there are separate but directly connected input and output networks. This latter model agrees with Ellis and Young (1996) that a direct lexical route entails either linked or shared input and output lexicons. In either case, repetition can be accomplished without accessing semantics. Another possibility suggested by Martin and Saffran (2002) is that semantic processing and non-semantic processing occur simultaneously, similar to the summated activation hypothesis in the serial model. It is proposed that the direct connections between input and output networks provide the crucial pathway for repetition, overriding semantically mediated activation (ibid.).

Connectionist approaches to reading are rather more complex, but the "Dual Route Cascaded" model developed by Coltheart, Curtis, Atkins and Haller (1993) (in Rapp, Folk & Tainturier 2001) is similar to the Ellis and Young (1996) serial model of reading described above. It has two non-semantic routes, a lexical and a sub-lexical route: the former consists of direct connections between lexical representations while the latter encodes the most frequent grapheme to phoneme mappings. Like Hillis and Caramazza's (1991; 1992) summated activation hypothesis (section 1.2.1.4), this model involves the integration of the routes at the level of phonological output.

1.2.2.2: Non-word production in interactive accounts

Non-word production in interactive activation models fits closely with the partial lexical retrieval theories in the serial model. Because of a reduced flow of activation, either between specific levels (Miller & Ellis 1987; Harley & MacAndrew 1992; Robson 1997) or throughout the system (Schwartz, Saffran, Bloch & Dell 1994), activation to the target node at the lexical level is not sufficient to inhibit competitors, so the target node does not have a strong advantage (Harley 1993a). When activation is severely reduced, semantic competitors are not activated enough to be selected. This explains why jargon aphasia is not characterised by semantic errors (Harley & MacAndrew 1992). Instead, both targets and competitors pass on their activation to the phoneme level. Because of a limited "trickle" of activation to this level, target phoneme nodes are only weakly activated and non-target nodes (i.e. those derived from competitors in the lexical level) are only weakly inhibited (Ellis 1985; Miller & Ellis 1987). Some target phonemes may be sufficiently activated to be selected, but other slots are filled by non-target phonemes. Reduced activation also leads to reduced *feedback* activation, which in turn leads to more non-word errors, as there is no feedback to reinforce patterns of activation which correspond to words (as discussed in more detail below in section 1.3.1).

Interactive activation accounts predict a continuum of target-relatedness, depending on the amount of target information available (Robson 1997; Schwartz et al. 2004). Frequency effects may be present, with high frequency words being more readily activated than lower frequency words because of their higher resting levels of activation (Schwartz et al. 2004). There should also be a normal phoneme frequency distribution, as the selected phonology is derived from lexical items, whether targets or competitors. Robson and her colleagues also found that high frequency phonemes were more likely to be preserved, as they are common to more words and therefore more likely to be activated by multiple lexical nodes (Robson 1997, Robson et al. 2003).

1.3: Difficulties for the models

1.3.1: Difficulties for the serial account

A prominent criticism of the serial model is its failure to account easily for two frequently reported phenomena in normal speech errors, the mixed error effect and lexical bias. It is not within the scope to discuss the former. As mentioned in section 1.2.2, lexical bias refers to the tendency for speech errors to be words rather than non-words. For example, in Baars, Motley and MacKay's (1975) experiment designed to elicit slips of the tongue, the word pair "dean bad" was more likely to slip to the word pair "bean dad" than "deal back" was likely to slip to the non-word pair "beal dack". In an interactive activation account, this can be accounted for by feedback from the phoneme level to the lexical level, as previously mentioned in section 1.2.2: a pattern of activation which corresponds to a real word is reinforced by this feedback and is therefore a more likely outcome than a non-word (Dell & Reich 1981). It was noted above that such a tendency may be abolished in jargon aphasia because of a reduced flow of activation to drive this feedback.

Serial models can only explain the occurrence of such errors by invoking a pre-articulatory editor, which feeds prepared output into the input system. This is more likely to detect and reject non-word than word errors. However, in their study of 15 people with aphasia, Nickels and Howard (1995) failed to find any evidence of a correlation between auditory processing skills and attempted self-corrections of phonological errors. From this they surmised that there was no clear-cut evidence of an editor in which output is fed back into the language system as auditory input. Lexical bias and its implications for aphasia will be discussed in more detail in Chapter 4.

A further difficulty for the serial account is the syntactic category effect, or the tendency for phonologically related word errors to share the syntactic category of their target (Goldrick & Rapp 2002). As these authors point out, because syntactic processing is assumed to occur at an earlier lexical level stage, it should not exert an influence at the phoneme level, so errors generated at this later stage should not show a tendency to preserve the syntactic category of the target. However, many studies (e.g. Best 1996; Blanken 1990; Dell et al. 1997); Gagnon, Schwartz, Martin, Dell & Saffran 1997; Martin et al. 1994) have shown such a bias.

A more general criticism of serial models is provided by Harley (1993a). He argues that serial approaches involve total catastrophic breakdowns in the system. If processing at one level fails, it will be totally halted (although this does not accord with partial lexical retrievals, in which activation is *not* all or nothing). Connectionist approaches, with distributed networks of features, allow for the "graceful degradation" of the language processing system, with a continuum of impairments, from the subtle to the severe. It is therefore argued that they are more successful at modelling the patterns found in aphasia. Furthermore, they can account for the simultaneous effects of different variables because of the interconnectivity (Harley 1993b).

1.3.2: Difficulties for interactive activation accounts

A question which needs addressing is *why* there should be interactivity. Levelt and his colleagues (1999) cite the principle of "Ockham's Razor": an account should be as parsimonious as possible, with the minimum number of processes and assumptions. An account which assumes cascading activation and feedback does not appear to obey this principle. However, proponents of interactive activation accounts argue that a bidirectional flow of activation allows the same lexical level to be used for input and output processing (e.g. Dell 1988, Dell & O'Seaghdha 1991, Martin & Saffran 2002), thus obeying the principle of parsimony. It could also be argued that the presence of feedback between levels provides monitoring which is internal to the production system, thus eliminating the necessity of an editor which has to feedback into the input system.

The main evidence against interactive activation accounts concerns timing and error types. These will not be discussed in great detail here, because they are not directly relevant to jargon aphasia and theories of non-word production. Briefly, with regard to timing, a serial account predicts only semantic activation at the early stage and only phonological activation at the later stage, while an interactive activation account predicts both types of activation at both stages because of cascading activation and feedback. Schriefers, Meyer and Levelt (1990) and Levelt and colleagues (1991) carried out experiments with non-brain injured people and found evidence of semantic activation only at the early stage. Schriefers et al. (1990) also found evidence of phonological activation only at the later stage, supporting a serial account.

Nickels (1995) finds further evidence against interactive activation accounts from the effects of variables on different error types. She argues that such accounts predict that the variables imageability, frequency and length (taken to be influential at semantic, lexical and phoneme levels respectively) should all have an effect on both semantic and phonological errors because of cascading activation and feedback. In a study of fifteen people with aphasia, an imageability effect was found for semantic but not phonological errors, and a length effect was found for phonological but not semantic errors. This supports a serial model, not an interactive activation account.

The response to both these criticisms of interactive activation accounts is that interactivity may be more subtle than previously assumed, so the influence of different variables is not as pervasive as predicted (Harley & MacAndrew 1995). Dell and O'Seaghdha (1991) respond to Levelt et al. (1991) by proposing a system which is "globally modular" but "locally interactive": adding a jolt of activation to the most activated representation at the end of each stage results in more of a serial effect, as it reduces the influence of competitors. These authors also propose that there may be feedback only between adjacent levels. Harley (1993b) found that in his computer simulation of an interactive activation account, Schriefers et al. (1990) and Levelt et al.'s (1991) findings could be replicated by adjusting the precise amount of interaction to give predominantly early semantic and late phonological activation. However, another general criticism of interactive activation accounts concerns the reliance on computer simulations to test patterns of errors in this way. It could be argued that a computer model can be tweaked to account for any patterns with which it is presented, for example, by manipulating the weights on the connections or the precise timing of activation.

The modification of fully interactive activation accounts (i.e. those in which there is unrestricted cascade and feedback at every level) has led to the development of models in which activation is more restricted. These are described below.

1.3.3: Partially interactive models

Models have been developed which share the best of both serial and interactive models while attempting to escape their various short-comings. Such models may have feedback between certain levels only, and differing combinations of excitatory and inhibitory connections between and within levels (Nickels 1995). For example, Harley (1990) developed a model with only feedforward connections between semantic and lexical units, but bidirectional connections between lexical and phoneme levels. This was motivated by a lack of empirical evidence for the existence of feedback between the lexical and semantic levels (in Harley & MacAndrew 1995).

Rapp and Goldrick (2000) and Goldrick and Rapp (2002) attempted to simulate the error patterns of three aphasic individuals. Five computer models were tested. Each model had the same basic architecture consisting of three levels: semantic features, a lexical or "L-level" and a phoneme level. The models differed in the way that activation flowed between these levels and in how much feedback occurred. This ranged from a totally interactive model (with feedback between all levels) to a purely serial model (with no feedback). The only model that adequately fitted the data of the three individuals was one in which there was cascading activation coupled with restricted feedback between the phoneme and L-level. The authors term this the Restricted Interaction Account, or RIA.

The RIA does not explicitly account for non-word production. In fact, one of the motivating factors behind its development was the need to explain patterns of *word* errors in people with aphasia. However, non-word production as explained by the fully interactive activation account could also be accommodated by the RIA: there is still the spreading activation necessary for the passing on of activation (from both targets and competing representations) from the L-level to the phoneme level. Weak feed-forward activation results in little or no feedback activation, so there is no reinforcement of word outcomes.

The next question is why there should be any benefit of having feedback between certain levels only, because it does not allow the sharing of input and output lexicons as highly interactive activation accounts do. However, as mentioned above (section 1.3.2), it does allows for a form of editing within the production system. In addition, feedback from the phonemic to the lexical level may hasten the selection of entries in the lexicon and the activation of phonemes because of the process of reverberation and reinforcement (Ellis & Young (1996).

1.4: Summary

Both serial models and interactive activation accounts have their problems in accounting for different features of processing and patterns of errors. Partially interactive models attempt to steer a course between the Scylla of the serial model and the Charybdis of the connectionist approach.

The study of RS and TK which follows will examine different features of the spoken output of both individuals on different tasks and attempt to relate these features to serial or (partially or totally) interactive activation models. It will be argued that the data are best accounted for by a model which has interactive activation at least between the lexical and phoneme levels.

Chapter 2: Introduction to the participants

Having given a brief overview of jargon aphasia and the explanations for it in the context of different models of spoken word production, it is now time to introduce the participants and to present the results of assessments carried out during routine clinical work. This introductory chapter will be followed by an exploration of their basic lexical skills using a range of core tasks (Chapter 3). Different features of their performance on these tasks will then be examined in further detail in the subsequent chapters, and an attempt will be made to relate these features to the different models of spoken word production described above in Chapter 1.

2.1: Introduction to RS

RS is a right-handed man who has worked as a driving instructor, and as a bus and coach driver. He is a monolingual English speaker. It has not been possible to establish for how many years he was in full time education. He lives with his partner, an adult daughter, two grandchildren and several Alsatians dogs. They also have another daughter and a son.

RS had a stroke in November 2001 when he was 60 years old and was admitted to a district general hospital. A CT scan at the time revealed a large area of infarction in the left middle cerebral artery area. An MRI scan carried out a year later in December 2002 showed that this was in the temporal and parietal lobes, extending towards the occipital lobe. He had suffered multiple transient ischaemic attacks during this period, and evidence was also found of deep white matter ischaemia, internal capsule infarction on the left, and lacunar infarcts in the right cortex and bilaterally in the thalamus.

RS came to the stroke rehabilitation ward of the hospital, where he remained for two months. Assessment was initially somewhat difficult, because RS was unable to follow tasks and showed limited awareness of his language problems. He appeared frustrated and angry that others could not understand him. However, towards the end of his stay in hospital, he began to show improved comprehension and awareness of his difficulties and agreed to language intervention. Following his discharge from hospital, he was seen as an outpatient, firstly in the rehabilitation unit of the hospital and then in his home.

RS spoke fluently and his utterances showed evidence of some syntactic structure. His expression, while mostly consisting of neologistic jargon, was peppered with intact phrases. These consisted mostly of common idioms, expletive expressions, and social or formal phrases. For example, when answering the phone to his speech and language therapist, he responded in clipped formal expressions, quite different from his normal style of speech, such as “Hello, may I ask who’s calling?” and “I’m afraid she isn’t in”. When he recognised the caller, he began to speak more informally, and his expression descended into largely unintelligible jargon. In addition, several related stereotypical words and non-words occurred across different contexts (e.g. “catapult”, “”caterpillar” and non-word variations of these). A sample of his connected speech is presented below.

2.1.1: Connected speech

At six months post-onset, RS was asked to describe a picture of a family preparing to go on holiday. His response was as follows:

"The toys are stirring to keep their /tə'ðɒt/ the keeping of /'tidraɪv/ (it is unclear what exactly he was referring to in this initial utterance). Him pushing his bike (pointing to a man carrying a suitcase). He's got his books to take to the car (pointing to the boy carrying a bucket and spade). Car... no, what have you if you want to put in the /sʌbl/ (pointing to the garage). A /'stɛdli/ pin, crystal, two /pə'lidmənz/ and a dustman (pointing respectively to a bunch of safety pins, a nailbrush, a mug and a spoon).

This sample demonstrates RS's use of non-words, both related (e.g. /stɛdli/ pin for safety pin) and unrelated (e.g. /pə'lidmənz/ for mug). There are also a large number of unrelated word errors (e.g. crystal for nailbrush). Some well-formed and relatively complex sentence structures were also noted (e.g. "He's got his books to take to the car"), but there were also some grammatical errors (e.g. "Him pushing his bike").

Even as RS began to show some insight into his difficulties, there were few attempts at self-correction. Therapy focussed on semantic tasks at the single word level and later at sentence level. Although he found writing and drawing difficult, he was able to use gesture and facial expression to great effect. Assessments were begun in hospital and continued after discharge, as presented below.

2.1.2: Input

A number of input tests were carried out. The findings are presented below in Table 2.1.

Table 2.1: RS: Scores on formal input tests

Test	Description	Score	Comments
PALPA 4	Auditory discrimination	30/40	
PALPA 5	Auditory lexical decision	75/80	(discontinued due to fatigue)
PALPA 47	Spoken word to picture matching	24/40	Errors: 10 C; 4 D; 2 U
PALPA 48	Written word to picture matching	16/40	Errors: 7 C; 6 D; 4 V; 7 U
Ps & Ps	Picture Version	45/52	

PALPA: Psycholingistic Assessments of Language Processing in Aphasia (Kay, Lesser & Coltheart 1992

Ps & Ps: Pyramids and Palm Trees (Howard & Patterson 1992)

C: Selection of close semantic foil

D: Selection of distant semantic foil

V: Selection of visual foil

U: Selection of unrelated foil

These findings suggested mild auditory input difficulties and moderate semantic processing difficulties, more on verbal than non-verbal semantics, and more on written than on auditory presentation.

2.1.3: Verb and sentence comprehension

It was noted in the preliminary observations and in the connected speech sample that RS made use of some verb structures in his spoken output. As word-class differences have been highlighted as being of interest in fluent aphasia (Marshall 2003) and as the PALPA subtests used focus mostly on nouns, verb and sentence comprehension were investigated in further tests. Sub-tests of the Verb and Sentence Test (Bastiaanse, Edwards and Rispens 2002) were used. On Verb Comprehension, RS scored 31/40. Seven errors involved the selection of related verb foils e.g. kneading → wringing. On the Sentence Comprehension sub-test, RS scored 19/40. He selected the reversed role foil on 14 errors. These tests suggested that RS had a mild-moderate impairment for understanding verbs in isolation, which was translated into a more severe impairment at the sentence level.

2.1.4: Spoken output

2.1.4.1: Naming

RS scored just 1/40 on PALPA 53: Oral Naming. Of his errors on this task, 33 were non-words which appeared to be unrelated to their targets (e.g. heart: /ˈlɛprə/; scissors:

/ˈtɛrəbɪnt/). There were also 11 apparently unrelated word errors (e.g. arrow: "photograph"; horse: "fire engine"). There was a single non-word which was clearly target-related (horse: /ˈhɔnəs/), and a single semantic/visual error: glove "hand". Perseveration was also a feature (e.g. screw: /ˈpɪldʌm/ followed by anchor: /ˈˈpɛdrʌm/). (Following Moses, Nickels & Sheard 2004b, for a response to be judged perseverative, it had to share at least half its phonemes with a previous response, or the same initial phoneme within 5 stimuli, the same final within 3 stimuli or the same main vowel with an immediately preceding response.) An interval of as many as 13 items appeared between perseverative responses. Furthermore, 5 unrelated non-words began with the onset /kr/ (e.g. shoe: /ˈkræsnæt/; yacht /ˈkrɪsmʌn/). RS showed some awareness of his difficulties in this task, with comments such as "I know… I can't…"; "Could be… but it isn't.".

2.1.4.2: Repetition

RS scored 33/80 on PALPA 9: Repetition x Imageability and Frequency. Of his errors, 21 shared at least half their phonemic content with the target. There was an imageability effect, with 21/40 high and 12/40 low imageability items correct, and an advantage for *low* frequency words, with 10/40 high and 23/40 low frequency items correct. He scored 19/80 on PALPA 9: Non-word Repetition, with 45 of his errors sharing at least half their phonemic content with the target. Although RS's repetition was impaired, it was clearly stronger than his naming. The fact that he could repeat some non-words suggests that sub-lexical processing was contributing to his relative success in this modality. However, lexical processing must also have been utilised, because words were repeated better than non-words. In addition, there was an imageability effect in word repetition, suggesting a degree of semantic involvement, and an influence of lexical frequency, although this was a tendency towards an advantage for *low* frequency words.

2.1.4.3: Reading

RS scored just 5/80 on PALPA 31: Reading x Imageability and Frequency. Of his errors, 16 shared at least half their phonemic content with the target. He scored 0/24 on PALPA 36: Non-word Reading, but 10 errors shared at least half their phonemes with the target. This suggested that RS's reading was more impaired than his repetition. However, the resemblance of nearly half the errors on non-word reading to their targets indicated some availability (albeit limited) of sub-lexical processes for reading.

2.2: Introduction to TK

TK is a right-handed monolingual English speaker who spent 17 years in full-time education. He trained as an artist, and having travelled extensively in Central and South America, he became the head of the art department at a local college. He lives with his wife who breeds Cavalier King Charles spaniels. They have two adult children.

TK had three strokes, the third and most severe being in June 2002 when he was 67 years old. A CT scan at the time revealed a large infarct in the left middle cerebral artery region.

He was discharged home after three months on the stroke ward and had weekly speech and language therapy as an outpatient. As well as general semantic therapy, TK was also encouraged to use total communication strategies. For example he showed some ability to write words he could not say (although this was partial and inconsistent). Drawing was also encouraged, but TK found the concept of using simple line drawings to communicate difficult. However, he developed an astonishing ability to sketch and paint in watercolours and oils with his left hand.

TK presented with fluent aphasia consisting of non-words and inappropriate words in sentence-like structures. Many of these words were unusual (e.g. "cornucopia", and "perambulator"). His speech was replete with what might be described as environmental and exclamatory noises, as well as some intact social phrases and expletive expressions. While on the ward, he frequently burst into song, but the words were still unrecognisable. Initially, while it was largely difficult to derive meaning from his speech, the occasional appropriate word or a close approximation could be discerned. His wife reported feeling that he sometimes "said words backwards".

2.2.1: Connected speech

TK was asked to describe a picture of a canal scene. His response is as follows:

"Here it's a bark (pointing to a dog) with a hole which is a talk (a man walking the dog) and he catches a cork with two barks along a road where a large chard (a tree stump) and leeks (reeds) with one two three four five six seven eight nine ten /rɑf/ and bits of /hɒmz/ (counting individual reed plants). We're still here as /ˈgɜkɪŋ/ boat (a canal boat) 'cos we like along here, and going round, we see the reed of the rude where the lockers rowed one two three four five six seven (counting windows on the boat) eight, no, three seven parts with a plan there (the decorative panel on the side of the boat) and the /ˈpɪtʃɪn/ (a man on the boat) about his /ˈʌləpɜt/ you see. Over there (a canoeist) you turned round with a /ˈpaʊndəz/ (the paddle) with two teats and wheats (the blades on the paddle), and you say go on."

As well as showing his use of inappropriate words and non-words, this passage also demonstrates TK's tendency towards perseveration, which he uses to almost sing-song effect (e.g. "It's a *bark* ... which is a *talk* and he catches a *cork* with two *barks*"; "the reed of the rude where the lockers rowed"; "two teats and wheats"). Some semantic errors were also noted (e.g. bark for dog; chard for tree stump).

Findings from the assessments carried out shortly after his CVI are presented below.

2.2.2: Input

The findings from formal tests are presented below in Table 2.2.

Table 2.2: TK: Scores on formal input tests

Test	Description	Score	Comments
PALPA 4	Auditory discrimination	24/40	
PALPA 4	(repeated after 3 months)	29/40	
PALPA 5	Auditory lexical decision	135/160	No frequency effect
PALPA 47	Spoken word to picture matching	18/40	Errors: 9 C; 4 D; 4 V; 5 N
PALPA 48	Written word to picture matching	28/40	Errors: 5 C; 3 D; 2 V; 2 U
Ps & Ps	Picture Version	47/52	

Like RS, these tests suggested the presence of some mild auditory input difficulties and moderate semantic difficulties. Unlike RS, TK's reading comprehension was superior to his auditory comprehension.

2.2.3: Verb and sentence comprehension

Again, sub-tests from the Verb and Sentence Test (Bastiaanse et al. 2002) were carried out. On Verb Comprehension, TK scored 31/40 while on Sentence Comprehension, he scored 20/40. Of his errors, 12 were reversed role foils. This demonstrates that like RS, TK had mild-moderately impaired verb comprehension to a similar degree as his noun comprehension, with more significant difficulties with sentence comprehension.

2.2.4: Spoken output

2.2.4.1: Naming

TK scored 4/40 on PALPA 53: Oral Naming. Of his errors, 16 were unrelated non-words (e.g. mountain: /fɜklz/; ladder: /ˈsɛrənd/) and 16 were unrelated words (e.g. comb: "sugar"; thumb: "bird"). There were 2 related non-word errors (cow /kaʊnd/; lemon: /ˈrəmənd), 2 related word errors (foot: "fate"; bird: "bowed"). Perseveration was also noted (e.g. "foul"; /gaʊl/; "goals" and "bowels" were produced to consecutive targets).

2.2.4.2: Repetition

TK scored 21/30 on PALPA 8: Non-word Repetition. This indicated the availability of the sub-lexical route for repetition. A slight length effect was noted, with an advantage for monosyllabic items. Word repetition was not tested at this stage.

2.2.4.3: Reading

TK scored 36/80 on PALPA 31: Reading x Imageability and Frequency. There was a negligible imageability effect and a small advantage for low frequency words (16/40 high and 20/40 low frequency items correct). He scored just 2/24 on PALPA 36: Non-word Reading, demonstrating some unwillingness to attempt items in this test. On the few that he did attempt, there was some evidence of sub-lexical processing ability: on six out of his nine error responses, at least half the phonemes were shared with the target.

2.3: Summary of initial clinical observations on RS and TK

RS and TK both presented with fluent aphasic speech in which the majority of content words appeared to be replaced by non-words or inappropriate real words. Both participants had severe difficulties with naming, with evidence of perseveration. RS appeared to have the predilection words "catapult" and "caterpillar" and non-word variations of these, which occurred across different sessions. TK did not tend to demonstrate such stereotypy, but he tended to use somewhat unusual words in error.

RS's reading was markedly impaired, while his repetition skills were a relative strength. In both reading and repetition, he demonstrated the availability of some sub-lexical processing, but the superiority of reading and repeating words over non-word tasks indicated lexical involvement. TK showed some sub-lexical repetition skills but it is not possible to comment on his sub-lexical reading because of his reluctance to attempt the non-word reading task. His word reading was clearly stronger than his naming, demonstrating the availability of non-semantic reading processes.

The similarities and differences between the two individuals were tantalising and appeared to warrant further investigation of the mechanisms involved. The initial questions posed by these observations are presented below in Chapter 3.

Chapter 3: Core data collection

3.1: Initial questions

The introduction to the participants above hinted at several questions to be pursued by an initial series of tests. These questions are outlined below:

- What task effects were there? Preliminary testing revealed interesting effects in reading and repetition, as well as in naming. For example, RS showed an imageability effect and an inverse frequency effect in repetition in PALPA Sub-test 8. Task differences may provide information on the processes available in spoken word production and the effects of damage on these processes (section 1.2.1.4; 1.2.2.1). Core testing therefore involved naming, reading and repetition tasks. The initial analyses will explore whether the individuals displayed task effects by comparing the total number of correct scores in these tasks.

- What types of errors were made in the tasks? Different patterns of errors may provide further evidence of task effects and of the processing engaged by each modality of production (section 1.2.1.4; 1.2.1.5; 1.2.2.1; 1.2.2.2). Specifically, the numbers of errors which were semantically related to their targets, and which were real words as opposed to non-words will be established.

- Were there any word class effects? One of the most striking features of jargon aphasia is its fluency, with the appearance of sentence-like structures (section 1.1). Because of the crucial role of the verb in sentence-processing, it has been claimed that an advantage for verbs might be expected in fluent aphasia (e.g. Jonkers & Bastiaanse 1998; Silveri, Perri & Cappa 2003), a prediction which goes against a general trend in both aphasic and non-brain injured people for an advantage for nouns (Marshall 2003). The participants' performances on nouns and verbs were therefore tested. Differences between the word classes will be examined by comparing the numbers of correct responses on nouns and verbs in each task.

- Were there any lexical frequency effects? As discussed in Chapter 1, different theories of error production in jargon aphasia make different predictions about the presence of lexical frequency effects (section 1.2.1.5; 1.2.2.2). Furthermore, while people with and without aphasia tend to have an advantage for words that are higher frequency in the language, people with jargon aphasia often appear to use bizarre "high-sounding" words (section 1.1). Indeed, both participants were observed to use unusual words in their spontaneous expression. A single case study has reported on inverse frequency effects in jargon aphasia (Marshall et al. 2001). Preliminary testing suggested that this might be present in RS's repetition (as seen in PALPA 9), and to a lesser extent in TK's reading (PALPA 31). Frequency effects will be explored by comparing the participants' overall performance on high and low frequency words in naming, reading and repetition.

- Was there any change over time? Different theories of error production in jargon aphasia make different predictions about recovery (to be examined in further detail in chapter 9). As this data collection took place over the course of a year, some recovery might be expected. This will be examined by comparing the number of correct responses in earlier and later trials of each task. Changes in error patterns will also be examined, as these may provide evidence for the changes in processing that underlie any recovery.

The initial analyses will not include an examination of the phonological relationship between targets and errors or patterns of perseveration. These areas will be pursued in later sections. Neither will this basic parsing of the data include a discussion of the relevant literature, which will be discussed in depth in the chapters that follow.

3.2: The stimuli

A set of 40 noun stimuli was developed, comprising the 20 high frequency and 20 low frequency words from PALPA Sub-test 54, frequency values being derived from Francis & Kuçera (1982). These stimuli were chosen as they were readily clinically available and the tests therefore easily replicable. The two groups were matched for length (in number of syllables and of letters, but not in number of phonemes). A verb set was created from items in the Object and Action Naming Battery (Druks & Masterton 2002). Forty verbs were selected by being matched as closely as possible in terms of frequency values (from Francis & Kuçera 1982) with each of the noun stimuli, thus creating a high frequency and a low frequency group. The verb stimuli were all monosyllabic in their base form except for one high frequency item (carry) and three low frequency items (juggle, tickle and iron). Items in the two frequency groups in the verb set were not matched pair-wise for length in the number of letters, but the mean length for both groups was similar, being 4.25 for the high frequency group and 4.2 for the low frequency group. The noun and verb sets were also matched for age of acquisition using values taken from Druks and Masterton (2002) or where these were not available, from Carroll and White (1973) or Gilhooly and Logie (1980). The stimuli are listed in Appendix 1.

Picture naming, oral reading and repetition tests were prepared for the noun and verb sets, thus creating six tests. For the noun set, an object picture naming test was created using black and white line drawings from Snodgrass & Vanderwart (1980). For the verb set, black and white line drawings of actions from Druks and Masterton (2002) were used. The stimuli in each set were randomised. Each of the 40 items in each set was presented in isolation. The stimuli were presented in the same order in each administration.

For reading and repetition tasks in the verb set, items were presented with the inflectional affix –ing. This was an attempt to make them unambiguously verbs. Without this, 32 of the 40 items could have been nouns as well as verbs (e.g. iron, drop, skate). For reading, items were presented in 14-pt. bold typeface, with each word being exposed in isolation. For repetition, each item was presented by the examiner. Again, the order of stimuli was maintained for each administration of reading and repetition. (A post hoc analysis of all trials of each task showed that neither RS nor TK showed task position effects in their performances, so maintaining the same order in each trial of a task was unlikely to have biased the results. The task position analysis is presented in Appendix 2). However, the order of stimuli was different in each of the three task types (e.g. nouns were presented in one order in naming, a different order in reading, and a different order still in repetition).

A single noun or verb task was administered in its entirety in each session. There was no blocking of different word class or task types because the participants had difficulty in switching from one task-type to another. The six tasks were presented in a random order within each trial set.

3.3: Error coding

The data were analysed for the number of different response types: correct responses (sub-divided according to whether they were to high or low frequency targets); semantic errors; responses which appeared to be derived from semantic errors (judged as such on the basis that they contained at least half the phonemes of a semantic relation); non-semantically related word responses (the criterion being that an item had to appear in Collins Concise Dictionary 2001 edition; no judgement was made at this stage as to whether the word was phonologically related to the target); non-word responses (again, no distinction being made as to whether they were related to the target or not); and other error types (e.g. false starts; circumlocutions; no responses). Items were assigned to these categories by two adjudicators, in order to provide a measure of reliability. Where a disagreement arose, this was resolved either by discussion or by recourse to a third party who had the "casting vote". Agreement was at a level of 93%.

3.4: Control data

All three tasks of the noun and verb sets were carried out by ten non-brain injured control participants (four men and six women) in the 55-70 year old age group, in order to establish name agreement and so that acceptable alternatives for the targets could be established. The tasks were also carried out by ten people (five men and five women) with non-jargon forms of aphasia, in order to establish that there was no intrinsic bias in the stimuli (e.g. an advantage for the verb stimuli or for low frequency stimuli). For control participants in both groups, each test was administered once. In the case of the non-brain injured controls, a noun test and a verb test (of a different task-type) was administered in a single session. Some of the control participants with aphasia were also able to undertake a noun and a verb test in a single session. In other cases a single test was administered per session, because of the individual's tendency to fatigue or because of difficulties in switching tasks. The results are presented below.

3.4.1: Non-brain injured control participants: Performance in naming, reading and repeating nouns and verbs

The mean (of a total of 40) and standard deviation of the number of correct responses (in total and in each frequency groups) in each task is shown in Table 3.1. A table showing the full error breakdown is presented in Appendix 3.

Table 3.1: Non-brain injured control participants: Mean and standard deviation of number of correct responses in each task

	Total Correct		High Frequency Correct		Low Frequency Correct	
	Mean	s.d.	Mean	s.d.	Mean	s.d.
Nouns Naming	38.60	1.17	19.70	0.48	18.90	1.10
Nouns Reading	40.00	0.00	20.00	0.00	20.00	0.00
Nouns Repetition	39.60	0.70	20.00	0.00	19.60	0.70
Verbs Naming	39.60	0.70	19.70	0.48	19.90	0.31
Verbs Reading	39.90	0.32	20.00	0.00	19.90	0.31
Verbs Repetition	39.90	0.32	20.00	0.00	19.90	0.31

There were 8 targets in the object naming task and 2 targets in the action naming task which elicited responses deemed to be acceptable alternatives to the target, the criterion being that they had to be listed with the target in Rogets International Thesaurus or in

Collins Concise Dictionary. It is somewhat problematic that for two object pictures (gun and house), the *majority* of the non-brain injured controls produced alternative low frequency sub-ordinate terms (revolver and pistol for gun, bungalow for house) for what were supposed to be high frequency targets. However, none of the aphasic controls or the research participants produced or partially produced these alternative names. Errors on naming were all semantic, visual or circumlocutory in nature (e.g. "hoeing" for raking; "clarinet" and "curtain rail" for flute; "putting up bricks" for building). Of these, 13 were successfully self-corrected. Out of the 31 errors made on the object and action naming tasks, 21 were made on low frequency targets.

All errors in reading and repetition with the exception of one item were formally related word errors (e.g. "sum" for thumb, "singing" for swinging). One non-word error was produced in reading verbs: /kɒmbɪŋ/ for combing. At least some of the errors in repetition may have been due to peripheral auditory input difficulties because in several cases, the participant acknowledged that he or she had not heard the word correctly and asked for it to be repeated. In reading and repetition, 5 of the 11 errors were successfully self-corrected. All 3 errors in reading were made to low frequency targets, and 7 out of 8 errors in repetition were made to low frequency targets. When all scores for each participant were combined and the numbers of correctly realised high and low frequency targets compared using a paired t test, there was a significant advantage for high frequency targets ($t(9) = 2.538$, $p < 0.05$).

3.4.2: Aphasic control participants

As with the non-brain injured control participants, the means and standard deviations for the number of correct responses for each task, in total and by frequency group, are presented in Table 3.2. Appendix 3 shows the full results, presented separately for each participant in order to show their individual patterns.

Table 3.2: Aphasic control participants: Mean and standard deviation of number of correct responses on each task type

	Total Correct		High Frequency Correct		Low Frequency Correct	
	Mean	s.d.	Mean	s.d.	Mean	s.d.
Nouns Naming	28.50	7.52	16.40	2.99	12.10	4.70
Nouns Reading	33.30	7.63	17.30	3.34	16.00	4.78
Nouns Repetition	33.80	5.14	18.20	2.10	15.50	3.54
Verbs Naming	27.30	8.60	13.80	4.19	13.50	4.91
Verbs Reading	29.90	11.69	15.20	6.32	14.70	5.58
Verbs Repetition	32.80	7.96	17.20	3.65	15.60	4.58

No unusual frequency effects were shown by these control participants, either as a group or as individuals. On the contrary, there was a trend towards an advantage for high frequency targets. When all the test scores for each of these participants were combined, and scores on high and low frequency items compared using a paired t test, significantly more words in the high frequency group were correctly produced ($t(9) = 4.09$, $p < 0.01$). Overall, there were no strong word class effects, but they were apparent in some individual cases: three control aphasic participants (DM, BT and VV) showed a markedly superior performance on nouns compared to verbs in reading, while a fourth (KL) showed the opposite pattern. A further participant (PW) showed a specific difficulty with repeating verbs. For all the participants who had a difficulty with verbs, there was a tendency either to omit or to change the inflectional affix.

Semantic difficulties were generally apparent only in naming. There was a general tendency for participants to produce more word errors than non-word errors. Overall, 401 word errors were produced compared with 228 non-word errors. The majority of "other errors" were circumlocutions, especially in the verb naming task, although one of the participants, MO'C, tended to produce circumlocutions on all tasks.

To summarise, the non-aphasic control participants showed ceiling effects on these tasks. The data from the aphasic control participants showed no clear-cut bias in favour of one word class over another, and both aphasic and non-brain injured control groups showed an advantage for high frequency words. In addition, there was a tendency to produce more word than non-word errors.

3.5: Research participant data

Each task was carried out four times with each participant over a period of thirteen months in the case of RS (May 2002-June 2003) and nine months in the case of TK (September 2002-June 2003). There were two periods of testing for each individual: an early period, consisting of the first and second sets of trials, and after an interval (of eight months in the case of RS and five months in the case of TK), a later period, consisting of the third and fourth sets of trials. Ideally, tests would have been carried out at more controlled intervals, but this was not possible for practical reasons such as illness and other access problems. However, the data still give a measure of performance over a period of time over which any change should be apparent.

Mention needs to be made of the statistical analyses used in the remainder of this chapter and in subsequent chapters. Because of the exploratory nature of this investigation, multiple comparisons were made to detect patterns in the data. This clearly increases the chances of type I errors occurring. In order to allow for this, Bonferroni adjustments have been used. It is acknowledged that these have been criticised for being over-conservative and increasing the risk of type II errors, because they reduce the p value to the extent where very few results appear to be significant (Perneger 1998; Jordan, Ong & Croft 1998). As the use of a single Bonferroni adjustment to cover all the comparisons in this thesis would reduce the p value to an extremely small value, a separate Bonferroni adjustment will be made for each participant in each chapter, depending on the number of comparisons made on the data. Thus in this chapter, 33 comparisons were made on the data of each participant. A

Bonferroni adjustment reduces the required value for significance to $p < 0.002$ (corrected to three decimal places). Although the interpretation of the data will be guided by those results which are significant at the Bonferroni level, results which do not make this level will not be dismissed if there is enough evidence to support their significance (e.g. if other results in a series all show a trend in the same direction). Conventional levels of significance will be indicated by asterisks (i.e. $p < 0.05$ = *; $p < 0.01$ = **; $p < 0.001$ = ***), and those comparisons which withstand the relevant Bonferroni adjustment for that chapter will be denoted by the abbreviation BA.

Initial analyses of the data on RS will be presented first, followed by the data on TK. This will be followed by a discussion of these analyses.

3.5.1: Initial analysis of the data on RS

The numbers of correct responses in each task (in total and by frequency group) and the full error breakdown for nouns and verbs are shown in Tables 3.3 and 3.4 respectively. On several items, multiple attempts were made to produce the target, so the total number of errors is often more than the number of targets on each trial (i.e. 40).

Table 3.3: RS: Naming, reading and repeating nouns over 4 trials

		Correct Responses			Error Responses					
	Task	Total	HiF	LoF	Sem	DSem	Word	NWord	Other	All E
Early	N1	1	1	-	2	2	6	36	4	50
	N2	2	2	-	4	5	20	30	-	59
Late	N3	6	5	1	1		15	19	3	38
	N4	1	1	-	1	6	20	25	3	55
	Total	10	9	1	8	13	61	110	10	202
Early	R1	12	8	4	1	-	17	18	-	36
	R2	3	3	-	-	-	27	24	-	51
Late	R3	9	5	4	3	-	18	27	-	48
	R4	7	5	2	-	-	22	24	-	46
	Total	31	21	10	4	-	84	93	-	181
Early	REP1	29	16	13	-	1	5	5	-	11
	REP2	32	15	17	-	-	3	9	-	12
Late	REP3	30	14	16	-	-	8	2	-	10
	REP4	31	17	14	-	-	2	7	1	10
	Total	122	62	60	-	1	18	23	1	43

(Key shown below Table 3.4)

Table 3.4: RS: Naming, reading and repeating verbs over 4 trials

		Correct Responses			Error Responses					
	Task	Total	HiF	LoF	Sem	DSem	Word	NWord	Other	All E
Early	N1	12	8	4	7	-	9	15	10	41
	N2	8	6	3	1	-	7	14	20	42
Late	N3	5	4	1	5	1	19	16	6	47
	N4	4	1	3	7	-	18	17	4	46
	Total	29	19	11	20	1	53	62	40	176
Early	R1	3	2	1	1	-	10	30	-	41
	R2	1	1	-	1	-	15	30	-	46
Late	R3	5	3	2	-	-	12	30	-	42
	R4	5	3	2	3	-	13	27	-	43
	Total	14	9	5	5	-	50	117	-	172
Early	REP1	19	12	7	1	-	6	14	-	21
	REP2	23	14	9	-	-	5	14	1	20
Late	REP3	23	11	12	-	-	1	17	-	18
	REP4	22	13	9	-	-	-	20	-	20
	Total	87	50	37	1	-	12	65	1	79

Key:

N	Picture naming	Sem	Semantic errors
R	Reading	DSem	Errors derived from semantic competitor
REP	Repetition	Word	Word errors
Total	Total correct	NWord	Non-word errors
HiF	High frequency correct	Other	Other error type
LoF	Low frequency correct	All E	Total number of errors

3.5.1.1: Task effects

The trials of each task were combined, and the tasks within each word class then compared. (That is, the best task was compared with the second best task, and the second best task with the third best task.) The chi-square test was used instead of the McNemar test because although the same stimuli were used in each task, it was not a repeat measure of the same task. In addition, the McNemar test was not possible because of the combining of trials. The findings are presented in Table 3.5.

All task differences were found to be significant. Repetition was the strongest task in both nouns and verbs. The weakest task in nouns was naming, but in verbs, it was reading. Task effects were also evident in the error patterns: more "other errors" were made in naming. These were mostly false starts or no responses in the noun task and circumlocutions in the verb task. Semantic-based errors also only really appeared in the naming task. In naming (nouns and verbs combined), 11% of errors were semantic-based (compared with 3% and 1% on reading and repetition respectively). The occasional appearance of what were classified as semantic errors in reading were often perseverative responses (e.g. grapes: "plum"; walk: "skip") or semantic *and* phonological errors (e.g. kiss: "lick"; drop: "drip").

Table 3.5: RS: Comparison between number of correct responses in naming, reading and repetition

	Comparison of Tasks	χ^2
Nouns	Repetition (122; 76%) > Reading (31; 19%)	103.71 (***BA)
	Reading (31; 19%) > Naming (10; 6%)	12.34 (***BA)
Verbs	Repetition (87; 54%) > Naming (29; 18%)	45.49 (***BA)
	Naming (29; 18%) > Reading (14; 9%)	6.04 (*)

(n; %): (number of correct responses across 4 trials; percentage this represents out of total of 160 targets in the 4 trials)

***: $p < 0.001$ **: $p < 0.01$ *: $p < 0.05$

ns: non significant

BA: withstands the Bonferroni adjustment

It may be questioned how errors may be recognisable as being clearly derived from semantic competitors (4% of all errors in naming). There should be a comparable proportion of errors clearly derived from their *targets*. Using the same criterion used for judging an error to be derived from a semantic competitor, 18 errors in naming (5% of the total number of errors in this task) were found to share at least half their phonemes with their target (e.g. hammer: /θʌmə/; drip: /rɪk/). The finding that errors which are clearly related to their targets occur in similar proportions to those which were said to be derived from semantic competitors supports the existence of the latter as an error type.

As well as semantic errors, there were several word errors which had no clear semantic relationship with the target. The presence of these items is interesting from a theoretical perspective. It was therefore useful to compare the proportions of these with the proportion of non-word errors. The comparisons between the proportions of non-word and word responses (i.e. the proportions of the sum of word + non-word errors), measured by a chi-square test, are presented below in Table 3.6. There were more non-word errors than word errors on all tasks, significantly so in naming nouns and reading and repeating verbs.

Table 3.6: RS: Comparison between number of word and non-word errors

Task	Word Errors	Non-word Errors	χ^2
Nouns Naming	61 (36%)	110 (64%)	28.08 (***BA)
Nouns Reading	84 (47%)	93 (53%)	0.92 (ns)
Nouns Repetition	18 (44%)	23 (56%)	1.22 (ns)
Verbs Naming	53 (46%)	62 (54%)	1.41 (ns)
Verbs Reading	50 (30%)	117 (70%)	53.76 (***BA)
Verbs Repetition	12 (16%)	65 (84%)	72.96 (***BA)

3.5.1.2: Word class effects

Comparisons between the numbers of correct responses in the two different word classes for each task are shown in Table 3.7. Numbers of correct responses are shown as percentages of the total possible number (160 in each case). Comparisons were made using the chi-square test. In the naming tasks, there were significantly more correct responses in the verb set than in the noun set. However, in reading and repetition, the opposite pattern was observed, with significantly more success in nouns than verbs.

Table 3.7: RS: Comparison between number of correct responses in noun and verb tasks

Task	Correct in Nouns	Correct in Verbs	χ^2
Naming	10 (6%)	29 (18%)	10.54 (**BA)
Reading	31 (19%)	14 (9%)	7.47 (**)
Repetition	122 (76%)	87 (54%)	16.90 (***BA)

3.5.1.3: Frequency effects

The numbers of correct responses to high and low frequency targets were compared using the chi-square test. The results are shown in Table 3.8. Percentages of the total possible number in each frequency group in each task (80 in each case) are also shown.

Table 3.8: RS: Comparison between number of correct responses to high and low frequency targets

Task	HiF	LoF	χ^2
Nouns Naming	9 (11%)	1 (1%)	6.83 (**)
Nouns Reading	21 (26%)	10 (13%)	4.84 (*)
Nouns Repetition	62 (78%)	60 (75%)	0.14 (ns)
Verbs Naming	19 (24%)	11 (14%)	2.63 (ns)
Verbs Reading	9 (11%)	5 (6%)	1.25 (ns)
Verbs Repetition	50 (63%)	37 (46%)	4.26 (*)

HiF: Number of correct responses to high frequency targets

LoF: Number of correct responses to low frequency targets

When trials were combined, there were more correct responses to high than low frequency targets on every task. These were significant in naming and reading in nouns and repetition in verbs (although these comparisons did not withstand the Bonferroni adjustment).

3.5.1.4: Change over time

The numbers of correct responses in the first pair of trials and second pair of trials of each task were compared using the chi-square test. The results are shown below in Table 3.9. Again, numbers of correct responses are also shown as proportions of the total possible number in each pair of trials of each task (80 in each case). When the numbers of correct responses on the first two trials combined were compared with those on the second two trials combined, there was little or no improvement. Indeed, the only significant result when the early and late pairs of trials were compared was a *worse* performance on the later trials in verb naming. This did not withstand the Bonferroni adjustment.

Table 3.9: RS: Comparison between number of correct responses in early and late trials

Task	Early Trials	Late Trials	χ^2:
Nouns Naming	3 (4%)	7 (9%)	1.71 (ns)
Nouns Reading	15 (19%)	16 (20%)	0.04 (ns)
Nouns Repetition	61 (76%)	61 (77%)	0 (ns)
Verbs Naming	20 (25%)	9 (11%)	5.10 (*)
Verbs Reading	4 (5%)	10 (13%)	2.82 (ns)
Verbs Repetition	42 (53%)	45 (56%)	0.23 (ns)

The McNemar test could be argued to be a more appropriate test to use here, as the comparison is of repeated measures. However, because the comparison involved two *pairs* of trials, it was not clear how items could be matched pair-wise. To compare only two single trials (for example, the first and fourth trial, or the second and third trial) would not give a full picture of change using all the data.

Comparisons between the numbers and proportions of word responses (out of the total number of word and non-word errors) in early and late trials were also made. These are presented below in Table 3.10. There was an increase in the proportion of word errors in naming and repeating nouns (significant in naming), and in naming and reading verbs. However, in reading nouns and repeating verbs, there was actually an increase in the proportion of non-word errors. This was significant in repeating verbs.

Table 3.10: RS: Comparison between number of word errors in early and late trials

Task	Early Trials	Late Trials	χ^2
Nouns Naming	26 (28%)	35 (44%)	4.77 (*)
Nouns Reading	44 (51%)	40 (44%)	0.92 (ns)
Nouns Repetition	8 (36%)	10 (53%)	1.10 (ns)
Verbs Naming	16 (36%)	37 (53%)	3.30 (ns)
Verbs Reading	25 (29%)	25 (30%)	0.02 (ns)
Verbs Repetition	11 (28%)	1 (3%)	9.57 (**BA)

3.5.2: Initial analysis of the data on TK

TK's performance on the same set of assessments will now be presented. The breakdowns of his correct and error responses are presented below in Tables 3.11 (Nouns) and Table 3.12 (Verbs).

Table 3.11: TK: Naming, reading and repeating nouns over 4 trials

		Correct Responses			Error Responses					
	Task	Total	HiF	LoF	Sem	DSem	Word	NWord	Other	All E
Early	N1	5	2	3	3	1	12	25	-	41
	N2	3	1	2	6	2	13	15	1	37
Late	N3	10	7	3	3	2	17	9	-	31
	N4	5	3	2	2	2	24	11	-	39
	Total	23	13	10	14	7	66	60	1	148
Early	RA1	16	7	9	1	-	9	17	-	27
	RA2	24	11	13	-	-	11	11	-	22
Late	RA3	26	14	12	-	-	9	11	-	20
	RA4	24	13	11	-	1	11	11	-	23
	Total	90	45	45	1	1	40	50	-	92
Early	REP1	13	4	9	-	-	23	7	1	31
	REP2	12	3	9	-	-	18	8	3	29
Late	REP3	19	9	10	-	-	16	5	-	21
	REP4	20	9	11	-	1	13	9	-	23
	Total	64	25	39	-	1	70	29	4	104

Table 3.12: TK: Naming, reading and repeating verbs over 4 trials

		Correct Responses			Error Responses					
	Task	Total	HiF	LoF	Sem	DSem	Word	NWord	Other	All E
Early	N1	2	2	-	6	-	13	16	7	42
	N2	1	-	1	9	-	11	19	2	41
Late	N3	4	3	1	6	2	17	5	8	38
	N4	7	5	2	6	1	5	14	9	35
	Total	14	10	4	27	3	46	54	26	156
Early	RA1	22	12	10	-	-	10	8	-	18
	RA2	12	5	7	-	-	11	19		30
Late	RA3	22	9	13	1	-	11	12	-	24
	RA4	22	11	11	-	-	9	12	-	21
	Total	78	37	41	1	-	41	51	-	93
Early	REP1	23	8	15	1	-	12	6	-	19
	REP2	21	9	12	1	-	9	8	-	18
Late	REP3	29	15	14	-	-	6	5	-	11
	REP4	22	11	11	-	-	12	8	-	20
	Total	95	43	52	2	-	39	27	-	68

Key:

N	Picture naming	Sem	Semantic errors
R	Reading	DSem	Errors derived from semantic competitor
REP	Repetition	Word	Word errors
Total	Total correct	NWord	Non-word errors
HiF	High frequency correct	Other	Other error type
LoF	Low frequency correct	All E	Total number of errors

3.5.2.1: Task effects

Comparisons between the tasks are summarised in Table 3.13 below. When the trials of each task were combined, reading was the strongest task in the noun tests, although the difference between this and repetition did not remain significant after the Bonferroni adjustment. In verbs, the best performance was on repetition, but not significantly so. Naming was significantly the weakest task in both noun and verb sets.

Table 3.13: TK: Comparison between number of correct responses in naming, reading and repetition

	Comparison of Tasks	χ^2
Nouns	Reading (90; 56%) > Repetition (64; 40%)	8.46 (**)
	Repetition (64; 40%) > Naming (23; 14%)	26.54 (***BA)
Verbs	Repetition (95; 59%) > Reading (78; 49%)	3.64 (ns)
	Reading (78; 49%) > Naming (14; 9%)	62.49 (***BA)

Most "other errors" were circumlocutions made in naming in the verb set. In repetition, there were three responses best described as environmental noises (/wʊf wʊf/; /brɪŋ brɪŋ/ and /brum brum/ were responses to "train", "church" and "harp" respectively). As with RS, semantic errors were only observed in naming. In total, there were 51 semantic or semantic-based errors in noun and verb naming (17% of the total number of errors on this task). In reading and repetition, just 2% of the errors were semantically based.

TK's rate of word error production was compared with his non-word error production over all four trials of each task. The results are shown below in Table 3.14. As with RS, the figure in brackets shows the percentage of the total of word + non-word errors, and it is this proportion which is the basis of the comparison.

Table 3.14: TK: Comparison between number of word and non-word errors

Task	Word Errors	Non-word Errors	χ^2
Nouns Naming	66 (52%)	60 (48%)	0.57 (ns)
Nouns Reading	40 (44%)	50 (36%)	2.22 (ns)
Nouns Repetition	70 (71%)	29 (29%)	33.96 (***BA)
Verbs Naming	46 (46%)	54 (54%)	1.28 (ns)
Verbs Reading	41 (45%)	51 (55%)	2.17 (ns)
Verbs Repetition	39 (59%)	27 (41%)	4.36 (*)

In naming and reading of both nouns and verbs, there was no significant difference between the proportion of word and non-word errors, but in repetition, there were significantly more word than non-word errors in both word classes. In the case of verbs, repetition was also the strongest task. However, there was no overall correlation between the number of correct responses and the proportion of word errors in a trial.

3.5.2.2: Word class effects

As with RS, numbers of correct responses in the two word classes were compared in the three tasks. The results are presented below in Table 3.15. In the naming and reading tasks, there were more correct responses in the noun set than in the verb set. However, in repetition, the opposite pattern was observed, with verbs having an advantage over nouns. The difference on this latter task was significant.

Table 3.15: TK: Comparison between number of correct responses in nouns and verbs

	Correct in Nouns	Correct in Verbs	χ^2
Naming	23 (14%)	14 (9%)	2.48 (ns)
Reading	90 (56%)	78 (49%)	1.80 (ns)
Repetition	64 (40%)	95 (59%)	12.01 (***BA)

3.5.2.3: Frequency effects

Numbers of correct responses to high and low frequency targets were compared. These findings are shown below in Table 3.16. There were negligible frequency effects on reading nouns and verbs and naming nouns and a small (but non-significant) advantage for high frequency verb targets in naming. However, there was an advantage for *low* frequency targets in repetition, significant in nouns (although this did not withstand the Bonferroni adjustment). This trend must be treated with caution, especially when it goes against the predicted pattern of an advantage for *high* frequency targets, although it is striking that there was a trend towards this unusual pattern in both word classes.

Table 3.16: TK: Comparison between number of correct responses to high and low frequency targets

Task	HiF	LoF	χ^2
Nouns Naming	13 (16%)	10 (13%)	0.46 (ns)
Nouns Reading	45 (56%)	45 (56%)	0.00 (ns)
Nouns Repetition	25 (31%)	39 (49%)	5.10 (*)
Verbs Naming	10 (13%)	4 (5%)	2.82 (ns)
Verbs Reading	37 (46%)	41 (51%)	0.40 (ns)
Verbs Repetition	43 (54%)	52 (65%)	2.10 (ns)

3.5.2.4: Change over time

The comparisons between the early and late trial sets are presented in Table 3.17 below. In all tasks, the comparison favoured the later trials. This was significant in repetition in nouns and naming in verbs, although not with the Bonferroni adjustment.

Table 3.17: TK: Comparison between number of correct responses in early and late trials

Task	Early Trials	Late Trials	χ^2
Nouns Naming	8 (10%)	15 (19%)	2.49 (ns)
Nouns Reading	40 (50%)	50 (63%)	2.54 (ns)
Nouns Repetition	25 (31%)	39 (49%)	5.10 (*)
Verbs Naming	3 (4%)	11 (14%)	5.01 (*)
Verbs Reading	34 (43%)	44 (55%)	2.50 (ns)
Verbs Repetition	44 (55%)	51 (64%)	1.27 (ns)

When changes in the ratios of word to non-word errors were investigated, there was an increase in the proportion of word errors relative to non-word errors in naming and reading in both word classes. This was significant only in naming in nouns. Comparisons between the proportions of word responses in early and late trials are shown below in Table 3.18.

Table 3.18: TK: Comparison between number of word errors in early and late trials

	Early Trials	Late Trials	χ^2
Nouns Naming	25 (38%)	41 (67%)	10.43 (**BA)
Nouns Reading	20 (42%)	20 (48%)	0.32 (ns)
Nouns Repetition	41 (73%)	29 (67%)	0.39 (ns)
Verbs Naming	24 (41%)	22 (54%)	1.64 (ns)
Verbs Reading	21 (44%)	20 (45%)	0.03 (ns)
Verbs Repetition	21 (60%)	18 (58%)	0.00 (ns)

3.6: Summary and discussion of the core data on RS and TK

3.6.1: Task effects

The first question posed concerned differences in modalities of spoken word production. This was addressed by comparing RS and TK's correct responses and error patterns on the different tasks (section 3.5.1.1; 3.5.2.1). Naming was significantly the weakest task for both participants in nouns (and in verbs for TK). The observation that semantic errors were largely confined to naming suggests that this task alone was *dependent* on semantic processing. The poor performance of both individuals on naming suggests that their processing via the semantic route was particularly impaired.

The superior performance on reading and repetition suggests that both RS and TK benefited from non-semantic activation in these tasks, which could be accommodated by a serial model or an interactive activation account. The availability of at least one processing route additional to damaged lexical-semantic processing can explain why they performed better on reading and repetition than on naming. For RS, repetition was by far the strongest task, possibly because it benefited the most from the availability of sub-lexical activation, as demonstrated by his non-word repetition performance (PALPA 9). As for reading, it was shown in Chapter 2 that although he did not achieve any whole correct responses in non-word reading (PALPA 36), nearly half the responses shared over half their phonemes with the target. This suggests that there was some sub-lexical availability for this task too, although this was clearly limited (perhaps because of orthographic input difficulties). This would explain why his reading in the research tasks was impoverished compared with his repetition performance.

TK also demonstrated some availability of sub-lexical activation for both non-word repetition (PALPA 8) and non-word reading (PALPA 36), which may explain why his performance on reading and repetition was far superior to that of naming. Reading was his strongest task in nouns, while repetition was the strongest in verbs, although there was no significant difference between the two tasks in either word class.

3.6.2: Word class effects

RS had significantly greater success naming verbs than nouns, but showed the opposite pattern in reading and repetition, most strongly in the latter (section 3.5.1.2). TK's performance in naming nouns was marginally better than his verbs, while in repetition, he performed significantly better on verbs than on nouns (section 3.5.2.2). His reading was approximately equal in both word classes. As a group, the control aphasic participants did not show a bias towards a particular word class effects in any task. When examined individually, two of them revealed significant word class effects in reading. However, the direction of these effects was inconsistent, with one showing an advantage for nouns and the other for verbs. It can therefore be concluded that there was no intrinsic word class bias in the stimuli themselves. The word class effects shown by RS and TK may be a factor of their individual processing strengths and impairments. A more detailed exploration of the word class issue will be presented in Chapter 8.

3.6.3: Frequency effects

The inverse frequency effect apparent in RS's word repetition in the preliminary PALPA assessments was not found here: he showed a normal frequency pattern, or a tendency towards an advantage for high frequency targets, significantly so in naming and reading in the noun set and in repetition in the verb set (section 3.5.1.3). Instead it was TK who produced showed a tendency towards an inverse frequency effect in repetition (section 3.5.2.3). This was weakly significant in the noun set. While the evidence from TK's data is not compelling, the data from the control aphasic participants tended to show a general trend towards the normal pattern, an advantage for high frequency words. It is therefore unlikely that TK's unusual pattern was caused by a bias in the stimuli. At the time of writing, only one case of an inverse frequency effect has been reported, by Marshall et al. (2001). This concerns naming tasks, and the favoured explanation concerns semantic neighbourhood density. TK's tendency towards an inverse frequency effect was in repetition, which, as discussed above, did not show a strong semantic influence. Further investigation of the inverse frequency effect will be presented in Chapter 7.

3.6.4: Change over time

Unfortunately, RS did not show a significant improvement in any task in terms of the number of correct responses (section 3.5.1.4). TK improved on all tasks, significantly so in repetition in the noun set and naming in the verb set, although not with the Bonferroni adjustment (section 3.5.2.4). In addition, there was an increase in the proportion of word responses in all tasks with the exception of repetition in both noun and verb sets. This shift, which was especially marked in naming nouns, needs to be explored in more detail. In addition, TK's improvement raises more questions: What exactly has improved? Can this improvement be sustained over further testing? Different theories of non-word production make different predictions about the evolution of jargon aphasia. A further longitudinal study (Chapter 9) will attempt to discover which pattern TK demonstrated, and which model best explains this.

3.6.5: Further Questions

These initial investigations have highlighted some interesting aspects of RS and TK's spoken word production, but they lead to more questions than they have answered: for example, why word class effects varied from task to task; why TK tended to have an advantage for low frequency targets, most strikingly in repetition; what lies behind TK's apparent improvement in spoken word production. In addition, there are other issues which have not yet been addressed, such as the phonological relationship between errors and their targets, and the patterns of perseveration demonstrated by both individuals. These themes will be explored in the chapters that follow.

The first question to be followed up concerns the classification of non-semantic error responses as word and non-words, and whether this distinction can be justified. On one hand, neither individual showed a consistent relationship between task success (in terms of the numbers of correct items) and the proportion of word errors relative to non-word errors, as might be predicted if "word" errors were of a different order from non-word errors. The number of non-word responses produced by the research participants also contrasted strongly with the control aphasic participants, who all produced more word than non-word errors. RS in particular consistently produced more non-words than words, most strikingly so in the naming of nouns and the reading and repetition of verbs. However, the number of "word" errors produced by both RS and TK makes them difficult to dismiss. This issue will be explored in more detail in the following chapter.

Chapter 4: Word errors

In the previous chapter, one of the response categories was word errors which were not semantically related to their targets. For example, RS produced "hospital" for the target thumb and "travelling" for writing, while TK produced "wife" for arm and "hoping" for juggling. Such responses may simply be strings of phonemes produced by the same mechanism as non-words (e.g. non-lexical generation, partial lexical retrieval, post-lexical distortion) which happen to resemble real words. Robson (1997) took this view, treating her participant LT's few word errors as non-word *jargon homophones* in the terminology of Butterworth (1979, 1985). Alternatively, they may be regarded as genuine lexical retrievals. A brief review of the literature on this subject follows.

4.1: Literature on word errors

In a serial model, word errors in normal speech production (or "malapropisms", if they are phonologically related to their targets) may be errors of lexical selection at the phonological level (Fay & Cutler 1977). As discussed in Chapter 1, in this type of model, the tendency to produce lexical errors at more than chance levels in normal speech production has been explained as being due to a failure of editing (section 1.4.1). Non-word errors are more easily detected and rejected, with word errors being more likely to "slip through the net". Interactive activation accounts have explained lexical bias as being due to patterns of activation across phoneme nodes that correspond to words feeding back to lexical nodes and thus being reinforced (ibid.).

So far, the discussion has been of speech errors in a normal language system. What of phonologically related word errors in a damaged system? In serial models such as Butterworth's (1989) account, formal errors (or formal paraphasias) could result from the same phonological processing errors as target-related non-words, making them jargon homophones. Alternatively, they could be lexical selection errors, resulting from either a correct address being mismatched to a phonological neighbour in the lexicon, or a partial address being matched to its closest phonological neighbour.

In the case of interactive activation accounts, Ellis (1985) argues that while reinforcement from feedback may apply to a normal system, a weakened system is less likely to have a strong enough flow of activation to drive the feedback. This results in a loss of advantage for lexical outcomes and an increased likelihood of non-word errors. Martin, Dell, Saffran and Schwartz (1994) agree that this is true if lexical retrieval difficulties are caused by weakened connections. However, they argue that if difficulties are caused instead by a pathologically increased rate of decay of activation, this still allows for phoneme to lexical level feedback and hence the reinforcement of word errors. In this hypothesis, errors occur when the target representation loses its advantage over its lexical competitors because its activation level has dropped (Martin & Saffran 2002). Thus the target word node "rat" activates the phonemes /r/ /æ/ /t/. These feed back to the word node "rat" but also to its neighbours such as "hat", "rap" and "rut". Because the activation of "rat" has decayed, it is no more likely to be selected than these neighbours.

Best (1996) considers Butterworth's (1989) model in which formal errors occur at the lexical stage to explain the formal errors made by her participant MF. However the length effect she found in naming causes problems for this account, because it suggests that the impairment is at the phonological encoding level. Best also considers an interactive activation account. However, this predicts *mixed* errors at higher than chance rates, because of the simultaneous influence of top-down semantic activation and bottom-up phonological activation. Thus in the example above, the word "cat" should have a double advantage as a competitor because of its semantic and phonological relationship with the word "rat". A mixed error effect was not found in MF's responses. Best proposes instead a dual mechanism, in which formal errors may result *either* from a lexical selection error (as in the Butterworth account) *or* from insufficient activation at the post-lexical level. In the latter account, if most of the target phonology is activated, only a small number of error phonemes are selected and a phonologically related non-word is produced. If fewer target phonemes are activated, feedback to the lexical level is needed for support, the result being a formal error.

Formal errors demand an explanation only if they are claimed to be a genuine error category and not simply jargon homophones. Various methods have been used by different authors to establish the legitimacy of this error category, primarily by attempting to determine whether they occur at greater than chance rates. Best (1996) compares the proportions of formal errors in MF's error corpus with the proportion of formal errors in a pseudo error corpus, created by substituting error phonemes with segments from the pool of phonotactically legal segments in each context. Significantly higher proportions of word errors were found in the real error corpus than in the pseudo-error corpus in naming but not in reading or repetition. However, Nickels and Howard (1995), using Best's methodology, failed to find evidence of formal errors occurring at more than chance levels in the data of two participants.

Gagnon, Schwartz, Martin, Dell and Saffran (1997) calculated the chance occurrence of errors resembling words. They found that if a set of 11 consonants and 10 vowels (the highest frequency phonemes in the language) were arranged into CVC combinations, 490 of the 1210 possible combinations corresponded to words, this proportion representing chance. This may be regarded as rather a high estimate: not only does it include only CVCs, when the rate of non-CVC phoneme strings would be lower, but the use of only high frequency phonemes also increases the chance of an error resembling a word. Despite this, the proportion of formal errors in the corpus of phonologically-related errors produced by their nine participants significantly exceeded this.

As well as examining whether formal errors occur at levels beyond chance, authors have used other indicators to establish the status of such errors. Some studies (e.g. Blanken 1990, Martin et al. 1994) have found that the formal errors tend to be higher frequency than their targets. This has been taken as evidence that these errors are genuine lexical selection errors, occurring when the activation of a lexical competitor surpasses the activation of the target because it has a higher resting level of activation (e.g. Martin & Saffran 2002). If word errors are jargon homophones and not true lexical retrievals, no such effect should be observed. However, other authors who argue for the genuine lexical status of formal errors have found no such frequency effect (e.g. Best 1996). Furthermore, Nickels (1997) argues that even where a frequency effect did occur, it could simply represent a regression to the mean: errors to low frequency targets would be expected to be higher in frequency.

In several studies, participants have tended to produce formal errors which matched the grammatical class of their targets (Blanken 1990; Martin et al. 1994; Gagnon et al. 1997; Goldrick & Rapp 2002). Again, this would not be predicted if word errors are jargon homophones. It has also been claimed that formal errors are different from non-word errors in the degree to which they share their phonology with their targets. That is, they are *less* target-related than phonologically related non-words (e.g. Martin et al 1994, Best 1996, Gagnon et al. 1997, Goldrick & Rapp 2002). This is taken as evidence that, unlike phonologically related non-word errors (assumed to arise from post-lexical distortion or partial retrieval of the *target* lexical representation), they result from the selection of a *non-target* lexical representation.

On the other side of the debate, length has been suggested as an indicator that word errors may be jargon homophones and not true lexical errors. Nickels and Howard (1995) used Franklin's (1989) argument that short strings of phonemes are more likely to correspond to words than long strings of phonemes (e.g. a random CVC string is more likely to resemble a word than a CVCVCC string), and should therefore be regarded as jargon homophones. Indeed, they found that the shorter a response, the more likely it was to be a "word", and the longer a response, the more likely it was to be a non-word.

The following sections examine the data of the two participants in the current study for evidence that their word errors are genuine lexical retrievals and not jargon homophones.

4.2: RS, TK and word errors

4.2.1: Proportions of word errors

Firstly, the proportions of word and non-word errors produced by RS and TK in each task were found. The classification of error types is based on that used by Best (1996) in the cases of her participant MF, Blanken's (1990) participant RB, and Martin et al.'s (1994) participant NC. The initial stressed response to each target was examined and classified as correct, a semantic error, a non-semantically related word or non-word or as "other" (including no responses). Following Best, the semantic error category in the current analysis includes multi-word responses. The current analysis also includes in this category errors which appear to be phonemic distortions of semantic errors (e.g. hand: /gʌv/) and mixed errors (e.g. horse: hoof), which Best considers as a separate category. Best also separates phonologically related and unrelated errors in the word and non-word categories. However, no judgement regarding phonological relationship was made here. All trials of nouns and verbs were combined for each task. The numbers of each response type are presented below in Table 4.1, along with the percentages of the total number of responses in that task they represent.

For RS, there were significantly more non-word errors than word errors in every task ($\chi^2 = 10.75$, $p < 0.01$; $\chi^2 = 23.77$, $p < 0.001$; $\chi^2 = 32.51$, $p < 0.001$ in naming, reading and repetition respectively). All these comparisons withstood a Bonferroni adjustment to $p < 0.007$ for the 7 comparisons made on the data of each participant in this chapter.

Table 4.1: Number and percentage of initial response types

	RS			TK		
	Naming	Reading	Repetition	Naming	Reading	Repetition
Correct	33 (10%)	36 (11%)	204 (64%)	35 (11%)	156 (49%)	154 (48%)
Semantic	64 (20%)	8 (3%)	2 (1%)	70 (22%)	3 (1%)	4 (1%)
Word	86 (27%)	106 (33%)	29 (9%)	103 (32%)	73 (23%)	106 (33%)
Non-word	125 (39%)	167 (52%)	84 (26%)	109 (34%)	88 (27%)	53 (17%)
Other	12 (4%)	3 (1%)	1 (0%)	3 (1%)	0 (0%)	3 (1%)

Results were more mixed for TK. In naming and reading, there was no significant difference between the numbers of word and non-word responses. However, in repetition, there were significantly more word errors than non-word errors ($\chi^2 = 23.51$, $p < 0.001$), again withstanding the Bonferroni adjustment.

For comparison, the percentages of these error types reported by Best (1996) (on naming tasks only) are shown below in Table 4.2. For ease of comparison with the current participants, semantic and mixed error categories are combined here, as are the phonologically related and unrelated sub-sets of words and non-words, and the categories of other response type and no response.

Table 4.2: Percentages of word and non-word responses produced by MF, RB and NC in naming tasks (adapted from Best 1996)

	MF (Best 1996)	RB (Blanken 1990)	NC (Martin et al. 1994)
Correct	44%	45%	27%
Semantic	27%	9%	17%
Word	12%	24%	20%
Non-word	7%	17%	21%
Other	10%	6%	15%

It is difficult to make direct comparisons between RS and TK and the three participants presented by Best, because on naming tasks, MF, RB and NC produced much higher proportions of *correct* responses (44%, 45% and 27% respectively) than RS and TK (10% and 11% respectively). However, it is apparent that for all three participants discussed by Best, the number of their word responses either matches or exceeds that of their non-word responses. TK's responses were comparable with this on all three tasks, but RS consistently produced more non-word responses than word responses. This may suggest that for RS at least, these responses are more likely to be jargon homophones. In order to explore this, some of the analyses discussed in the literature review (section 4.1) were undertaken, as described below.

4.2.2: Frequency of responses compared to frequency of targets

In order to examine the prediction that word errors tend to be higher frequency than their targets, the frequency values of the participants' non-semantic word responses were established (from Francis & Kuçera 1982) and compared to those of their targets. Where a response could be either of a homophone pair, the item with the highest frequency of the pair was used. For example, /si/ was taken to represent "see" and not "sea", because the former has a higher frequency than the latter. All trials of nouns and verbs for each task were combined. Table 4.3 shows the proportions of word responses that are of higher frequency than their individual targets.

Table 4.3: Number of word responses higher in frequency than their targets

	Naming	Reading	Repetition
RS	32/86 (37%)	39/106 (37%)	16/29 (55%)
TK	51/103 (50%)	29/73 (40%)	36/106 (34%)

Despite a rather unsophisticated analysis, with the added lenient procedure of taking the higher frequency value in the case of homophone pairs, neither participant showed a tendency for word errors to be higher frequency than the targets. In fact, responses tended to be *lower* in frequency than their targets on two out of three tasks for both participants.

4.2.3: Word class of word errors

The following analysis examines the prediction that word errors should conform to the word class of the target. All non-semantic word errors were classified as to whether they conformed to or violated the word class of the target. Only the noun tasks were considered in this analysis because of concerns that cueing the –ing inflectional affix on the verb stimuli would bias word errors to resemble verbs, thus conforming to the word class. Where a word could belong to more than one word class (e.g. /si/ as "sea" or "see"; "love" as a noun or verb), the word class with the highest frequency value (from Francis & Kuçera 1982) was accepted. To use the same example as above, "see" has a much higher frequency than "sea", so /si/ was regarded as the verb "see". Words were regarded as having an ambiguous class if there was a frequency rating of less than 50 between entries for the same word in two word classes. For example, "love" rates 145 as a verb and 179 as a noun. It was therefore regarded as ambiguous. Table 4.4 below shows the numbers and percentages of word errors in each noun task (with all trials combined) which conformed to or violated the target word class (i.e. nouns). The ambiguous responses were omitted.

For both RS and TK, there was stronger support in naming than in reading and repetition for the prediction that word errors should be of the same word class as their targets. It is difficult to interpret the significance of these findings because the *chance* of a word error belonging to a certain word class cannot be established. Such errors could resemble not just nouns or verbs, but other classes of content or function word. Indeed, in the error data examined here, there were errors resembling adjectives, pronouns, relative pronouns and prepositions. However, the fact that this makes the chance of an error belonging to a certain word class much less than fifty percent strengthens the claim that the errors examined here conformed to the word class of the target at higher than chance levels.

Table 4.4: Number of word errors in noun tasks conforming to or violating word class of their targets

	RS		TK	
	Conform	Violate	Conform	Violate
Naming	30 (65%)	10 (22%)	36 (59%)	17 (28%)
Reading	36 (59%)	19 (31%)	18 (53%)	14 (41%)
Repetition	7 (39%)	9 (50%)	34 (51%)	21 (31%)

4.2.4: Length

As discussed in the review, it has been suggested that short phoneme strings are more likely to correspond to a word by chance, and should therefore be regarded as jargon homophones. The following analysis examines length in syllables. With trials and word classes of each task combined, the numbers of non-semantically related word and non-word errors of different syllable lengths were found. In the case of the verb tasks, -ing inflectional affixes were removed. The results are shown below in Table 4.5 and 4.6.

Table 4.5: RS: Number of word and non-word errors by length in syllables

	Words				Non-words			
No. syllables	1	2	3	4	1	2	3	4
Naming	76	10	-	-	42	49	31	3
Reading	92	13	1	-	95	60	10	-
Repetition	21	8	-	-	42	32	7	1
Total	189 (86%)	31 (14%)	1 (0%)	- (0%)	179 (48%)	141 (38%)	48 (13%)	4 (1%)

Table 4.6: TK: Number of word and non-word errors by length in syllables

	Words				Non-words			
No. syllables	1	2	3	4	1	2	3	4
Naming	99	4	-	-	72	23	14	1
Reading	69	4	-	-	62	19	7	-
Repetition	98	8	-	-	49	3	1	-
Total	266 (94%)	16 (6%)	- (0%)	- (0%)	183 (73%)	45 (18%)	22 (9%)	1 (0%)

For both participants, there was a strong tendency for word responses to be monosyllables, whereas non-words showed higher proportions of polysyllables. In the case of both participants, when all tasks were combined, significantly more word errors than non-word errors were monosyllables (for RS, $\chi^2 = 82.37$, $p < 0.001$; for TK, $\chi^2 = 45.89$, $p < 0.001$; both withstand the Bonferroni adjustment). This appears to support the claim that responses which appear to be word errors are in fact short phoneme strings which happen to resemble real words. However, Gagnon and colleagues' (1997) calculation of the chance of a phoneme string resembling a word takes this into account by examining short responses only. This is examined below.

4.2.5: Do word responses occur at greater than chance levels?

As discussed in section 4.1, Gagnon and her colleagues (1997) found that 490 out of 1210 (40%) CVC combinations formed real words. This proportion was taken to be a measure of the chance that a random CVC phoneme combination will resemble a word. They then compared the proportions of the phonologically related CVC errors produced by their nine aphasic participants which were words with this "chance" proportion.

A similar analysis was carried out here, finding the proportion of RS and TK's CVC errors which were words. Noun and verb trials were combined in each task, and the number of non-semantically related CVC responses was found (with -ing inflections removed from verb responses). The proportions of these which were words were compared with the "chance" proportion as defined by Gagnon et al. (1997). These authors used a one-sample t test to examine the average deviation of the actual rate of formal error production from the chance rate for nine participants. Because each task in the case of the two participants in the current analysis was considered separately, a chi square test was used, in order to compare the proportion of CVCs which were words with the chance proportion (490/1210). The results are presented below in Table 4.7. The numbers of CVC word errors are shown as a proportion of the total number of CVC errors (i.e. word + non-word errors).

Table 4.7: Proportions of word CVCs compared with chance

	RS		TK	
	Word CVCs	χ^2	Word CVCs	χ^2
Naming	37/50 (74%)	22.15 ***(BA)	69/114 (61%)	17.14 ***(BA)
Reading	46/85 (54%)	6.08 *	42/74 (57%)	7.60 **
Repetition	20/45 (44%)	2.43 (ns)	70/91 (77%)	45.81 ***(BA)

Like Gagnon and her colleagues' participants, RS and TK produced CVC word errors at rates significantly greater than an estimate of chance in all tasks with the sole exception of repetition in the case of RS. The comparisons in naming for both RS and TK and repetition for TK were strong enough to withstand the Bonferroni adjustment. Gagnon et al. (1997) point out that longer phoneme strings have lower lexical densities, and thus have a less than 40% chance of corresponding to words. Of RS's non-CVC errors, 28% (naming), 32% (reading) and 13% (repetition) were word errors. Of TK's non-CVC errors, 39% in naming, 33% in reading and 53% in repetition were words. It is therefore suggested that the proportions of RS and TK's non-CVC errors which were words were still significantly above chance.

4.3: Summary and discussion of word errors

RS produced word errors at significantly lower rates than non-word errors, while TK produced the two error types at similar rates in naming and reading, with significantly more word than non-word errors in repetition (section 4.2.1). However, this need not imply that RS's word errors were more likely to be jargon homophones.

The finding that RS and TK's word errors tended to occur at levels exceeding Gagnon and colleagues' (1997) calculation of chance (section 4.2.5) supports the hypothesis that they were genuine lexical retrievals and not jargon homophones. Although it was shown in the analysis of length (section 4.2.4) that their word errors tended to be monosyllabic, which according to Nickels and Howard (1995) makes them more likely to be jargon homophones, the Gagnon et al. (1997) analysis allows for this by calculating the chance of word outcomes solely on such monosyllabic (CVC) responses. Furthermore this can be regarded as a rigorous test because the estimate of chance is high, being based around high frequency phonemes. The other analyses presented here are more ambivalent, but none provide strong evidence *against* the hypothesis that word errors are genuine lexical items, as summarised below.

It has been suggested that word errors should be higher in frequency than their targets, making them more readily retrieved. However, in common with MF (Best 1996), neither

RS nor TK showed any such tendency (section 4.2.2). This is not necessarily problematic for the hypothesis that they are genuine lexical retrievals, given that neither RS nor TK showed a strong positive frequency effect in general. In addition, some studies claiming the existence of genuine word errors predict that they should be less target-related than non-word errors. Looking ahead to the next chapter, this prediction was not supported: there was no less evidence of target-relatedness on words than on non-words (section 5.2.3). This is problematic for serial accounts, in which word errors arise from the selection of a non-target lexical representation, while related non-words arise from the target lexical representation. However, an interactive activation account in which word outcomes are reinforced by feedback from the phoneme level to the lexical level does not make any such prediction about target relatedness.

In support of the hypothesis that RS and TK's word errors had genuine lexical status, it was found that they tended to conform to the grammatical class of the target (section 4.2.3). This appears to conflict with an account in which word errors result from bottom-up activation from the phoneme level to the lexical level, because the preservation of word class implies top-down influence from syntactic information. However, it may be that lexical representations of the same word class as the target are more likely to be activated by top-down activation than lexical representations of different word classes. Thus a noun target will lead to the activation of other nouns. Because they are already activated, they are more likely to be selected by feedback activation. In other words, lexical competitors which share the same word class as the target have a double advantage (Goldrick & Rapp 2002). In the cases of the current participants, evidence of word class preservation was stronger in naming than in reading and repetition. As discussed previously, naming appeared to be the single task reliant on semantic activation, entailing the activation of syntactic information. Reading and repetition appeared to be at least partially accomplished via non-semantic processing, by-passing the level at which syntactic information such as word class is accessed.

Further evidence in support of the genuine "word" status of these errors and the hypothesis that they arise from feedback can be found from the observation that as TK improved over the four trials, the proportion of his word errors increased relative to his non-word errors (section 3.5.2.4). This was most striking in naming: on the first two trials, 38% of his (non-semantic) errors were words, compared with 67% on the second pair of trials. The increase in the proportion of word errors in naming may indicate an increased flow of activation to the phoneme level to allow feedback to the lexical level.

If as is argued here, word responses are genuine lexical retrievals and not jargon homophones, and they arise from feedback from the phoneme level to the lexical level, why does this advantage for lexical outcomes appear to be so inconsistent? Both RS and TK have jargon aphasia characterised by non-word production, and it has already been noted in Chapter 3 that they produced higher proportions of non-word errors than the aphasic control participants. It may be that the reinforcement of word errors by feedback from the phoneme level to the lexical level is subject to fluctuations in the degree of random noise: when there is more noise in the system, there is less activation flowing down to the phoneme level to drive the feedback.

A further point to be made here is that the literature seems to concern only *related* word errors. Very little has been said about *unrelated* word errors and where they may arise from. Kohn and Smith (1994b) explain them within a serial model, where the address from semantics to phonology is accessible but read incorrectly, so that another representation is randomly selected. Unrelated word errors could also result from lexical selection errors in an interactive activation account (Foygel & Dell 2002). These authors note that such errors are unlikely "unless the system is degraded enough for noise to have a large impact". Alternatively, if they arise from the reinforcement of a string of phonemes which may be derived from a variety of sources (e.g. target or competitor lexical nodes, or from previous responses), a strong phonemic relationship to their targets is not necessarily predicted.

Furthermore, it may be that errors, whether words or non-words, have a closer relationship to their targets than is immediately apparent. The following section examines this possibility in more detail.

Chapter 5: Target relatedness

One of the contentious issues in the debate on non-word error production is the phonological relationship between the target and error. This issue can also be applied to word errors, as mentioned above in Chapter 4. Both participants produced word and non-word errors which were clearly related to their targets. For example RS produced /blɒt/ for bottle and /snagnɛf/ for snail, while TK produced /keɪbl/ for table and /hɒtʃ/ for watch). They both also produced errors with a more marginal relationship with their targets. For example RS produced /kʌp/ for axe and /hizən/ for horse, while TK produced /həʊst/ for window and /rɪpənz/ for clown. Before analysing the data produced by the current participants, a review of the literature is presented.

5.1: Literature on target relatedness

As discussed in Chapter 1, different theories of non-word production make different predictions regarding the likelihood of target relatedness of errors. Anomia theories predict that errors should bear no such relationship beyond chance becaus they are not derived from a lexical representation, target or otherwise, being generated by a device creating a random string of phonemes (e.g. Butterworth 1979) or syllables (Buckingham 1981) or by phonological reconstruction (Kohn & Smith 1994b; Kohn et al. 1996). Similarly in dual impairment theories, an error is derived from a semantic competitor, not the target lexical representation, so it should not be phonologically related to it.

In some serial models, a speaker may produce two types of non-word error, those which are non-lexically generated and hence not target related beyond chance, as described above, and those which are based on partial lexical retrieval (Butterworth 1979; Kohn & Smith 1994b; Kohn et al. 1996). Errors based on partial lexical retrieval should be target related, as at least some of the target phonology has been successfully retrieved. According to Robson (1997), if the same speaker is producing both error types, there should be a bimodal distribution of relatedness, with errors either being target related (in the case of partial lexical retrieval) or not (in the case of non-lexically generation).

Schwartz et al. (2004) and Wilshire (2002) discuss another possible dual account of target relatedness in non-word errors, which they term the dual origin theory. This theory assumes that non-words may be derived either from partial lexical retrieval, as discussed above, or from post-lexical distortion (in the conduction theory). In this account, errors resulting from either mechanism should show evidence of target relatedness. However errors caused by post-lexical distortion should be more highly target related than those derived from partial lexical retrieval, because they entail the successful retrieval of the target lexical representation. A bimodal distribution is therefore predicted, with errors being highly target related or less highly target related. This seems unlikely, because different degrees of partial lexical retrieval and of phonemic distortion are predicted. In other words, it should not be the case that an error caused by phonemic distortion would always be clearly more target related than an error caused by partial lexical retrieval. It is also not clear why there should be a stark distinction between two degrees of target relatedness and not a smooth continuum.

In order to examine the evidence for this theory, Schwartz and her colleagues (2004) and Wilshire (2002) inspected the combined non-word error corpus of 18 individuals with fluent aphasia. They found not the bimodal distribution of target relatedness suggested by the dual origin theory, but a normal distribution of the number of phonemes shared by targets and errors. Because of this and other evidence, the dual origin theory was rejected in favour of a single origin account, in which non-word errors can *only* be derived from partial lexical retrieval. As with Miller and Ellis's (1987) study, which reached similar conclusions, this is placed in an interactive activation account of error production. Robson (1997) also used an interactive activation account to explain how LT's apparently unrelated non-words (or "abstruse neologisms") were actually target related, and that there was a continuum of target relatedness.

So far, this review has mentioned only target relatedness in non-word errors. It was also noted in the previous chapter (section 4.1) that a conduction account predicts that non-word errors should be more target related than word errors because they originate from the target lexical representation, while word errors are assumed to originate from a different lexical representation. However, interactive activation models make no such prediction, with word errors occurring because of feedback from the phoneme level to the lexical level (Schwartz et al. 1994). If anything, word errors might be predicted to be more target related than non-word errors, because the activation allowing the feedback to occur should also entail the activation of more target phonology. The following investigation examines target relatedness in both word and non-word errors.

5.2: RS, TK and target relatedness

5.2.1: Is there evidence of target relatedness beyond chance?

In order to ascertain whether the participants' responses in each task bore more resemblance to the target than would be expected by chance, the procedure used by Robson (1997) (derived from Miller & Ellis 1987), was adopted. All four trials of nouns and verbs for each task were combined. As with the previous analysis, only the initial stressed response to a target was examined. Semantic and semantic + phonological errors were removed, because they were assumed not to have been motivated by the target. Circumlocutions and other multi word/non-word errors were also removed. The categories of word and non-word errors were preserved and analysed separately.

The number of phonemes a response shared with its target (regardless of the position within the word) was calculated. (For verbs, the "-ing" suffix was removed from both targets and responses prior to the analysis.) The total number of *shared* phonemes in each error set was found as a proportion of the total number of *all* phonemes in that set. A pseudo-error corpus was created by randomly reassigning errors to targets (still within a category, e.g. word responses in naming, non-words in reading). The number of phonemes shared by the new pairings of target and pseudo-error was calculated over the total number of phonemes. This randomisation was carried out three times. The median proportion was then selected (e.g. in RS naming: word responses, the three pseudo error sets shared 28/293, 40/293 and 50/293 phonemes with the targets, so 40/293 was selected as the median proportion). The proportion from the real error corpus was compared with that from the median pseudo error corpus, to establish whether the number of shared phonemes in the target + real error pairings was significantly greater than the number of shared phonemes in the target + pseudo-error pairings, the latter representing a chance relationship between target and error. The proportions of target phonemes in word and non-word errors are shown in Table 5.1 and 5.2 below, along with the significance of the comparison with each pseudo error corpus (using a chi-square test).

Table 5.1: RS: Proportion of error phonemes shared with targets and comparison with pseudo-error corpus

Task	Word Errors	χ^2	Non-word Errors	χ^2
Naming	57/293	3.57 (ns)	116/727	3.23 (ns)
Reading	100/349	20.29 (***BA)	201/601	47.23 (***BA)
Repetition	55/92	34.88 (***BA)	207/342	130.8 (***BA)

Table 5.2: TK: Proportion of error phonemes shared with targets and comparison with pseudo-error corpus

Task	Word Errors	χ^2	Non-word Errors	χ^2
Naming	80/323	9.98 (**BA)	90/456	12.04 (***BA)
Reading	108/233	57.20 (***BA)	175/334	88.51 (***BA)
Repetition	83/219	18.82 (***BA)	74/170	39.25 (***BA)

BA: Comparison withstands Bonferroni adjustment to $p < 0.002$ for the 27 comparisons made on the data of each participant in this chapter

For RS, there was evidence of target relatedness in word and non-word errors beyond chance in reading and repetition, but not in naming. For TK, there was evidence of target relatedness in word and non-word errors in all three tasks.

5.2.2: Distribution of number of target phonemes in error responses

A general trend to target relatedness over a large number of errors may be the result of a small number of items being highly target related, other responses showing no relatedness beyond chance. On finding that LT's responses in naming tasks tended to be more target related than expected by chance, Robson (1997) then examined the distribution of target related phonemes in order to test for the presence of such a biasing effect. A similar analysis was carried out on the responses of the current participants: trials of each task (nouns and verbs together) were combined and the numbers of words and non-words sharing 0, 1, 2, 3 etc target phonemes were found. The results are presented below in Table 5.3 and 5.4.

For both RS and TK, both word and non-word errors tended to be clustered at the lower end of the distribution. In the case of RS, 94% of error responses in naming, 94% in reading, and 64 % in repetition shared 0, 1 or 2 phonemes with their targets. For TK, these figures were 94% of error responses in naming, 72% in reading and 89% in repetition. In both cases, few items contained more than 3 target phonemes. There was no evidence of a bimodal effect, but rather a smooth continuum of target relatedness.

Table 5.3: RS: Distribution of number of target phonemes in error responses

	0	1	2	3	4	5	6	7
Naming: words	42	33	8	1	1	-	-	-
Naming: non-words	49	46	19	10	1	-	-	-
Reading: words	31	48	23	2	-	-	-	-
Reading: non-words	49	58	46	10	4	1	-	-
Repetition: words	-	7	18	4	-	-	-	-
Repetition: non-words	1	10	35	28	5	1	2	1

Table 5.4: TK: Distribution of number of target phonemes in error responses

	0	1	2	3	4	5	6	7
Naming: words	47	36	15	4	1	-	-	-
Naming: non-words	44	32	14	6	-	-	-	-
Reading: words	17	19	20	17	-	-	-	-
Reading: non-words	10	20	29	21	4	-	2	1
Repetition: words	51	25	23	3	1	-	-	-
Repetition: non-words	17	16	7	8	5	-	-	-

This supports Robson's findings, and provides evidence for a continuum of target relatedness, and not for the presence of two distinct types of response, highly target related and non-target related (as in anomia theories) or highly and moderately target related (as in dual origin theory). However, while it may appear from this that where target relatedness existed, it was a genuine and general property of each group of responses and not the result of biasing by a small number of highly target related items, some reservations remain. It is curious that TK's naming was found to be target related beyond chance, yet nearly half of his word and non-word responses did not share any phonemes with their targets. Robson (1997) ran a further test to strengthen her argument for target relatedness as a general property of LT's non-words. She checked whether there was evidence of target relatedness even when a response showed only a minimal amount of overlap with the target by ascertaining whether each set of items sharing one, two three etc. phonemes with the target was more target related than predicted by chance.

A similar analysis was carried out here on tasks where there was evidence of target relatedness (i.e. reading and repetition for RS, and all three tasks for TK). The same procedure for testing for target relatedness described above was carried out taking separately the set of words and non-words sharing one, two and three phonemes with the target. The proportions of the total number of phonemes shared with the targets in each set are presented below in Table 5.5, along with the comparisons with the pseudo error corpus using the chi square test.

Table 5.5: Proportion of error phonemes shared with targets and comparison with pseudo-error corpus within each number of shared phonemes

		RS Responses		TK Reponses	
Task; response type	No. SP	PSP	χ^2	PSP	χ^2
Naming; words	1	n/a	n/a	36/111	7.93 (**)
	2	n/a	n/a	28/47	14.31 (***BA)
	3	n/a	n/a	n/a	n/a
Naming; non-words	1	n/a	n/a	43/185	6.58 (*)
	2	n/a	n/a	26/59	13.39 (***BA)
	3	n/a	n/a	n/a	n/a
Reading; words	1	48/157	12.43 (***BA)	21/65	0.94 (ns)
	2	46/83	14.35 (***BA)	36/57	22.63 (***BA)
	3	n/a	n/a	51/62	49.08 (***BA)
Reading; non-words	1	55/218	8.34 (**)	20/66	6.53 (*)
	2	92/175	46.64 (***BA)	58/101	37.62 (***BA)
	3	30/42	13.76 (***BA)	63/87	34.97 (***BA)
Repetition; words	1	n/a	n/a	25/81	4.95 (*)
	2	36/55	23.22 (***BA)	46/71	38.21 (***BA)
	3	n/a	n/a	n/a	n/a
Repetition; non-words	1	10/36	0.69 (ns)	16/45	6.02 (*)
	2	70/121	35.09 (***BA)	n/a	n/a
	3	64/123	61.55 (***BA)	24/32	22.76 (***)

Key:

SP: Shared phonemes

PSP: Proportion of shared phonemes over total number of phonemes in set

n/a: analysis not carried out because no evidence of target relatedness in the original analysis or because too few items in the set (<8) to carry out the analysis

BA: Withstands Bonferroni adjustment to $p < 0.002$

In the case of RS, almost all sets showed evidence of target relatedness significantly higher than chance, the exception to this being non-word responses in repetition sharing one phoneme with their targets. For TK, again most sets were significantly more target related than chance, with the exception of word responses in reading sharing one phoneme with their targets. Even though not all the comparisons withstood the Bonferroni adjustment, there was a clear trend towards target relatedness beyond chance even when few phonemes were shared with the target.

5.2.3: Comparison between the target relatedness of words and non-words

As discussed previously (section 4.1), some theories of non-word production, most notably the conduction theory, predict that non-word errors should be more target related than word errors. This is because they are derived from the target lexical representation followed by post-lexical distortion, whereas word errors are derived from a non-target lexical representation. To examine this, the proportions of target related phonemes from the results of the original target relatedness analysis were used (i.e. the *real* error corpora of word and non-word responses, not the *pseudo-error* corpora. For example, for RS in naming, 57/293 phonemes in word responses were shared with their targets, while 116/727 phonemes in non-word responses were shared with their targets). The proportions of target related phonemes (of the total number of phonemes) in word and non-word errors were compared with a chi-square test. The results are presented in Table 5.6. There was no significant difference in target relatedness between word and non-word errors in the case of either participant.

Table 5.6: Comparison between target relatedness of word and non-word errors

	RS		TK	
Task	Direction of difference	χ^2	Direction of difference	χ^2
Naming	Words > non-words	1.81 (ns)	Words > non-words	2.81 (ns)
Reading	Non-words > words	2.34 (ns)	Non-words > words	2.01 (ns)
Repetition	Non-words > words	0.02 (ns)	Non-words > words	1.26 (ns)

5.3: Summary and discussion of target relatedness

For RS in reading and repetition and TK in all three tasks, responses were found to be more target related than would be predicted by chance alone (section 5.2.1). An analysis of the distribution of the number of shared phonemes showed that for both participants, where target relatedness was found, it was not the result of a small number of responses being very close phonologically to their targets, with the majority of responses being unrelated.

On the contrary, a continuum of target relatedness was found. A further check on this showed that even responses sharing only one phoneme with their targets tended to be more target related than predicted by chance (section 5.2.2).

The finding that RS's naming showed no evidence of target relatedness beyond chance indicates such severe lexical retrieval difficulties that minimal phonological information was available. This could be accommodated into a serial model, in which strings of phonemes are generated in the absence of lexical activation (e.g. Butterworth 1979) or into an interactive activation account, in which a high level of random noise causes the selection of non-target phonemes, with insufficient activation from the target lexical node to its phonemes to inhibit this (e.g. Dell et al. 1997). TK did show evidence of target relatedness in naming, suggesting that there was enough activation from the lexical level to the phoneme level to allow some selection of target phonemes.

For both participants, reading and repetition showed strong evidence of target relatedness, suggesting the activation and selection of some target phonology. This suggests that RS and TK both benefited from non-semantic activation in these tasks, boosting their performance in terms of target relatedness of errors, as well as numbers of correct responses. This can be accommodated into a model in which reading and repetition are accomplished by direct or sub-lexical activation, circumventing impaired semantic processing, or one in which semantic activation (albeit severely restricted) and non-semantic activation are summated, allowing for partial lexical retrieval. This is described in a serial model with respect to reading (e.g. Hillis & Caramazza 1991, 1992) in section 1.2.1.4, and in an interactive activation account with respect to repetition (e.g. Martin and Saffran 2002) in section 1.2.2.1.

If reading and repetition both benefited from non-semantic information, how can differences in target relatedness between the two tasks be explained? For example, RS shows a far superior performance on repetition to his performance on reading. On repetition, 84% of word and non-word responses shared at least two phonemes with their targets. For reading, this was reduced to 32% of responses. At first sight, it is tempting to look for differences between the tasks as evidence of two different processes being responsible for response generation, with errors in repetition arising from post-lexical distortion and errors in reading arising from partial lexical retrieval (as in the dual origin theory discussed but rejected by Schwartz et al. 2004 and Wilshire 2002). Alternatively, the different levels of performance may have reflected varying abilities with the input component of the task. It is assumed from the preliminary investigations that RS's auditory input and non-word repetition skills were superior to his visual input and non-word reading skills (section 2.1.2), so it seems entirely plausible that more non-semantic activation was available for repetition than for reading.

In contrast to RS, TK's reading was superior to his repetition (section 2.2.2), but the difference between the two tasks was less marked than in the case of RS. In reading, 59% of responses shared at least two responses with the target, compared with 30% of responses in repetition. This can be explained by his superior visual input skills relative to his auditory skills.

There was no evidence to support the hypothesis that word errors were less target related than non-word errors because they arose from a non-target lexical representation (section 5.2.3). On the other hand, it was speculated that an interactive activation account may predict more target relatedness on word errors, because these may result from increased activation to drive feedback from the phoneme level to the lexical level to reinforce word outcomes. However, this proposal was not supported by the evidence. There was little difference between the target relatedness of the two error types.

While it has been demonstrated that a large number of errors were phonologically related to their targets, there were, for both participants, many unrelated errors. It was observed informally that many of the non-target related errors, words and non-words, were actually phonologically related to each other. For example, in RS's reading. the successive targets frog, door, heart and butterfly elicited the responses /glʌv/, /kʌm/, /glʌv/ and /gəʊv/. In TK's naming, the successive targets harp, knife, book, gun, horse and heart elicited the responses /hætʃ/, /hɜtʃ/, /hɜtʃ/, /putʃ/, /futʃ/ and /tʃɜtʃ/. What patterns lie behind these relationships? A further question concerns the availability of error phonology: why are certain phonemes more easily accessed than target phonemes in the event of reduced activation? The following chapter investigates the phenomenon of perseveration and stereotypical phonology.

Chapter 6: Perseveration

The perseveration in the speech of RS and TK may help explain the production of non-target related word and non-words in jargon aphasia. A brief review of the literature on perseveration follows.

6.1: Literature on perseveration

Recurrent perseveration, the sub-type of perseveration in Sandson and Albert's (1984) taxonomy most closely associated with aphasia, has been defined as the unintentional repetition of a response in the absence of the stimulus that initially elicited it (Hirsh 1998). *Total* perseveration refers to the perseveration of a whole word or non-word (e.g. Hirsh 1998; Moses, Nickels and Sheard 2004a & b). *Partial* perseveration or *blended* perseveration refers to the perseveration of just part of a previous word or non-word, with the remaining phonological material being derived from other sources, such as the target or lexical competitors (ibid).

Most authors agree that anomia is the underlying cause of perseveration. In other words, perseveration is a response to lexical retrieval difficulties (e.g. Cohen & Dehaene 1998; Hirsh 1998; Gotts, della Rochetta and Chipolotti 2002). Moses et al. (2004a) describe it as resulting from difficulties activating the target representation at a specific level of processing combined with normal residual activation at that level.

Cohen and Dehaene (1998) agree that the nature of perseveration corresponds to the level of the lexical retrieval difficulty, so that total perseveration corresponds to a semantic-lexical level impairment, whereas a blended perseveration corresponds to a phonological level impairment. They use a serial account to describe this, but such a theory can also be accommodated into an interactive activation account in which weakened connections cause a reduced flow of incoming activation (e.g. Martin et al. 1994; Dell et al 1997; Martin, Roach, Brecher & Lowery 1998). Indeed, Dell (1986) argues that in the event of such lexical retrieval difficulties, previous responses have an advantage over other lexical substitutions because they have been primed by recent activation, so their resting level of activation is temporarily raised. Vitkovitch and Humphreys (1991) agree with the notion of a priming effect, arguing that residual activation actually remains in the connections between semantic processing and the lexical level rather than in the levels themselves.

However, an account in which total perseveration is explained as the residual activation of a previous lexical representation overriding weak incoming activation has difficulties explaining the total perseveration of non-word responses, which do not have lexical representations (Hirsh 1998; Moses et al. 2004b). Santo Pietro and Rigrodsky (1982) propose that total perseverations may arise from the phoneme level, as an extreme example of the carry-over of the phonemic structure of a response to a response immediately or very closely following it. Alternatively, total perseveration could result from the recombining of perseverative material at the phoneme level which by chance resembles a previous combination (Moses et al. 2004b). These authors argue that perseveration arising at the phoneme level could have two different causes. It may occur because of damage at the phoneme level itself, in which case responses should be a blend of target and perseverative phonology. However, it may occur because of damage at higher semantic-lexical levels, resulting in minimal target activation reaching the phoneme level. Responses are therefore assembled from phonemes whose activation persists at this lower level.

Several authors have found semantic relationships between targets and perseverative responses (e.g. Santo Pietro & Rigrodsky 1986; Vitkovitch & Humphreys 1991). Martin and colleagues (1998) compared perseverative responses occurring at different intervals following their source and found that responses at longer intervals were more likely to have a semantic relationship with the *current* stimulus. They argued that such perseverative errors could be sustained over long intervals because they benefited from both residual activation (from previous targets) and spreading activation (from the current target) to semantic neighbours, residual activation alone being insufficient to cause a perseveration after a delay.

Hirsh (1998) did not find evidence of semantic or phonological relationships between the targets and perseverative responses of her participant CJ. However, there was evidence of semantic relationships between targets *sharing* a response. For example, the stimuli “carrot” and later “pumpkin” both led to the response “myralin”. Hirsh, like Moses and colleagues (2004b), argues that total perseverations may arise from the phoneme level: a string of phonemes is generated in response to the failure of lexical-phonological activation. When a further failure occurs on a new target which is semantically connected to the target initially eliciting the phoneme string, the same string is re-activated. Hirsh argues that this could be sustained over the long intervals she found between non-word perseverations. It would have been interesting if a further naming or reading task had been developed with stimuli from a limited number of semantic categories, because this theory suggests that a non-word "code" would be set up for each category, so that all non-word error responses to targets within that category would be identical.

Moses and her colleagues (2004b) found that when tested on picture naming, reading and repetition, their participant KVH also produced large numbers of perseverative responses which were not immediate. They do not specify the maximum size of the interval between a perseverative response and its source, but 38% of unrelated non-word total perseverations occurred after gaps of more than five items. One possibility they consider is that certain phonemes are more readily available as "default" segments to fill gaps in the event of failure of activation at the phoneme level. The repeated use of such phonemes causes the appearance of perseveration.

Such phonemes may be available because they are high frequency in the language (Moses et al. 2004b). However, as these authors point out, this implies that error data in jargon aphasia follow a normal phoneme frequency distribution. This was not found by Butterworth (1979) in the unrelated non-word errors of his participant KC. Perecman and Brown (1981), Peuser and Temp (1981) and Blanken (1993) also found that their respective jargon aphasic participants' output differed from the normal frequency distribution of the language in question.

Blanken (1993) also found that his participant TW tended to overuse /g/ and /k/ as initial consonants, and frequently suffixed responses with the unit "–gel" or variations such as "–gelel" and "-kel". Blanken hypothesised that these were stereotypical blockers at "subphonemic" levels of processing. Kohn, Smith and Alexander (1996) also describe an over-reliance on certain segments in the process of "phonological reconstruction", in which incomplete phonological information is padded out from a limited pool of phonemic elements. It has been suggested that in time, individuals with jargon aphasia may develop their own idiosyncratic phoneme frequency distribution: certain phonemes may become high frequency because of long-term changes to the resting levels of activation and are therefore easily activated in the event of reduced activation from the lexical to the phonological level (Robson 1997; Moses et al. 2004b).

6.2: RS, TK and perseveration

This account will attempt to answer the following questions:

- What is the extent of the perseveration exhibited by the participants in each task?

- Do perseverative responses tend to follow the initial response immediately, or are there lengthy intervals between them? If so, can semantic relationships between perseverative responses and their targets explain how residual activation is sustained?

- Is there a relationship between perseverated responses within a single task and patterns of phoneme frequency across different contexts?

- Do non-word total perseverations occur, and if so, how can they be accounted for?

6.2.1: Proportions of total and blended perseveration in each task

In this and all subsequent analyses in this section, only noun tasks were examined. This was because of the large number of multi-word responses in the verb tasks (specifically in naming). As in previous analyses, only the initial stressed error response to each target was included. The numbers of total perseverations and blended perseverations in each task (with all four trials combined) were found. This count did not include the initial instance (or source) of the word/non-word or segment(s). Using the criteria suggested by Moses and colleagues (2004b), a response was coded as a blended perseveration:

- if the same initial phoneme was repeated within five responses
- if the same final phoneme was repeated within three responses
- if the same main vowel was repeated in a consecutive response
- if it shared at least half its phonemes with a previous response (in approximately the same order), regardless of the distance from the previous response

It should be noted that responses were included even if the repeated phonemes were also shared with the target. The findings are shown below in Table 6.1. Perseverative responses are shown as proportions of the total number of error responses on that task (again, counting only the initial response to each target). The total number of correct responses in each task is also shown, in order to show the relationship between task success and the extent of perseveration.

Table 6.1: Number of total and blended perseverations in each task

	RS			TK		
	Naming	Reading	Repetition	Naming	Reading	Repetition
Correct	10	31	122	23	90	64
TP	11/150 (7%)	16/133 (12%)	2/40 (5%)	36/137 (26%)	5/81 (6%)	17/104 (16%)
BP	102/150 (68%)	88/133 (66%)	27/40 (68%)	78/137 (57%)	48/81 (59%)	60/104 (58%)
TP & BP	113/150 (75%)	104/133 (78%)	29/40 (73%)	114/137 (83%)	53/81 (65%)	77/104 (74%)

Key:

TP: Number and proportion of total perseverations

BP: Number and proportion of blended perseverations

TP & BP Number and proportion of total and blended perseverations

The participants produced striking numbers of perseverative responses. In both cases, 76% of error responses averaged across the three tasks were perseverative. It is acknowledged that there was a high level of chance of an item being coded as a blended perseveration, given the broad inclusion criteria. However, both participants produced blended perseverations at levels exceeding those of the aphasic control participants. Across all three tasks, 217/323 (67%) of RS's error responses and 186/322 (58%) of TK's error responses were classified as blended perseverations. When the error responses of the aphasic control participant with the greatest number of *total* perseverations were examined, 23/61 (38%) across the three tasks were classified as blended perseverations. This was significantly less than the proportion of blended perseverations produced by RS ($\chi^2 = 19.02$, $p < 0.001$) and TK ($\chi^2 = 8.32$, $p < 0.01$). The former withstood the Bonferroni adjustment to $p < 0.002$ for the 20 comparisons for each participant in this section.

For TK, there was a relationship between task difficulty and the extent of perseveration: naming, the task with the fewest correct responses, also showed the highest proportion of perseveration, while reading, the most successful task, had the lowest proportion of perseveration. However, the differences between the tasks were not significant. It was noted that they could be accounted for by differences between the proportions of total perseveration in each task, with proportions of blended perseverations remaining approximately equal. For RS, there were approximately equal proportions of perseveration on all three tasks, regardless of their relative success rate.

6.2.2: Intervals between perseverative responses and their sources

The interval (i.e. the number of intervening stimuli) between each total perseveration and its most proximate source was found. Blended perseverations were not included because the criteria for classification as a blended perseveration were confounded with interval size. That is, the more remote a response was from another, the less likely it was to be counted as a blended perseveration. The findings are presented below in Table 6.2.

Table 6.2: Number of intervening stimuli between sources and total perseverations

		Number of Intervening Stimuli					
		0	1	2	3	4+	Range
RS	Naming	4	-	-	-	7	0-14
	Reading	2	2	3	2	7	0-8
	Repetition	1	-	1	-	-	0-2
TK	Naming	18	7	-	2	9	0-21
	Reading	3	1	1	-	-	0-2
	Repetition	11	3	1	1	1	0-4

For both RS and TK, a striking number of total perseverations did not occur immediately. In the case of RS, when all tasks were combined, 20 out of 29 total perseverations (69%) occurred after gaps of at least 2 stimuli, with 14 (50% of the total) occurring at gaps of at least 4 stimuli. For TK, 15 out of 58 (26%) total perseverations occurred after at least 2 stimuli, with 10 (17%) occurring at gaps of at least 4 stimuli. For TK, the majority of these sustained total perseverations occurred in naming, whereas in the case of RS, there were high numbers of sustained total perseverations in reading as well as naming.

6.2.3: Semantic relationships between targets and perseverative responses

As discussed in the literature review (section 6.1), responses may be sustainable over longer intervals if they also benefit from a semantic relationship with the new target

(Martin et al. 1998). However, only 7 of RS's 29 total perseverations (4 in naming, 3 in reading) and 9 out of TK's 58 total perseverations (7 in naming, 1 in reading and 1 in repetition) had such a relationship. The example in TK's reading occurred after an interval of 22 stimuli, but otherwise, perseverative responses with a semantic relationship with the new target did not appear to be associated with particularly lengthy gaps.

6.2.4: Interim summary of perseveration within a single task

RS and TK both produced perseverative responses at rates exceeding those of the aphasic control participants (section 6.2.1). Perseverative responses were often far from their sources (section 6.2.2), but there was no evidence that semantic relationships between them and the new target helped sustain activation over these intervals (section 6.2.3). The question of how activation persisted without being erased by subsequent responses remains. The following section investigates patterns of phoneme use, in order to explore this issue.

6.2.5: Phonemic content

6.2.5.1: Phoneme frequency distribution

An analysis of the phonemic content of RS and TK's errors examined initial responses in noun tasks, whether or not they were perseverative. Responses coded as semantic, semantic + phonemic errors or multi-word responses were removed. All other word and non-word responses in the combined 4 trials of each task were analysed for the consonants used. These were ranked in order of frequency of occurrence, and this ranking was compared to the CELEX Lexical Database for the English phoneme frequency distribution (Baayen, Piepenbrock & Gulikers 1995) using the Spearman rank correlation coefficient test. The results are shown below in Table 6.3.

Table 6.3: Correlation between English phoneme frequency distribution and participants' phoneme frequency distribution in error responses

	RS	TK
Task	Rs	Rs
Naming (words)	0.49 (*)	0.41 (*)
Naming (non-words)	0.69 (***BA)	0.52 (**)
Reading (words)	0.51 (**)	0.54 (**)
Reading (non-words)	0.52 (**)	0.63 (***BA)
Repetition (words)	0.56 (**)	0.57 (**)
Repetition (non-words)	0.70 (***BA)	0.35 (ns)

Rs: Spearman rank correlation coefficient rho

Like Robson's participants LT (Robson 1997, Robson et al. 2003), the phoneme distribution of both participants' error responses in all three tasks (with the sole exception of repetition of non-words in the case of TK) correlated significantly with the normal English frequency distribution. However, when the distributions were inspected, it was noted that in both cases, certain consonants were over-represented. This was examined in the following analysis.

6.2.5.2: Patterns of favoured consonants

The sets of word and non-word error responses on each trial of each noun task were inspected for their most frequently occurring consonant. These are shown below in Table 6.4. Where there was a tie, the consonants in question are shown together.

Table 6.4: Most frequently occurring consonants in each trial

	RS		TK	
	Words	Non-words	Words	Non-words
Naming Trial 1	/t/ /b/ /g/	/k/	/s/	/k/ /h/
2	/k/	/l/	/h/	/h/ /tʃ/
3	/k/	/k/	/h/	/m/ /h/ /θ/
4	/k/	/s/	/h/	/h/
Reading Trial 1	/l/	/l/	/m/	/k/
2	/l/	/l/	/h/	/l/
3	/l/	/l/	/w/	/l/
4	/g/	/l/	/k/	/m/
Repetition Trial 1	/m/	/t/ /n/ /l/ /k/	/r/	/n/
2	/k/	/l/	/f/	/f/ /ʃ/
3	/n/	/l/	/ŋ/	/b/ /h/ /ŋ/
4	/k/	/l/	/h/ /l/	/f/

For both participants, certain consonants were the most frequent in at least a third of the 24 error sets (word and non-word errors on the fours trials of the three tasks). In the case of RS, /l/ was the most frequent consonant in 12 error sets and /k/ in 8 error sets. In the case of TK, /h/ was the most frequent consonant in 10 error sets. It is acknowledged that the cut-off point of a third of all error sets may appear somewhat arbitrary. However, no consonants approach the predominance of /k/ or /l/ in the case of RS or /h/ for TK.

6.2.5.3: Interaction between favoured consonants and perseveration

One of the proposals discussed in the review of the literature was that perseverative responses may occur because of the use of default phonemes in the event of a failure to retrieve target phonology (Moses et al. 2004b). This predicts an interaction between over-used phonemes and perseverative errors. In other words, such phonemes should occur at greater rates in perseverative responses than in non-perseverative responses. To investigate this, the participants' perseverative and non-perseverative error responses (examining initial responses only) were examined for the occurrence of their favoured consonants (i.e. /k/ and /l/ for RS, and /h/ for TK). This is shown below in Table 6.5.

For RS, there were consistently higher proportions of the favoured consonants in perseverative than non-perseverative errors in all tasks. When the totals across all tasks were considered, /k/ and /l/ both occurred in significantly higher proportions in perseverative than non-perseverative responses ($\chi^2 = 21.32$, $p < 0.001$ and $\chi^2 = 8.21$, $p < 0.01$ respectively; only the former withstands the Bonferroni adjustment). This supports the prediction of an interaction between the incidence of perseveration and the presence of favoured consonants. That is, there was high chance of a perseverative response containing such a consonant. This in turn supports the hypothesis that perseverative responses were based around stereotypical phonology. The consonants in question, /k/ and /l/, did not necessarily have to occur together: they did so in 61 out of the 246 perseverative responses (25%), forming an initial consonant cluster in 24 of these (10% of the total).

Table 6.5: Number of favoured consonants occurring in perseverative and non-perseverative error responses

	RS				TK	
	Numbers of /k/		Numbers /l/		Numbers of /h/	
	P	NP	P	NP	P	NP
Naming	85/113 (75%)	6/29 (21%)	51/113 (45%)	9/29 (31%)	73/114 (64%)	1/19 (5%)
Reading	26/104 (25%)	5/29 (17%)	64/104 (62%)	9/29 (31%)	8/53 (15%)	4/28 (14%)
Repetition	12/29 (41%)	2/11 (18%)	15/29 (52%)	5/11 (45%)	16/77 (21%)	5/22 (23%)
Total	123/246 (50%)	13/69 (19%)	130/246 (53%)	23/69 (33%)	97/244 (40%)	10/69 (14%)

P: Perseverative responses

NP: Non-perseverative responses

The findings were less clear-cut in the case of TK. While /h/ (which appeared exclusively as an initial consonant) occurred significantly more frequently in perseverative than non-perseverative responses when all three tasks were combined ($\chi^2 = 15.26$, $p < 0.001$; withstands the Bonferroni adjustment), this difference can be attributed to naming alone. There was little difference between the two types of responses in reading and repetition.

6.2.5.4: Task position effects of perseveration and use of favoured consonants

It could be argued that the high rates of use of certain consonants in the perseverative responses of both participants were the result of an accelerating rate of perseveration over the course of a trial. This was examined by analysing the number of perseverative responses and of the occurrence of the favoured consonants within them in each noun trial in the naming task quarter by quarter (i.e. with 10 responses in each quarter), to establish whether these numbers increased. The results are presented below in Tables 6.6 and 6.7.

Table 6.6: RS: Task position effects of perseveration and /k/ and /l/ in naming trials

	1st quarter			2nd quarter			3rd quarter			4th quarter		
	P	/k/	/l/	P	/k/	/l/	P	/k/	/l/	P	/k/	/l/
Trial 1	5	5	1	8	8	7	9	7	5	9	6	4
Trial 2	7	6	3	10	9	8	7	6	5	5	2	2
Trial 3	5	1	2	7	3	3	8	8	4	3	3	1
Trial 4	6	2	5	7	6	2	10	6	1	8	5	2

Table 6.7: TK: Task position effects of perseveration and /h/ in naming trials

	1st quarter		2nd quarter		3rd quarter		4th quarter	
	P	/h/	P	/h/	P	/h/	P	/h/
Trial 1	6	6	9	5	5	2	7	1
Trial 2	5	3	7	4	6	6	10	6
Trial 3	3	2	7	6	8	6	6	1
Trial 4	7	7	9	4	10	8	8	8

P: Perseverative Responses (total and blended)

Neither RS nor TK demonstrated a tendency for the rate of perseveration or the use of their favoured consonants to increase over the course of a trial.

6.2.5.5: Comparison between use of favoured consonants and highest frequency consonants in English

The strong representation of /k/ and /l/ for RS may be due to the fact that they are mid-high frequency phonemes in English and their popularity as error phonemes merely reflected this. (Out of the 25 consonants in the CELEX distribution, /l/ is the fifth most frequent and /k/ the eighth most frequent consonant. TK's favoured consonant /h/ is lower, being the sixteenth most frequent consonant.) To investigate this possibility, the proportions in the participants' perseverative responses of the four highest frequency consonants in the

CELEX database for English, /n/ /t/ /s/ and /d/, were found. These are shown below in Tables 6.8 and 6.9, along with the proportions of /k/ /l/ (in the case of RS) and /h/ (in the case of TK) for comparison.

Table 6.8: RS: Number of favoured consonants and high frequency consonants in perseverative responses

	/k/	/l/	/n/	/t/	/s/	/d/
Naming	85/113 (75%)	51/113 (45%)	27/113 (24%)	23/113 (20%)	22/113 (19%)	18/113 (16%)
Reading	26/104 (25%)	64/104 (62%)	15/104 (14%)	10/104 (10%)	11/104 (11%)	6/104 (6%)
Repetition	12/29 (41%)	15/29 (52%)	9/29 (31%)	13/29 (45%)	2/29 (7%)	2/29 (7%)
Total	123/246 (50%)	130/246 (53%)	51/246 (21%)	46/246 (19%)	35/246 (14%)	26/246 (11%)

While some of these high frequency phonemes were strongly represented in individual tasks (most notably /t/ in RS's repetition and /n/ and /t/ in TK's reading and /n/ in his repetition), overall none approached the proportions of the favoured consonants in perseverative responses. In the case of RS, the most strongly represented high frequency consonant, /n/, appeared at significantly lower rates than /k/ ($\chi^2 = 46.09$, $p < 0.001$) or /l/ (χ^2

= 54.55, $p < 0.001$). In the case of TK, /n/ (again the most strongly represented high frequency consonant) occurred at significantly lower rates than /h/ ($\chi^2 = 36.43$, $p < 0.001$). All comparisons withstood the Bonferroni adjustment. This suggests that if there were "default" consonants in these individuals' production systems, it was not because of their high frequency in the English language (even though the errors of both participants followed the English phoneme frequency distribution), but something more idiosyncratic.

Table 6.9: TK: Number of favoured consonants and high frequency consonants in perseverative responses

	/h/	/n/	/t/	/s/	/d/
Naming	73/114 (64%)	11/114 (10%)	25/114 (22%)	26/114 (23%)	3/114 (3%)
Reading	8/53 (15%)	14/53 (26%)	9/53 (17%)	3/53 (6%)	2/53 (4%)
Repetition	16/77 (21%)	17/77 (22%)	8/77 (10%)	10/77 (13%)	7/77 (9%)
Total	97/244 (40%)	42/244 (17%)	42/244 (17%)	39/244 (16%)	12/244 (5%)

This supports the proposal that certain phonemes may be overused because of changes in their resting levels of activation following the onset of aphasia, making them readily available as "gap-fills" (e.g. Moses et al. 2004b). The use of default phonemes as the basis of a large number of the participants' perseverative responses may explain why these responses can occur even with large intervals between them.

6.2.5.6: Origin of total perseverations

As discussed above, some authors (e.g. Hirsh 1998; Moses et al. 2004b) have argued against the theory that that total perseverations arise from residual activation at the lexical level, on the grounds that some individuals with jargon aphasia produce non-word total perseverations, which clearly cannot be lexical retrievals. Total perseverations are therefore proposed to arise at the phoneme level, either because of the carry-over of phonemic activation from one response to the next, or, where there are intervals between perseverative responses, because of the chance rearrangement of perseverative elements so that the current response is identical to a previous one (Moses et al. 2004b). This is certainly an attractive explanation in the cases of RS and TK, especially given the evidence for the presence of default segments in total as well as blended perseverations.

However, while both participants produced some non-word total perseverations, it was noted that the majority were real words. This was examined more formally by comparing the numbers of word and non-word total perseverations in each noun task (taking the initial response only, as previously). This is shown below in Table 6.10.

For both RS and TK, there were more word than non-word total perseverations on each task. When the totals for each participant were considered, the difference was highly significant (for RS, $\chi^2 = 28.57$; for TK, $\chi^2 = 24.14$, both significant at $p < 0.001$, withstanding the Bonferroni adjustment). This is all the more striking given that overall, both participants produced more non-word than word errors.

Table 6.10: Number of word and non-word total perseverations

	RS		TK	
	Word TPs	Non-word TPs	Word TPs	Non-word TPs
Naming	8	2	23	12
Reading	14	2	4	-
Repetition	2	-	14	3
Total	24	4	41	15

TPs Total Perseverations

It could be argued that word and non-word total perseverations arise from different sources: word items from the lexical level and non-word items from the phoneme level, by the mechanisms described above. If this was the case, it would be predicted that the two types would differ in their default phoneme content: only non-word total perseverations would be based around default phonemes. This prediction was examined by comparing the proportions of /k/ and /l/ (in the case of RS) and /h/ (in the case of TK) in word and non-word total perseverations. The results are shown below in Table 6.11.

There was no significant difference in the proportions in the case of either participant (although it is acknowledged that the number of non-word total perseveration was perhaps too small for a true comparison).

Table 6.11: Number of favoured consonants in word and non-word total perseverations

	RS		TK
	/k/	/l/	/h/
Word total perseverations	8/24 (33%)	17/24 (71%)	25/41 (61%)
Non-word total perseverations	2/4 (50%)	4/4 (100%)	12/15 (80%)
Comparison (χ^2)	0.41 (ns)	1.56 (ns)	1.77 (ns)

6.3: Summary and discussion of perseveration

RS and TK both produced high rates of perseverative responses in all tasks, regardless of the relative level of success on each task. There were two main difficulties in explaining their patterns of perseveration. Firstly, long intervals were found between perseverative responses and their sources (section 6.2.2) when it may be expected that residual activation would be erased by a following non-perseverative response. There was no evidence that semantic relationships between perseverative responses and their current targets supported the reappearance of the responses after such gaps (section 6.2.3). Secondly, the total perseveration of non-words could not be explained by residual activation at the lexical level (section 6.2.5.6).

The first question, regarding the sustaining of perseverative responses over intervals, can be accounted for by the availability of specific phonemic material. It was found that for both participants, there were certain consonants which were over-represented across different trials and tasks (section 6.2.5.2). These were regarded as default segments, and they were especially prevalent in perseverative responses (6.2.5.3). Although both participants demonstrated phoneme frequency distributions which correlated with English, their favoured consonants were not the highest frequency in the English distribution (6.2.5.5). This supports the proposal that in jargon aphasia, there may be long-term changes in the resting levels of activation of certain phonemes, making them more readily available as default segments across intervals in a speech context, and even across different contexts (e.g. Moses et al. 2004b).

It is proposed that there were two types of perseverative response: those which were based on stereotypical phonology and those which were not. The former, more global pattern may have predominated in the naming of both participants, explaining the lengthy gaps observed between perseverations and the large proportions of the default phonemes in this task. It may have occurred when little activation reached the phoneme level from higher semantic-lexical levels. The latter, more local pattern may have been more common in reading and repetition, especially in the case of TK. This was reflected in the interval data (6.2.2), where there tended to be only small gaps between perseverative responses and their sources in reading and repetition, and in the observation that perseverative responses in these tasks contained smaller proportions of /h/ than those in naming (6.2.5.3).

This leads to a further issue as to why certain phonemes may become high frequency in the phonology of an individual following brain injury. It was also noted in Chapter 2 (section 2.1) that RS had stereotypical words "catapult" and "caterpillar", which occurred in the experimental tasks and in his spontaneous speech. The fact that both contain his apparent default phonemes /k/ and /l/ raises the possibility that either such stereotypical words are based around a back-bone of default phonemes and they become lodged in the system because of their lexical status, or that it is the stereotypical words which come first, their phonemes then becoming high frequency because of their overuse. Unfortunately, it is not within the scope of this work to address this issue further.

The second question, regarding the occurrence of non-word total perseverations, can be answered if total perseverations arise from the phoneme level rather than the lexical level, as argued by Moses et al. (2004b) (section 6.2.5.6). They may result from the phonemic carry-over of whole items if they occur immediately, or from the chance rearrangement of phonemic material available for perseveration if they occur after intervals. The fact that more total perseverations were words than non-words can be explained in a model with feedback activation from the phoneme to the lexical level. Strings of phonemes may combine and recombine to form error responses with perseverative elements. If such a string happens to resemble a real word, this is reinforced and therefore more likely to be reproduced in its entirety. This supports the proposal made in Chapter 4 that word errors are genuine lexical retrievals resulting from interaction between the lexical and phoneme level (section 4.3).

Chapter 7: The question of frequency

It was noted in the introduction to the participants that they both tended to produce unusual words in their spontaneous speech (section 2.1; 2.2). There had been a hint of an inverse frequency effect in one of RS's preliminary clinical tests (PALPA 9: Repetition; section 2.1.4.2). However, in his core data, there was a consistent trend towards an advantage for high frequency targets on all noun and verb tasks (section 3.5.1.3). TK's output was also peppered with unusual and often archaic words (section 2.2). His wife commented that he seemed to use words that sounded "as if they're from Mastermind". It was also TK who showed a trend towards an advantage for low frequency words in repetition in the initial analysis of the core data (section 3.5.2.3). Frequency effects have been mentioned in some of the previous analyses (for example, whether word errors tended to be higher frequency than their targets, in section 4.2.2). A more systematic examination of the frequency effects in the data of both participants is warranted. This is preceded by a review of the literature on lexical frequency, which is presented below.

7.1: Literature on frequency effects

Intuitively, it might be predicted that more common words in a language are more easily accessed than less common words. Indeed, there is strong and widespread evidence of an advantage for high frequency words in both unimpaired and aphasic individuals. In the case of unimpaired speech, it has been found that word production is faster for higher frequency words (e.g. Monsell, Doyle & Haggard 1989; Morrison, Ellis & Quinlan 1992; Jesheniak &

Levelt 1994) and also more accurate (e.g. Monsell et al. 1989; Jescheniak & Levelt 1994). Dell (1990) found that low frequency targets induced more phonological errors than high frequency targets, while Harley and Brown (1998) found that low frequency words were more prone to "tip of the tongue" experiences. Vitkovitch and Humphreys (1991) found that in speeded naming, more errors were made on low than high frequency targets, and errors tended to be higher frequency than their targets. Several studies of people with aphasia have found that high frequency targets are named more accurately than low frequency targets (e.g. Ellis et al. 1983; Blanken 1990, 1993; Miceli et al. 1991). Blanken (1990) and Martin et al. (1994) found that their participants' formal errors tended to be higher frequency than their targets, while Gotts et al. (2002) found that errors were more likely on low frequency targets.

If frequency effects in language processing are so pervasive, from where do they arise? Early studies of frequency effects tended to focus on printed word recognition, most commonly in a visual lexical decision task (e.g. Morton 1969; Forster & Chambers 1973; Balota & Chumbley 1984, all cited in Balota & Chumbley 1985). Frequency effects have been found in other word recognition tasks, for example in semantic or word class categorisation (Monsell et al. 1989). According to "direct activation" models, frequency is coded in the representation itself and its readiness to be activated. For example in Morton's logogen model (1969), high frequency words have lower thresholds to be reached before they "fire". More pertinent to the current research, frequency is also widely assumed to be encoded in speech *production,* either as firing thresholds (like Morton's logogen) or in Dell's interactive activation account (e.g. 1986, 1988), as resting levels of activation. High frequency words are assumed to have higher resting levels of activation and therefore need less incoming activation to be selected.

In two-stage models of lexical access, there is much debate about which stage or level gives rise to the frequency effect (Best 1996). Dell (1990) argues that frequency is coded at the lexical level because greater frequency effects are found in naming than in oral reading. (Naming requires activation from semantics via the lexical level, but reading can by-pass this level). Other authors have argued that frequency is coded at the phonological level. Nickels (1995) examined frequency in different error types and found that phonological errors showed a frequency effect, while semantic errors did not. She argues that this is consistent with a serial two-stage model in which the phonological level is frequency-sensitive, but not with an interactive activation account, which should predict frequency effects in both semantic and phonological errors. This is because even if frequency is encoded at the phoneme level, cascade and feedback between levels should give rise to a frequency effect on semantic errors as well. This would also be the case in a model with feedback only from the phoneme level to the lexical level (Harley & MacAndrew 1995).

Jescheniak and Levelt (1994) found that when they gave their non-brain injured participants an English to Dutch translation task, the low frequency homophones shared the advantage of their high frequency pairs in the speed in which they were processed. They argue that homophone pairs share a representation at the phonological level, which must also be the level which is frequency-sensitive. Harley and Brown (1998) also found that tip of the tongue states (TOTTs) were more likely to occur on low frequency words. Assuming that

TOTTs occur when the lexical representation has been successfully retrieved, this suggests frequency is coded in the subsequent stage of lexical access, i.e. the phonological level. Harley and MacAndrew (1995) note that locating frequency in the word form level causes difficulties for models where there are not single phonological representations but patterns of activation across phonemes (e.g. Dell 1990). However, it may be that in this model, frequency is encoded across a network, not at any particular level of nodes.

Other authors have suggested that the locus of the frequency effect is neither in the lexical level nor in the phoneme level but in the connections between levels (e.g. Harley & McAndrew 1995). Vitkovitch and Humphreys (1990) propose that the connections between semantic and lexical levels for high frequency words are maintained at higher levels of activation than for low frequency words. Hirsh (1998) found that perseverations were more likely to occur on low frequency items in naming, but there was no frequency effect on perseverative responses in reading. She therefore argues that frequency is coded in the route between the semantic-lexical level and the phonological level (assumed to be utilised in the naming process but not necessarily in reading) and not in the phonological level itself (assumed to be used by both naming and reading processes).

Despite a wealth of evidence for frequency effects in non-brain injured people and people with aphasia, such effects are not universal (Nickels & Howard 1995; Marshall et al. 2001; Gordon 2002). The failure to find a frequency effect in some studies of aphasic individuals may be because the processing level sensitive to frequency is unimpaired (Marshall et al. 2001). Furthermore, several authors have suggested that frequency is confounded with other variables. For example, Nickels (1995), Morrison et al. (1992), and Levelt et al. (1999) have argued that age of acquisition, not frequency, is the main influencing variable in naming. Ellis et al. (1983) argue that frequency is confounded with length, and that when length is controlled, frequency effects disappears. Many studies (including the current one) use *printed* word frequencies (e.g. from Francis & Kuçera 1982) in the study of *spoken* word production, as there is assumed to be a close correlation between print word and spoken word frequencies. Some authors have argued that familiarity may be a better measure of spoken word frequency (e.g. Funnell & Sheridan 1992; Nickels & Howard 1995).

While not all people with aphasia have an advantage for high frequency, there is a dearth of evidence for the converse pattern, i.e. an advantage for *low* frequency words. Although people with jargon aphasia are often observed to use somewhat unusual words or "high sounding" expressions (section 1.1), there is only a single reported case study of the *inverse* frequency effect, in which low frequency words appear to be more available than high frequency words. Marshall et al. (2001) report on JP, who showed a predilection for low frequency words including "fibula", "fistula" and "epiglottis". Not only did JP produce more correct responses to low frequency than high frequency targets in a variety of naming tasks, she also used low frequency error responses in place of high frequency targets. In addition, JP often produced (incorrect) subordinate terms, for example "daffodil" for flower and "collie" for dog.

Marshall and her colleagues first examined the theory that the inverse frequency effect was in fact the bi-product of an inverse *length* effect, as discussed by Best 1994. That is, JP's low frequency words may have been longer and more distinctive phonologically and/or orthographically, making them more salient in the lexicon and therefore more accessible. However, there was no evidence that longer words were easier to access. Furthermore, if the inverse frequency effect arose in the phonological level, it should be apparent in other tasks requiring access to that level. However, reading (which was assumed to be processed lexically and not sub-lexically, because JP could not read non-words) did not show an inverse frequency effect. Reading was more successful than naming, suggesting that this task was processed by the direct lexical route. In other words, only semantically mediated tasks were prone to the inverse frequency effect.

This led to the hypothesis that the locus of the inverse frequency was in semantic processing: in an interactive activation account, representations sharing many semantic features spread their activation to their semantic neighbours which then compete with them, especially when there is excessive noise in the system. Representations with few neighbours do not spread their activation and therefore do not have so much competition. Low frequency words are assumed to have fewer semantic neighbours than high frequency words and may therefore benefit from their outlier status.

As Marshall and colleagues acknowledge, the difficulty with this explanation is that in connectionist models, neighbourhoods are thought to *facilitate* activation, not inhibit it (Andrews 1989; Grainger 1990; Harley & Brown 1998). Low frequency words are found to benefit more from dense neighbourhoods, as they need support from spreading activation and reverberation (Grainger 1990; Harley & Brown 1998). High frequency items are less reliant on this support. Furthermore, Grainger argues that the more distinct the phonology/orthography of a word, the greater the frequency effect, as it has less support from neighbours. Thus low frequency words with distinctive forms should be more disadvantaged than either low frequency words with simpler forms or high frequency words. Indeed, Harley and Brown (1998) found that tip of the tongue states were more likely on low frequency words with few neighbours. They found that length was confounded with neighbourhood size, but there were independent effects of neighbourhood size and frequency when length was controlled. Gordon (2002) studied neighbourhood effects in aphasia, and found facilitative effects of neighbourhood density, as well as word frequency on lexical retrieval.

However, other studies have found inhibitory neighbourhood effects. For example, Luce and Pisoni (1998) studied spoken word recognition, which they envisaged as a process of discriminating between competing phonologically similar words. They described this as a "Neighbourhood Activation Model" (NAM). Furthermore, they found that neighbourhood frequency, as well as neighbourhood size had an inhibitory effect (i.e. words with high frequency neighbours were less easily recognised than words with low frequency neighbours). They therefore describe frequency as *relative*, not *absolute*. Pollatsek, Perea and Binder (1999) found similar effects in written word recognition tasks, arguing that an inhibitory effect of high frequency neighbours may mask a facilitatory effect of low frequency neighbours. However, Vitevitch (1997) applied NAM theory to speech *production*, and found that neighbourhood size and frequency both had facilitatory effects, so that whereas in perception, neighbours compete with the target, in production, they lend support to the target.

In summary, frequency has been found to have pervasive effects throughout the language processing system in perception and production. Overwhelmingly, the trend is towards an advantage for high frequency words, yet attempts to localise it have resulted in fierce debate. Neighbourhood effects in perception and production are also an issue which may interact with frequency effects. An explanation for the extremely rare phenomenon of an *inverse* frequency effect remains even more elusive.

7.2: RS, TK and frequency effects

The initial investigation is of the frequency effects in the numbers of correct responses of RS and TK. All noun and verb trials were added together for each task. The numbers of correct responses for low and high frequency words were compared using a chi-square test. The results are shown in Table 7.1 below.

Table 7.1: Number of correct responses to high and low frequency targets

	Naming			Reading			Repetition		
	HiF	LoF	χ^2	HiF	LoF	χ^2	HiF	LoF	χ^2
RS	28	12	7.31 (**BA)	30	15	5.82 (*BA)	112	97	3.10 (ns)
TK	23	14	2.48 (ns)	81	84	0.11 (ns)	68	91	6.61 (*)

Key: HiF high frequency targets LoF low frequency targets

For RS, the number of correct high frequency responses outnumbered that of low frequency responses in all tasks. The difference was significant for naming and reading (in both cases withstanding the Bonferroni adjustment to $p < 0.017$ for the 3 comparisons made with RS's data in this chapter). This tendency towards a normal frequency effect, in which high frequency words have an advantage over low frequency words, was similar to that seen in the control aphasic participants (section 3.4.2).

TK showed an advantage for high frequency targets in naming, but an advantage for low frequency targets in repetition. The latter was significant, but it did not withstand a Bonferroni adjustment to $p < 0.002$ for the 25 comparisons carried out on TK's data in this chapter. A glance at the distribution of TK's responses in the four trials of each task suggested that it was the two earlier trials which showed the most striking patterns. A further analysis of the data examined the two pairs of trials separately. The findings are shown below in Table 7.2.

Table 7.2: TK: Number of correct responses to high and low frequency targets on earlier and later trials

	Naming			Reading			Repetition		
	HiF	LoF	χ^2	HiF	LoF	χ^2	HiF	LoF	χ^2
Early Trials	5	6	0.10 (ns)	34	37	0.23 (ns)	24	45	11.24 (**BA)
Late Trials	18	8	4.59 (*)	47	47	0.00 (ns)	44	46	0.10 (ns)

In the earlier trials, there was a significant advantage for low frequency targets in repetition. In this task, there was a shortfall in the number of high frequency responses which were correct compared with reading. In the later trials, there was a significant frequency effect in the *normal* direction (i.e. an advantage for high frequency words) in naming, and minimal frequency trends in reading and repetition. It is striking that the fading of the inverse frequency effect in repetition occurred alongside a general improvement, which was mostly due to an increase in the number of *high* frequency items being successfully retrieved.

It is acknowledged that so far, there is only weak evidence of an inverse frequency effect, in the number of correct responses on a single task, repetition. However, it would be difficult to argue that this represents a type 1 error, because the effect was consistent in each of the first two trials, in both nouns and verbs. The finding that both RS and the control participants showed a trend towards a normal frequency effect indicates that there was not an inherent bias in the stimuli. Was there more evidence of an inverse frequency effect to be found in TK's data? If low frequency targets in repetition were more likely to be successfully retrieved than high frequency targets because more activation was available, they should also have had an advantage in the degree to which errors were target related. The following analysis examines this prediction.

7.3: Further examination of frequency effects in the data on TK

7.3.1: Frequency effects and target relatedness in repetition

As with the original analysis of target relatedness (section 5.2.1), the proportions of phonemes which responses shared with their targets in repetition were found, this time considering responses to high and low frequency targets separately. Instead of comparing an error corpus against a pseudo error corpus, the proportions of shared phonemes in the high and low frequency error corpora were directly compared against each other. All noun and verb trials were combined, but word and non-word responses were separated, as they were in the original analysis of target relatedness. As previously, only initial responses were inspected, with exclusions as before (section 5.2.1). The proportion of target phonemes in the two frequency groups were compared using the chi square test of significance. The results are presented below in Table 7.3.

Table 7.3: TK: Number of phonemes shared by high and low frequency targets and their errors in repetition

	High frequency targets	Low frequency targets	χ^2
Word errors	38/190 (20%)	46/127 (36%)	10.28 (**BA)
Non-word errors	28/77 (36%)	46/93 (49%)	2.94 (ns)

Both word and non-word responses to low frequency targets were more target related than responses to high frequency targets. This was significant for the word responses, withstanding the Bonferroni adjustment. As the inverse frequency effect in the number of correct responses was stronger in the earlier two trials, a further examination of target relatedness considered the early and later trials separately, as shown below in Table 7.4.

Table 7.4: TK: Number of phonemes shared by high and low frequency targets and their errors in early and late trials of repetition

	Words			Non-words		
	HiF	LoF	X^2	HiF	LoF	χ^2
Early	21/115	27/69	(LoF) 9.74 (**BA)	10/40	23/45	(LoF) 6.08 (*)
Late	17/75	19/58	(LoF)1.69 (ns)	18/37	23/48	(HiF) 0.00 (ns)

HiF: High frequency targets Lof: Low frequency targets

To summarise so far, in the case of TK, two pieces of evidence of an inverse frequency effect in repetition have been found. At the early stage, he showed an advantage for low frequency targets both in terms of the number of correct responses successfully retrieved and in the degree of target relatedness of error responses. These effects had faded by the second trials, alongside a general improvement. The following sections explore possible explanations for these findings in more detail.

7.3.2: Frequency and neighbourhood effects

The hypotheses put forward by Marshall and colleagues (2001) for an inverse frequency effect are first considered, to determine whether one of them could account for TK's data. The first possibility is the phonological hypothesis, in which low frequency words are more salient and less affected by random noise between phonological neighbours. There are a number of difficulties with this in the case of TK. Firstly, it requires low frequency words to belong to low density phonological neighbourhoods, because of greater length and greater phonological complexity. Therefore, an inverse *length* effect in repetition is predicted (i.e. an advantage for longer targets). However, in the experimental tasks, high and low frequency words were matched for length. Furthermore, PALPA Subtest 7 (Syllable Length Repetition) showed no indication that repetition improved with length: 8/8 one-syllable words, 5/8 two-syllable words and 6/8 three-syllable words were correct. Secondly, this explanation offers no clue as to why the inverse frequency effect should appear more strikingly in repetition and not in the other tasks, as they all share the same phonological output processing components.

Marshall and colleagues' second proposed explanation for an inverse frequency effect is the "semantic hypothesis", in which low frequency words have fewer *semantic* neighbours and are therefore less likely to pass on spreading activation to their neighbours. Therefore they have less competition, an important factor in a system afflicted by an increase in random noise. This explanation cannot easily accommodate the data on TK because it would predict an inverse frequency effect in picture naming at least as large as that observed in repetition, because this is the task in which semantic processing is most relied upon. Nevertheless, some of the tasks carried out by Marshall and her colleagues on their participant JP were carried out with TK. They are not reported here because the findings were unremarkable and did not support a semantic hypothesis.

7.3.3: Frequency effects and sub-lexical activation

A further possibility is that the inverse frequency effect in repetition arose because low frequency words were more able to circumvent lexical damage by taking advantage of sub-lexical processing. This hypothesis is investigated below.

In order to investigate the integrity of TK's sub-lexical processing for repetition, his repetition of non-words was assessed twice (using PALPA subtest 8), once at the time of the early trials and again six months after the second pair of trials, thus providing an "early" and "late" score. Table 7.5 below shows these scores together with TK's early and late repetition of high and low frequency words (i.e. scores from the first two and the second two trials).

Table 7.5: TK: Number of correct responses in early and late trials of repetition

	Early Trials	Late Trials
High frequency targets	24/80 (30%)	44/80 (55%)
Low Frequency targets	45/80 (56%)	46/80 (57%)
Non-words	21/30 (70%)	20/30 (66%)

TK achieved a high level of success in non-word repetition, confirming that sub-lexical processing was available. It is especially striking that non-word repetition was *better* than word repetition. The greatest contrast was between non-words and high frequency words in the early trials, with the former having a significant advantage ($\chi^2 = 14.44$, $p < 0.001$). This was significant enough to withstand the Bonferroni adjustment. The difference between non-words and low frequency words was not significant ($\chi^2 = 1.72$).

These data suggest that TK's repetition was accomplished most successfully by sub-lexical processing. It is hypothesised that low frequency words were similar to non-words in that they were processed by sub-lexical activation. Further support for the similarity between low frequency words and non-words comes from the observation that the success rate of repetition in these two item types did not change in time, suggesting that they were somehow similar. In contrast, the repetition of high frequency words improved significantly enough to withstand the Bonferroni adjustment ($\chi^2 = 10.23$, $p < 0.01$). TK's success rate on the repetition of high frequency words therefore equalised that of low frequency words, reducing the inverse frequency effect.

If low frequency words tended to be repeated sub-lexically while high frequency words were repeated lexically, this suggests that the two types of word were processed differently at the auditory input level. Specifically, low frequency words must have been rejected as real words at the input level and processed sub-lexically as non-words instead. Errors on high frequency words may be explained as lexical selection errors at input level: if activation to this level was weak, the target lexical representation may not have been activated. If the target belonged to a dense neighbourhood, a *non-target* lexical representation from this neighbourhood could be activated. However, if the target belonged to a sparser neighbourhood, a lexical representation may not have been activated at all, so the item would be rejected as a real word and processed sub-lexically. This assumes that the high frequency words belonged to high density phonological neighbourhoods while low frequency words belonged to low density neighbourhoods.

Further support for this hypothesis comes from the observation that in repetition, there was a higher word to non-word error ratio than on the other tasks (section 3.5.2.1). This can be explained if errors on high frequency words resulted from the selection of a non-target lexical representation at the auditory input level. It is therefore predicted that errors on high frequency targets would be more likely to be words than errors on low frequency targets. This prediction was borne out: when all repetition trials of nouns and verbs were combined (counting initial responses only), 66/90 errors on high frequency targets were words, compared with only 40/70 errors on low frequency targets. This difference was significant ($\chi^2 = 4.62$, $p < 0.05$) although it did not withstand the Bonferroni adjustment.

This hypothesis would predict a *normal* frequency effect in tasks tapping into auditory input processes, with high frequency targets being more likely to be recognised correctly as words than low frequency words. Unfortunately, there was no such effect on PALPA 5 (Auditory Lexical Decision), which was carried out at the time of the early trials (i.e. when the inverse frequency effect was most apparent). Equal numbers of high and low frequency words (37/40) were correct. However, it should be noted that control of stimuli in this PALPA subtest has been questioned. Woolf (2004) found a complex interaction between neighbourhood, imageability and frequency: high frequency stimuli showed a relationship between imageability and neighbourhood (with high imageability words having larger neighbourhoods than low imageability words), while for low frequency words, there was no significant relationship between imageability and neighbourhood. Therefore if the high frequency group in the PALPA stimuli includes low imageability items (which have sparse neighbourhoods), then the neighbourhood advantage for high frequency items will be lost.

A further auditory lexical decision task was devised, using the noun targets from the experimental tasks. A set of non-words was produced by changing a single phoneme in each word from the target set (e.g. hair /hɛə/ → /gɛə/). Each word and non-word was presented twice, in random order. TK made just 5 errors on 160 items, 2 being rejections of low frequency words and 3 being acceptances of non-words derived from low-frequency targets. A normal frequency effect, with a disadvantage for low frequency words, cannot be claimed on such a small number of errors. In addition, this task was carried out after the second set of trials, when the inverse frequency effect had already diminished.

Both auditory lexical decision tasks demonstrated that *most* words, whether high or low frequency, were correctly recognised as lexical items (93% on PALPA 5, and 97% on the second auditory lexical decision task. They do not support the hypothesis that low frequency words were rejected as lexical items and were therefore treated as non-words. However, a different explanation for these puzzling data has not been forthcoming.

7.4: Summary and discussion of frequency effects

TK showed a significant inverse frequency effect on both nouns and verbs on the two earlier repetition trials, measured both by the number of correct items (section 7.2) and by target relatedness (section 7.3.1). The observation that the production of RS and the control participants showed a tendency towards normal frequency effects (section 7.2) suggests that TK's patterns were unlikely to be due to a bias in the materials. There appeared to be a specific difficulty for high frequency targets in repetition relative to reading, which low frequency words somehow escaped. The disappearance of the inverse frequency effect and the overall improvement in terms of number of correct items on the later trials of repetition can both be explained by an increase in the number of correct high frequency items.

Various explanations were considered. There was little support for the hypothesis that low frequency words had an advantage at the phonological output level because of their salience, because there was no inverse length effect (section 7.3.2). In addition it was unclear why this should affect repetition but not the other tasks, which all share the same output processes. The hypothesis that low frequency words benefited from the effect of salience in semantic processing was also rejected, because an inverse frequency effect should be more striking in picture naming, a task more reliant on semantic activation (ibid.).

The alternative explanation was that the inverse frequency effect in repetition occurred because low frequency words relied on sub-lexical activation, which proved to be more successful than lexical processing (section 7.3.3.). This was supported by the finding that non-word repetition actually had a higher success rate than word repetition. More specifically, the repetition of high frequency words was significantly *worse* than that of non-words. The hypothesis that low frequency words behaved like non-words was supported by the finding that while TK's performance on high frequency words improved, his performance on non-words and low frequency words remained static, suggesting that they were processed by the same mechanism, and that this mechanism was different from that utilised by high frequency words.

It was therefore suggested that some distinction was made between high frequency and low frequency words at the level of auditory lexical input. A weak input into auditory processing reduced the chances of the target lexical node being selected. High frequency targets from dense phonological neighbourhoods were prone to lexical selection errors. This was supported by the high word to non-word ratio of errors made to high frequency targets in repetition (relative to other tasks and to errors made to low frequency targets). However, low frequency targets from less dense phonological neighbourhood were less likely to activate and select a lexical node at all. The target was therefore rejected as a real word and processed sub-lexically, as if it were a non-word. The finding that low frequency words were actually slightly disadvantaged compared with non-words may have been because not all low frequency words were processed sub-lexically. If an error lexical node was activated, then this would be processed lexically, in the same way as a high frequency word.

Put in more functional terms, the hypothesis suggests that TK was better at repetition when he used basic phonological processes. His ability to repeat non-words more successfully than words suggests that simple phonological tasks could be accomplished more easily than anything requiring lexical-semantic processing. This theory seems to accord with other more anecdotal features of TK's production, for example his imitation of environmental noises and music on the radio, as well as the intact prosody and social and expletive phrases commonly seen in other individuals with jargon aphasia.

The pattern of non-word repetition which is superior to word repetition is extremely rare. Bryan and Howard (1992) descrithe case of DF, a child whose lexical phonology was said to be "frozen". It was argued that while phonological processing rules were successfully applied to non-words, words were constrained to being processed via a lexical system in which phonological representations were not being updated in the light of developing phonological awareness. These authors argue that the problem was in output phonology.

The current study proposes that TK's problem was in auditory input. However, there remains a striking parallel in the two cases, in that "surface" phonological processing appears to be superior to deeper lexical processing, and items processed sub-lexically fare better than items processed via a damaged or underdeveloped lexical system.

It is hypothesised that TK's reading was initially superior to his repetition because of a stronger signal at the input level, increasing the chances of the target node being activated at this level. His superior performance on reading compared to naming indicates the availability of non-semantic processing routes. His sub-lexical reading skills were found to be inconsistent: when PALPA 36 (Non-Word Reading) was carried out initially he scored only 2/24 (section 2.2.4.3). When it was repeated after the first pair of trials, he scored 16/24, a markedly superior performance. It is therefore proposed that for reading, TK benefited from semantic and direct lexical activation and (possibly only by the later trials) sub-lexical activation, with little difference between high and low frequency words. Recovery in *repetition* may have entailed an increase in the strength of activation at the auditory input level, so high frequency targets were more likely to be selected and processed by multiple routes, as in reading. This improvement led to high frequency targets in repetition equalising reading in accuracy rates (Table 7.2), and also to the levelling out of the frequency effect.

The major problem for the hypothesis outlined above is that the normal frequency effects it predicts in auditory lexical decision tasks were not seen (although this may have been because the stimuli were not controlled for neighbourhood, the crucial factor in this hypothesis). It is also acknowledged that by the time tasks were devised to test out this hypothesis, the inverse frequency effect appeared to have diminished, and it was therefore not possible to capture its cause. For example, it would have been useful to carry out an auditory lexical decision task using stimuli designed to test for neighbourhood effects at the time when the inverse frequency effect was still present. Furthermore, the superiority of non-word repetition might have been more rigorously demonstrated by a task using non-words matched with the experimental word stimuli (perhaps using the non-words derived from the stimuli described in the second auditory lexical decision task). As it is, the theory remains purely speculative and under-supported.

A further puzzle in TK's performance on repetition is that he showed an advantage for verbs over nouns, in contrast to his performance in naming and reading, in which the advantage was for nouns over verbs. This raises the question as to whether this could be bound up with the inverse frequency effect in repetition. TK's advantage for verbs in repetition is part of a much larger question for both participants: why did different tasks show different word class effects? This will be explored in the following chapter.

Chapter 8: Word class effects

So far, many of the analyses have combined noun and verb responses, in order to examine the features of errors which were found to be common to both word classes. However, in the section on the core data collection, it was seen that both individuals showed word class effects, or a tendency for performance to vary on a task according to whether nouns or verbs were being presented. To summarise, TK produced significantly more correct responses in the verb set compared to the noun set (section 3.5.2.2). RS, on the other hand, produced significantly more correct responses in verbs relative to nouns in the naming task, but significantly more correct responses in the nouns relative to verbs in reading and repetition (section 3.5.1.2).

This section will investigate these effects in more detail, exploring the patterns of each individual separately. Firstly, as with previous chapters, a review of the substantial literature on word class effects and the theories behind them is presented.

8.1: Literature on word class effects

Word class effects have been observed in many studies of people with aphasia and non-brain injured speakers. Verbs tend to be more vulnerable than nouns, perhaps because of their later age of acquisition and/or because of their greater semantic and phonological complexity (Marshall 2003). However, there are many individuals for whom verbs are more accessible than nouns (ibid.). A classical division made in studies of aphasia is between people with fluent aphasia, predicted to have difficulties processing nouns with a relative preservation of verbs, and people with non-fluent aphasia, predicted to have more difficulties processing verbs than nouns (e.g. Jonkers & Bastiaanse 1998; Hillis, Tuffiash & Caramazza 2002; Silveri, Perri & Cappa 2003). However, individuals with fluent aphasia do not necessarily have an advantage for verbs (Berndt, Mitchum, Haendiges & Sandson 1997a; Berndt, Burton, Haendiges & Mitchum 2002a).

This review will discuss hypotheses that place word class differences at the semantic (conceptual) level or the post-semantic levels of processing. This latter group includes theories in which either syntactic processing or morphological complexity are the source of word class dissociations.

8.1.1 Semantic hypothesis of word class differences

There are cases reported in the literature in which word class differences show clear semantic influences. For example, McCarthy and Warrington (1985) reported on ROX, who had an impairment for verbs in both comprehension and production, while Marshall, Pring, Chiat and Robson (1996a) and Marshall, Chiat, Robson and Pring (1996b) report on RG, who had a clear *advantage* for verbs in both modalities. His errors were predominantly semantic. Furthermore, he showed an advantage for abstract nouns (a reverse concreteness effect).

At their simplest, semantic accounts of word class differences propose that the representations of objects and actions are encoded in different parts of semantic memory, and differential damage to one of these regions may result in a specific deficit for that class (Bates, Chen, Tzeng & Opie 1991). Another theory suggests that the more commonly observed advantage for nouns over verbs can be explained by an imageability effect: imageability is assumed to be a measure of semantic richness, and as verbs are less imageable than nouns, they are predicted to have less available semantic information and therefore to be less easily accessed (Bird, Howard & Franklin 2000).

It is proposed that the converse pattern, an advantage for verbs over nouns (e.g. RG in Marshall et al.1996a & b), occurs because noun and verb representations are dependent on different types of knowledge in semantic memory, and word class differences reflect the differential damage or sparing of these types of knowledge (ibid.). This theory arises from research into category specific deficits (as reviewed by Capitani, Laiacona, Mahon & Caramazza 2003). A classic study of category specific deficits was that of JBR (Warrington & Shallice 1984), who showed a selective deficit for living things. It was argued that this was caused by damage to the areas of the cortex responsible for sensory/perceptual/visual information, upon which representations for living things rely for their retrieval. Damage to areas of the cortex responsible for motor/functional information might lead to a difficulty processing non-living items such as man-made artefacts which are more dependent on this type of knowledge. Similarly Gainotti and Silveri (1996) found that their participant, LA, had a specific deficit for animals, food and musical instruments (all argued to be more reliant on sensory information than functional information), and had more difficulties with tasks involving the presentation of perceptual information relative to functional information.

This has been termed the "sensory/functional theory" (SFT) (e.g. Caramazza & Shelton 1998). It has been linked to word class effects in what has been dubbed the "extended sensory/functional theory" or ESFT (Bird, Howard & Franklin 2001). Associations have been found between the sparing of abstract terms and the sparing of verbs relative to nouns. This is hypothesised to be because of the relative sparing of domains of functional/relational information (important for the processing of verbs) alongside damage to the domains of sensory/perceptual attributes (important for the processing of nouns) (Bird et al. 2000). To summarise Bird and colleagues's standpoint, a *verb* deficit could result from an imageability effect or a selective deficit for functional information, whereas a *noun* deficit could be explained by a selective deficit for sensory/perceptual information (Marshall 2003).

Semantic theories have been described as "reductionist" (e.g. Druks 2002) because they reduce the noun/verb dissociation to an artefact of a semantic variable or dimension (such as imageability or the relative impairment or sparing of visual/sensory or functional information), instead of regarding it as a genuine lexical distinction. They have been criticised because they depend on the sensory/functional theory of category specific deficits, which is disputed (e.g. Caramazza & Shelton 1998; Shapiro & Caramazza 2001a & b). For example, Capitani and colleagues (2003) discovered that in most of the cases they reviewed, the associations between a deficit for living things and a deficit for visual/perceptual information predicted by SFT were not found. Furthermore, it has been argued that in some cases, the differences between categories can be attributed to the poor control of variables such as familiarity (Funnell & Sheridan 1992; Funnell & De Mornay Davies 1996; Capitani et al. 2003). However, although Gainotti and Silveri (1996), and Lambon Ralph, Howard, Nightingale and Ellis (1998) did find some effect of familiarity in their cases, this was not enough to explain category-specific deficits fully.

Semantic hypotheses are also challenged by cases of word class effects in production but not in comprehension (e.g. Miceli, Silveri, Nocentini & Caramazza 1988; Berndt et al. 1997a; Kim & Thompson 2000), although this could still be explained by the different processing demands of input and output tasks (Marshall 2003). Furthermore, word class effects have been found even when semantic variables such as imageability were controlled (e.g. Berndt et al. 2002a; Berndt et al. 2002a; Berndt, Haendiges, Burton & Mitchum 2002b). The latter authors also found an absence of verb deficits even in individuals sensitive to imageability. Such evidence necessitates a search for theories which look beyond semantics for the locus of word class effects.

8.1.2: Post-semantic hypotheses of word class differences: Syntactic accounts

Most two-stage models, serial and interactive, assume that syntactic information, including word class, is specified at an early stage of lexical access, the lexical or lemma level (Breedin, Saffran & Schwartz 1998). The lemma is assumed to be the unit of processing which refers to the syntactic properties of the given word for the purposes of grammatical encoding and sentence planning (Kempen & Huijbers 1983, in Nickels 1997). In the model devised by Levelt and colleagues (1999), the lemma does not actually contain syntactic information, but "points" to it (Nickels 2001). In Dell's interactive activation account, the syntactic level in the word-shape network is connected to word nodes in the lexical network. Lexical selection involves the addressing of the lexicon to fill a slot in a syntactic frame in the word-shape network. Units in the word node level are assumed to be "marked" for grammatical class (Dell 1986). The most highly activated node of the proper syntactic category is selected and inserted into the slot in the syntactic frame (Dell et al. 1997).

In many models with a lexical or lemma level, representations at this level are shared by input and output modalities. As with semantic hypotheses, this suggests that an impairment at this level should show word class dissociations in comprehension as well as production tasks. However, if the representations themselves are intact, input and output processes may be affected differently, with output processes being the most demanding and therefore the most vulnerable (Berndt et al. 1997a; Kim & Thompson 2000).

More difficult to explain with a lexical level account are cases where there are dissociations between output modalities. Caramazza and Hillis (1991) report on SJD and HW, who each had difficulties with a specific word class in a single output modality. For example, SJD could not write verbs she could produce orally, while oral and written production of nouns were unaffected. As semantic processing for both individuals was found to be intact, word class was argued to be coded at a level independent of semantic information. Shapiro, Shelton and Caramazza (2000) report on JR, who showed an advantage for verbs in production tasks but an advantage for nouns in comprehension tasks. Modality specific deficits have also been reported by Marshall, Pring and Chiat (1998), whose participant EM had an advantage for nouns in spoken naming, but not in written naming, reading aloud or comprehension.

Caramazza and his colleagues used modality-specific word class deficits to argue for a lemma-less model of spoken word production, the Independent Network (IN) model (e.g. Caramazza 1997). In this model, the lexical semantic network activates in parallel the syntactic network (which is organised into sub-systems, e.g. word class, gender, number) and all word form representations (or lexemes) sharing semantic features in the phonological and orthographic word-form networks (or the P-lexeme and the O-lexeme networks). Syntactic information is only *primed* by direct activation from the semantic network, needing activation from the selected word-form in the relevant lexeme network to activate it fully (ibid.). The IN model has been used to explain the modality-specific word class deficits in the cases of SJD (Caramazza & Hillis 1991), EBA (Hillis & Caramazza 1995) and JR (Shapiro et al. 2000) discussed above, and others such as Dante (Badecker, Miozzo & Zanuttini 1995) and PW (Rapp & Caramazza 1997, in Caramazza 1997).

Both lemma and IN models propose a syntactic locus of word class effects, whether syntax is accessed before or after the word form. In both models, a lexical representation is accessed along with the grammatical information which allows it to be used correctly (Druks & Carroll 2005). The flow is bidirectional, so that the lexical representation activates grammatical features and vice versa (ibid.). Syntactic processing can be viewed as the dovetail joint between lexical retrieval and sentence production (see Dell's 1986 account, outlined above). A close relationship between a syntactic level word class deficit and sentence processing difficulties is therefore predicted (Berndt, Haendiges, Mitchum & Sandson 1997b; Marshall et al. 1998; Kim & Thompson 2000; Marshall 2003). Conversely, is there a link between relatively spared verb retrieval and the evidence of some intact syntactic structure in fluent aphasia?

To address this question, Zingeser and Berndt (1988) report on HY, whose action naming was far superior to his object naming. As there was little or no verb advantage in reading or repetition, the word class dissociation was assumed to be in the connections between semantics and the word form level, with verb representations getting additional activation from syntactic processing. As further support for this "syntactic boost", the retrieval of nouns was found to be facilitated by the provision of a sentence context (e.g. "He mailed the letter without a ..."). It was found that both a syntactic frame and a high degree of semantic biasing (in the example above, the words "mailed" and "letter") were necessary. A less semantically biased sentence (e.g. "The police had never seen a man so ...") did not facilitate noun retrieval. The authors argue that the facilitation of noun production in the sentence context is at least partly due to HY's superior verb skills. Breen and Warrington (1994) found a similar effect with their participant, NOR, who also had an advantage for verbs. It was found that a meaningful sentence context was necessary for the facilitation (as opposed to the provision of a verb alone, a definition or a semantically meaningless syntactic frame), but the semantic bias did not need to be as strong as Zingeser and Berndt (1988) suggested. For example, NOR could complete open-ended sentences such as "she found an old …" but not syntactically correct and semantically meaningless sentences such as "The world was on top of the …".

To recap, syntactic hypotheses of word class differences propose a close relationship between verb retrieval and syntactic processing, whether syntax is accessed from the lexical or lemma level or from the word-form representation. An advantage for verbs may be closely connected to the syntactic skills observed in cases of fluent aphasia (although this cannot always be the case, because some people with fluent aphasia do not have an advantage for verbs).

8.1.3: Post-semantic hypothesis: morphological complexity

The normal tendency towards an advantage for nouns over verbs may be due in part to the relative morphological complexity of verbs (Bates et al. 1991). The issue of how morphologically complex forms are produced is particularly germane to this study because the verb forms in the tests had inflectional affixes. It therefore merits discussion. In models with a lexical or lemma level, whether serial or interactive, morphology is encoded in a level between this level and the phonological level (e.g. Dell 1986; Levelt et al. 1999). In Caramazza's Independent Network Model, it is encoded at the word form lexicon. The main question posed by the literature is whether morphologically complex words are stored as whole units (e.g. Bybee 1988, in Allen and Badecker 2001) or as decomposed forms (i.e. as stem + affix), for example in the Addressed Augmented Model or AAM (e.g. Caramazza, Laudanna & Romani 1988).

In AAM, all morphologically complex forms are decomposed into stems and affixes at the morpho-syntactic level. At the word form level, very high frequency morphologically complex forms can be accessed as whole words, while other words have to be assembled from their parts (Caramazza et al. 1988; Alegre & Gordon 1999). In practice, this means that irregularly inflected forms, which tend to be very high frequency, are retrieved as whole items (e.g. eat → ate; see → saw) while regularly inflected items are accessed in their decomposed form (e.g. hunt → hunt + ed → hunted; prune → prune + ed → pruned).

Support for AAM comes from reports of jargon aphasia in which unrelated non-words have well-formed inflections which may or may not be used appropriately (e.g. Panzeri, Semenza, Ferreri & Butterworth 1990; Allen & Badecker 2001). This has been taken as evidence that the language system distinguishes stems and affixes, and can retrieve an affix even when the stem is unavailable. In addition, individuals producing morphological errors have been reported who show dissociations between regularly and irregularly inflected words. For example SJD (Badecker & Caramazza 1991) made fewer errors on irregularly inflected forms. The deficit was assumed to be at the word-form level, where regular and irregular forms are processed differently. Both lemma models (e.g. Dell 1986; Levelt et al. 1999) and IN models (e.g. Caramazza 1997) can accommodate AAM and regular/irregular morphological form dissociations: each type has a morpho-syntactic level and a word form level, with the latter being the source of the dissociation between regularly and irregularly inflected words (Druks & Carroll 2005).

Having examined the literature, the word class patterns demonstrated by the two individuals will now be explored.

8.2: TK and word class effects

It was found in the initial analysis of the core data that TK's naming of nouns was better than verbs, although this was not significant (section 3.5.2.2). As noted in the literature review, an advantage for naming objects over naming actions is the prevailing pattern in people with aphasia and in non-brain injured people (e.g. Marshall 2003). There was little difference between TK's performance on nouns and verbs in reading, but in repetition, his performance on verbs was significantly *better* than on nouns ($\chi^2 = 12.01$, $p < 0.001$). This withstands a Bonferroni adjustment to $p = 0.006$ for the 9 comparisons carried out on TK's data in this section reducing p to 0.003. The difference between nouns and verbs in repetition was significant on the earlier two trials ($\chi^2 = 9.20$, $p < 0.01$, withstands the Bonferroni adjustment) but narrowly missed significance on the later trials ($\chi^2 = 3.66$).

8.2.1: Sub-lexical hypothesis for repeating verbs

It was argued in the previous chapter on TK's inverse frequency effects that the *less* he relied on lexical processing routes, the better he did. The inverse frequency effect disappeared as his retrieval of high frequency items improved. There is a striking parallel between the fading of the inverse frequency effect and the reduction of the difference between the word classes in repetition in the trials over time. In the case of word class differences, TK's repetition of nouns improved significantly between the early and late trials ($\chi^2 = 5.10$, $p < 0.05$) whereas his repetition of verbs did not ($\chi^2 = 1.27$). Just as the reduction in the inverse frequency effect was due to an improvement in the performance on high frequency targets, the reduction in the word class effect was due to an improvement in his performance on nouns.

It is therefore suggested that while TK's performance on repeating *nouns* benefited from an increasing flow of activation through the lexical-semantic route, this benefit was not experienced in repeating *verbs.* Like low frequency targets, verbs in repetition may initially have had an advantage because of a reduced dependency on lexical processing. This predicts that during the early stage of the data collection, if verbs in the repetition task were somehow induced to be retrieved via the lexical-semantic route, TK's performance would be reduced. As with the inverse frequency effect, it is acknowledged that the word class effect was largely lost by the time further investigations were begun. However, even at the time of the second set of trials, there was still an advantage for verbs which only narrowly missed significance. Tasks were therefore devised to encourage semantic processing in repetition.

Task 1: Repetition following a lead-in sentence

Each verb (in the –ing form) was put into a subject-verb-object sentence and read out to TK (who was not shown the sentence to read). The verb was repeated by the presenter at the end of the sentence. TK was asked to repeat just the verb. For example, the presenter would say "The boy is kicking the ball. Kicking" and TK was then required to say "Kicking". He scored 23/40, a similar performance to that on the original 4 verb repetition trials (on which he scored 23, 21, 29 and 22 respectively). This clearly does not support the prediction of a diminished performance when he was encouraged to repeat using the semantic route. It may be that he simply did not process the sentence at all as it was too burdensome, but focused only on the verb presented at the end of the sentence as if it was a standard single word repetition task. A further task designed to harness semantic processing was devised, using pictures instead of sentences.

Task 2: Repetition with pictures

TK was asked to repeat verbs, each being presented orally alongside the same action picture that was used in the naming task. It was predicted that the use of a picture would encourage the use of semantic activation for repetition, and that this would reduce his performance. He scored 13/40, significantly worse than his performance on the original verb trials when they were combined ($\chi^2 = 9.31$, $p < 0.01$, withstands the Bonferroni adjustment). It may be objected that this was as much a picture naming task as a repetition task. However, this can be challenged by TK's level of success, which clearly outstripped his performance on naming verbs (in which he scored 2, 1, 4 and 7 on the four trials). This suggests that he was using his repetition skills in this task, but the provision of pictures hindered his performance.

This is contrary to a general expectation that pictures should *facilitate* word retrieval by providing additional activation, especially as TK was found to have good picture recognition skills, as seen in his performance on the picture version of Pyramids and Palm Trees and the PALPA word to picture matching subtests 47 and 48 (section 2.2.2). It appears that there was something rather peculiar about repetition in that he was hampered when he was encouraged to process semantically. How does this compare with a task such as object naming, which *relies* on semantic processing, and in which it is predicted that additional semantic activation should boost performance? In order to explore this, the basic object naming task was modified by providing additional semantic/syntactic information in the form of a sentence lead-in. This is described below.

Task 3: Object naming in a sentence completion task

For each of the 40 target nouns, a sentence was presented which could be completed by that noun. The sentences were "high probability", with semantic cues being provided by the verb and/or at least one semantically related noun (e.g. "He was chopping logs with the ….." (axe); "Pour the fruit juice into a …." (glass)). The object picture for the target used in the original task was provided at the end of the sentence. TK was shown each sentence with the gap at the end followed by the picture, and the sentence was also read out by the presenter. Four trials of this task were carried out. TK scored 20, 22, 17 and 21. This was a dramatic improvement on his performance on the four trials of the basic object naming task, in which he scored 5, 3, 10 and 5. When the combined trials in each group were compared using a chi-square test, the scores on the sentence completion task were significantly better than those on the original task ($\chi^2 = 46.52$, $p < 0.001$; withstands the Bonferroni adjustment). It is difficult to argue that this could be because of a general improvement, because the sentence completion task was carried out immediately after the completion of trials 3 and 4, in which he scored 10 and 5 respectively. His enhanced performance on this task provides a striking contrast with his performance on the repetition tasks described above. It may be objected that in Repetition Task 1, TK was thought not to be processing the lead-in sentence, and yet in this sentence completion task, he must have been processing the sentence in order for it to facilitate his noun retrieval. However, in the repetition task, the sentence was only presented orally, whereas in the object naming task, TK was able to hear *and* read the sentence: his superior reading skills may have enabled him to process the sentence.

8.2.2: Discussion of TK and word class effects

The main question was why TK performed significantly better on verbs than nouns in repetition. There was some (but not compelling) support for the hypothesis that in this task, he benefited from using primarily non-semantic sources of activation for this task, and that his performance on the repetition of verbs suffered when semantic/syntactic processing was encouraged (section 8.2.1). The evidence was stronger on the task involving repetition with pictures (Task 2). The finding that semantic information *disadvantaged* repetition contrasted with the opposite outcome in object naming, in which his performance was *facilitated* by the provision of additional semantic/syntactic information. The reason for this may be a specific difficulty with the semantic representation of verbs. However, this predicts a greatly impoverished performance on action naming, when in fact this was not significantly worse than object naming.

There is a striking parallel in the early trials of the repetition task between an advantage for verbs over nouns and an advantage for low frequency words over high frequency words. Intriguingly, both these features diminished in the later trials. In the previous chapter, it was argued that the inverse frequency effect arose in repetition because low frequency words were processed sub-lexically, thus avoiding TK's lexical/semantic impairment. Paradoxically, this option was less available to high frequency words because they were more likely to engage lexical processing. A similar account might be offered for the word class effect in repetition. Verbs were treated as non-words and thus benefited from TK's relatively good sub-lexical skills. Support for this came from a repetition task which encouraged lexical processing. Simply asking TK to repeat a verb in the presence of a picture substantially lowered his performance. It could be argued that the provision of a context disadvantaged TK in other ways, for example by increasing the processing load of the task. However, this is challenged by the sentence completion task (task 3). This showed that TK's naming was significantly boosted by a semantic/syntactic context. In other words, when the task was *necessarily* semantic (as in naming), context helped. When the task was *optionally* semantic (as in repetition), it hindered.

It is difficult to explain why verbs should have been processed sub-lexically more readily than nouns. As with the inverse frequency effect, because the effect did not arise in reading, the dissociation is suggested to have occurred at the auditory input level. As the mean frequency of the verbs was similar to that of nouns, the word class effect cannot be an artefact of the inverse frequency effect, with verbs being processed like non-words because they were low frequency. A possible solution is that weak activation at input level and the subsequent difficulties in activating a lexical representation were further beleaguered by the additional burden of processing morphologically complex words. A lexical representation would be less likely to be activated so the verb would be processed sub-lexically instead. Unfortunately this hypothesis was not tested at the time of the early trials when the difference between nouns and verbs was observed. For example, the verbs could have been presented without the inflection, which would be predicted to reduce the advantage for verbs because they would be processed lexically, like nouns. Alternatively, the repetition of *nouns* would be predicted to improve if they too had inflectional affixes (which would be predicted to induce sub-lexical processing). As with the inverse frequency effect, TK's repetition with respect to word class remains somewhat elusive.

8.3: RS and word class effects

The initial data collection with respect to RS revealed that in naming, there was a significant advantage for verbs relative to nouns ($\chi^2 = 10.54$, $p < 0.01$). This was reversed in reading and repetition, where his scores on verbs were significantly *worse* than on nouns (in reading, $\chi^2 = 7.47$, $p < 0.01$; in repetition, $\chi^2 = 16.90$, $p < 0.001$). The latter withstands the Bonferroni adjustment to 0.002 for the 32 comparisons made on RS's data in this section. These issues are addressed in the analyses which follow. The first section explores the possibility that word class differences resided within semantic processing. It is followed by sections exploring syntactic and morphological factors.

8.3.1: Semantic hypothesis of advantage for verbs in naming

The observation that the word class effects in naming were different from those in reading and repetition invites an explanation concerning semantics, because naming was the only task reliant on semantic processing. As discussed in the literature review, the semantic theory of word class effects postulates that such effects reflect semantic category differences between objects and actions, the variable of imageability or damage to the part of semantic memory encoding either functional or perceptual information.

The investigations below are based on the "extended sensory/functional theory" (ESFT) described in the literature review (section 8.1.1). According to ESFT, RS's advantage for verbs over nouns in naming may have arisen because he was more able to access functional semantic information (which is more important for processing verbs) than perceptual information (which is more important for nouns). He would therefore be predicted to fare better on processing items from categories of non-living things (which are richer in functional information) than on items within the category of living things (which rely more heavily on perceptual information). Tasks were carried out to test this prediction, as described below.

Task 1: Word to picture matching on living vs. non-living things

The task was based on materials from Funnell, Hughes and Woodcock (2006). There were two categories of living things (animals and fruit/vegetables), and two categories of non-living things (implements and vehicles), with 18 items in each. These items were matched for age of acquisition. Each item was targeted once in a spoken word to picture matching task, with three semantic distractors from the same category (all distractors being taken from the pool of 72 items). The order of items was random so that all four categories were mixed up. This task was carried out over two consecutive sessions, with 36 items being presented in each. The results are presented below in Table 8.1.

Table 8.1: RS: Number of correct responses by category on spoken word to picture matching

	Living Things		Non-Living Things	
	Animals	Fruit/Vegetables	Tools	Transport
Number Correct	12/18	14/18	16/18	18/18

There was a significantly higher proportion of correct responses on "non-living things" than on "living things" ($\chi^2 = 6.4$, $p < 0.05$). This advantage for non-living things relative to living things was consistent with a hypothesised sparing of functional information relative to sensory information. In turn, this sparing of functional information may be associated with an advantage for action naming relative to object naming. However, as discussed in the literature review, supposed category-specific deficits may be confounded with familiarity. From what is known of RS's background and interests, it is plausible that vehicles and tools are more familiar to him than animals and green grocery (as mentioned in the introduction, he has worked as a bus and coach driver and as a driving instructor). A second task, with a different method of testing for an advantage for functional information, was carried out in order to establish whether a category-specific effect could again be demonstrated.

Task 2: Definitions based on functional vs. perceptual features

A different set of items was used, in a replication of Lambon Ralph and colleagues' (1998) adaptation of Gainotti and Silveri's (1996) definitions task. Gainotti and Silveri (1996) prepared two sentences for each of 16 animals and 12 objects, one defining the item using functional information and the other using perceptual information. For example, for spectacles: (perceptual): "Something made up of a frame and two glass lenses"; (functional): "Something you wear to improve your eyesight". The participant was required to name the items according to the definition. As Lambon Ralph et al. (1998) acknowledge, it is not ideal that neither the numbers of items in each category nor their variables such as familiarity were matched.

Because of RS's poor naming skills, the current study follows Lambon Ralph and colleagues' (1998) adaptation: instead of naming the items, RS was required to choose between five written words, one of these being the target of the definition, the other four being distractors taken from the pool of stimuli from the same category (animals or objects). The definition and then the five written words were read out, and RS was asked to select the word matching the definition. The same set of distractors was used for each of the two definitions. This task was carried out over two sessions, each target having its visual definition in one session and its functional definition in the other (but with an equal number of visual and functional definitions across all items in each session). If RS had relatively spared functional information, an advantage for the definitions based on functional information and the category of objects should be apparent (so his best score should be on the functional definitions for objects). The findings are presented below in Table 8.2.

Table 8.2: RS: Number of correct responses by category to perceptual vs. functional definitions

	Animals		Objects	
	Perceptual	Functional	Perceptual	Functional
Number Correct	13/16	15/16	8/12	4/12

Contrary to the prediction, RS was significantly better on the category of animals than on the objects category ($\chi^2 = 9.45$, $p < 0.01$) although this does not withstand the Bonferroni adjustment. Furthermore, there was little difference in accuracy between definitions using perceptual information (21/28) and those using functional information (19/28). Overall, his *worst* score was on the functional definitions for objects, contrary to the prediction made above. These findings therefore contradict those from Task 1, which suggested an advantage for non-living items. There is therefore little support for the theory that an advantage for verbs might be associated with an advantage for functional features in an "extended sensory/functional theory" (ESFT) of word class dissociations.

The integrity of RS's semantic knowledge could have been probed further by using drawing, but he was unable or unwilling to carry out drawing tasks. His impoverished naming skills also prohibited more extensive testing of an animacy/inanimacy dissociation. There was no word class effect in comprehension tasks (he scored 31/40 on VAST Verb Comprehension Sub-test, compared with 29/40 on the second administration of PALPA Spoken Word to Picture Matching) or anecdotal evidence of an advantage for abstract words (although this was not tested formally, for example in a synonym judgement task). Overall, the dearth of evidence for a semantic basis of the advantage for verbs in naming requires investigations into different sources of this effect.

8.3.2: Syntactic activation hypothesis of advantage for verbs in naming

In the current study, RS was required to name action pictures. It was observed that in this task, despite the instruction to produce a single word response, he often produced a sentence or phrase. Over the four trials, he produced 28 responses judged to be circumlocutions (e.g. building: "putting up a square"; smiling: "waiting for a smoke"). This error type did not occur in object naming. Furthermore, there were three examples of the correct verb being produced, followed by an appropriate object or preposition ("carrying the book"; "combing his hair"; "ran round"). This invites a similar explanation for RS to that used in the case of HY (Zingeser & Berndt 1988). It was proposed that HY's superior performance on verbs was due to additional activation from syntactic processing, which may be by-passed (or at least not relied upon) by reading and repetition. Of course, *object* naming proceeds via the connections where syntactic processing is thought to occur, but this task may not harness syntactic activation in the same way as action naming, in which an *event* is processed.

This hypothesis suggests that if noun naming takes place within a sentence context, a similar effect of syntactic facilitation may be observed. Zingeser and Berndt found that HY's noun production improved when he was given a sentence context providing both a syntactic frame and semantic cues. A similar test was administered, in order to explore the facilitation of noun production in the case of RS.

8.3.2.1: Object naming in a sentence completion task

The same sentence completion task described above in the case of TK (section 8.2.3 Task 3) was carried out twice with RS. On each trial, he correctly named 7 out of the 40 pictures. This was only a slight improvement on his performance on the original four trials, in which he produced 1, 2, 6 and 1. There was therefore little support for the prediction that the provision of a sentence would improve RS's noun retrieval.

8.3.2.2: Syntactic processing in reading and repetition

A further method of exploring the hypothesis that syntactic activation facilitated word retrieval in naming was to encourage it in reading and repetition. The following experiments tested the prediction that word retrieval in these tasks should benefit from syntactic activation by attempting to provide additional syntactic/semantic information.

This prediction is in effect a reversal of that made in the case of TK in repetition, where it was predicted that semantic/syntactic context should *inhibit* verb retrieval.

Task 1: Reading and repetition following a sentence frame

The task using "lead-in" sentences carried out with TK (section 8.3.2, Task 1) was repeated with RS: each verb was put into a sentence with the verb being presented again at the end of the sentence. RS did both the auditory version carried out with TK, and on a separate occasion, a written version. In this, the sentence was printed with the verb printed again at the end (e.g. The boy is kicking the ball. kicking). RS was required to read the sentence to himself, then to read aloud the verb at the end of the sentence. Table 8.3 below presents the results alongside the number of correct responses on the original verb and noun trials.

Table 8.3: RS: Correct responses on reading and repeating verbs with a lead-in sentence compared with original verb and noun trials

	With Lead-in Sentence	Original Verb Trials				Original Noun Trials			
Trial no.	(1 trial only)	1	2	3	4	1	2	3	4
Reading	5	3	1	5	5	12	3	9	7
Repetition	33	19	23	23	22	29	32	30	31

In reading, there was no improvement compared with results on the original verb trials when a sentence context was provided. The number of correct responses in this new test did not approach that of reading nouns, although there was some inconsistency across the original four trials. However, in repetition, RS's performance on verbs did appear to be enhanced by the provision of a sentence context. When compared with the combined trials of verb repetition, there was a significant improvement ($\chi^2 = 10.55$, $p < 0.01$; withstands the Bonferroni adjustment). Results were boosted to a level similar to the scores on the noun trials. To return to reading, it is possible that this task was simply too great a linguistic burden for RS, given his deficits in this modality. Further ways of testing reading with the provision of a context were devised.

Task 2: Reading verbs with pictures

In a task similar to one carried out with TK for repetition (Section 8.3, Task 2), a context was provided by showing RS the action picture used in the naming task at the same time as the written word. RS scored 8/40, a significant improvement on the combined verb reading tests ($\chi^2 = 4.14$, $p < 0.05$; does not withstand the Bonferroni adjustment) and comparable with his inconsistent performance on nouns. As with TK, it could be argued that RS was simply naming pictures, in this case his improved score reflecting his advantage for naming verbs. Another test was carried out, again with pictures to avoid the burden of having more words to read, but using pictures of the subject and object, not of the actions themselves.

Task 3: Reading verbs in a "sentence frame" with pictures

This test used subject-verb-object sentences with the target verbs (e.g. "The boy is eating the grapes"). The subject and object were represented pictorially (without the written or printed noun), with the verb printed between the two pictures. The tester started the sentence by producing the subject noun followed by the auxiliary verb (e.g. "The boy is…"), and RS was asked to read the verb aloud, and then to name the object picture (e.g. "eating" + "the grapes". This test was carried out twice. He scored 7/40 and 9/40 on reading the verbs aloud. When these two scores were compared with the combined scores on the original verb trials, there was again a significant improvement ($\chi^2 = 6.17$, $p < 0.05$, does not withstand the Bonferroni adjustment).

8.3.2.3: Discussion of syntactic activation hypothesis

It was speculated that RS may be similar to HY (Zingeser and Berndt 1988): his superior verb skills in naming may have been due to additional syntactic activation. HY's noun retrieval was enhanced by the provision of a sentence context, argued to be due in part to his relatively spared verb retrieval. For RS, there was little difference in his performance on object naming when a sentence context was provided. The comparison between HY and RS is difficult because HY's word retrieval skills were far superior to those of RS: HY achieved 30-35% accuracy on an object naming test, and 62.5% on an action naming test. This compares with RS's 2.5-15% accuracy rate on the noun trials and 10-30% accuracy rate on the verb trials. Given his more severe deficits, with a less marked advantage for verbs, it is not surprising that RS did not respond so dramatically to this task.

There was some support for the hypothesis that syntactic activation facilitated word retrieval from tests in which the reading and repetition of verbs were given contexts. This was more clearly demonstrated in repetition with the provision of a "lead-in" sentence. Findings in reading were less clear-cut: there was no improvement in performance with a lead-in sentence, possibly because this simply increased the linguistic load for RS's already impoverished reading skills. However, there were weakly significant gains in the two tests using pictures instead of words to provide a semantic/syntactic context.

In these attempts to provide a context for reading and repetition, it is not possible to ascertain whether it was the provision of a syntactic frame which provided an extra drive to lexical retrieval, or whether RS was facilitated by semantic information in the sentence or picture. For example, in the sentence "The boy is kicking the ball", it may have been the syntactic constraint and the provision of the argument structure which facilitated the retrieval of the verb, or it may be the use of additional semantic cues such as the word "ball". In order to adjudicate, a further task to carry out would have been to require RS to read or repeat verbs with the provision of a syntactic frame without any additional semantic cues (e.g. "He is .... (eating)."), similar to the "carrier phrase condition" described by McCall, Cox, Shelton and Weinrich (1997).

The findings of enhanced verb retrieval in repetition (and to a lesser extent, reading) in a sentence context agree with the findings in naming by Zingeser and Berndt (1988) and Breen and Warrington (1994): syntactic and semantic processing can facilitate word retrieval. This may explain why in picture naming, RS's performance on verbs was superior to that on nouns: the action pictures in the verb test gave syntactic and/or semantic information which enhanced the activation of the target verb. This suggests a post-semantic locus of the word class dissociation at the level at which syntactic information is encoded. However, this hypothesis does not explain why RS's performance was *worse* in reading and repetition of verbs than of nouns. This is explored below.

8.3.3: Morphological complexity hypothesis of difficulties with reading and repetition of verbs

8.3.3.1: Length effects

A possible answer to the question posed above may lie in the length of the target. RS was being asked to read or repeat an –ing form, making the verb targets longer than most of the noun targets. PALPA subtests 30 (Syllable Length Reading) and 7 (Syllable Length Repetition) were carried out to determine whether length was a factor. Each test was administered twice. The results are shown below in Table 8.4. There were 8 items of each syllable length, making a total of 24 items in each sub-test.

Table 8.4: RS: Correct responses in syllable length reading and repetition

	Total correct	1 syllable	2 syllables	3 syllables
PALPA 30 (Reading) 1	1	1	-	-
PALPA 30 (Reading) 2	3	1	1	1
PALPA 7 (Repetition) 1	13	7	2	4
PALPA 7 (Repetition) 2	15	8	3	4

RS was so impaired on the reading tests that it was not possible to discern any length patterns. In repetition, monosyllabic words were clearly easier than 2- or 3- syllable words. When the two trials were combined, this difference was significant ($\chi^2 = 13.33$, $p < 0.001$ when compared with 2-syllable items; $\chi^2 = 7.58$, $p < 0.05$ when compared with 3-syllable items; the former comparison withstands the Bonferroni adjustment). There was no significant difference between 2- and 3- syllable items. It therefore appears that length might be partly responsible for the difficulty with the verb targets relative to noun targets.

8.3.3.2: Preliminary reflections on inflectional morphology

A further explanation for RS's disadvantage for verbs in reading and repetition may lie in morphology. RS tended to preserve the –ing inflection in 139 out of the total of 172 errors (81%) in the 4 reading trials and 77 out of 78 errors (99%) in repetition. This occurred on non-word as well as word errors (e.g. /drʌθɪŋ/ for carrying; /fɪʃnɪŋ/ for driving; "/skuvɪŋ/ the book" for drawing). The difficulty could be attributed to a difficulty with composing morphologically complex forms from stems and inflections, with the affix being readily retrieved at the expense of the word stem. According to AAM, an impairment at word-form level should leave regular forms more vulnerable than irregular forms, because both the stem and affix must be retrieved separately and then combined. Therefore the next step was to check for a dissociation between regularly and irregularly inflected forms. PALPA Subtests 34 and 11 were administered, to examine lexical morphology in reading and repetition respectively. The results are shown below in Table 8.5. Each cell shows the score out of a total of 15.

Table 8.5: RS: Correct responses in reading and repetition of different types of morphologically complex words

	R	CR	D	CD	I	CI
PALPA 34 (Reading)	1	1	0	1	0	2
PALPA 11 (Repetition)	2	6	11	6	12	12

Key:

R:	Regularly Inflected	CR:	Unaffixed Phonological Control
D:	Derivational	CD:	Unaffixed Phonological Control
I:	Irregularly Inflected	CI:	Unaffixed Phonological Control

There were no clear patterns in reading because of the small number of correct items. The prediction that irregular forms should be more easily read than regular forms was not supported. This may be because of the severity of RS's reading difficulties. In repetition, there was no significant difference in the total number of correct responses made on regularly inflected items compared with their phonological controls. However, there were significantly fewer correct responses made to regularly inflected items than to irregularly inflected items (χ^2 = 13.39, $p < 0.001$; withstands the Bonferroni adjustment). It is somewhat problematic that there was also a significant difference between the unaffixed controls for the regularly and irregularly affixed items (χ^2 = 5.00, $p < 0.05$; does not withstand the Bonferroni adjustment), even though the items were matched for length. The finding that he also repeated words with derivational affixes better than words with inflectional affixes and also than their own phonological controls suggests that his performance was somewhat erratic on this task.

There would be further support for the hypothesis that RS demonstrated a difficulty with accessing regularly inflected forms if he was found to have similar difficulties with inflectional affixes other than –ing. To test this, a different inflection was used.

8.3.3.3: Performance on verbs with past inflection

All 40 items from the verb set were converted into their past forms. This resulted in 26 regular and 14 irregular forms. (It is not ideal that the two groups were unequal in number.) RS was asked to read and on the following session to repeat these forms. The results are shown below in Table 8.6. Percentages of the maximum number (i.e. out of 40 in total, 26 for regularly and 14 for irregularly inflected items) are shown in brackets.

Table 8.6: RS: Correct responses in reading and repetition of regularly and irregularly inflected items

	Total Correct	Regularly Inflected	Irregularly Inflected
Reading	2 (5%)	1 (4%)	1 (7%)
Repetition	20 (50%)	9 (35%)	11 (79%)

In reading, there were too few correct responses to discern a pattern. However, in repetition, RS showed a significant advantage for irregularly inflected items over regularly inflected items (χ^2 = 7.03, p< 0.01; does not withstand the Bonferroni adjustment). This suggests a specific difficulty for regularly inflected items. There would be further support for this hypothesis if such an effect was found in nouns as well as verbs. The following test examines this prediction.

8.3.3.4: Performance on nouns with plural inflections

The original set of noun stimuli was used (with the exception of "grapes", which was already a plural form) with the plural inflectional affix added. RS was asked to read and in a later session to repeat these items. He scored 4/39 on reading, worse than his performance on three out of the four trials in the original noun set, in which he scored 12, 3, 9 and 7, although the difference with the combined scores was not significant. More strikingly, he scored 14/39 on repetition, worse than his performance on the trials in the original set, in which he scored 29, 32, 30 and 31. When these four trials were combined, the difference was significant (χ^2 = 23.60, p < 0.001; withstands the Bonferroni adjustment).

8.3.3.5: Discussion of morphological complexity in reading and repetition

While a simple length effect cannot be ruled out as a factor in RS's inferior performance on reading and repetition of verbs compared to that of nouns, these analyses suggest that there was a specific difficulty with processing regularly inflected words. In reading, there were too few correct responses to reveal patterns of responses to regularly and irregularly inflected targets. However, in repetition, there was a disadvantage for regularly inflected forms, as seen in PALPA 11 and in the experimental verb set with past inflections. It may be objected that the advantage for irregularly inflected forms may have been because they tended to be higher frequency than regularly inflected forms, especially as RS demonstrated a significant frequency effect in repeating verbs. Indeed, the mean frequency value of the irregularly inflected past forms (from Francis & Kuçera 1982) was found to be 59.07, while that of the regularly inflected forms was 21.38. However in PALPA 11, regularly and irregularly inflected words were matched for frequency.

The hypothesis of a disadvantage for morphologically complex words was supported by the finding that when plural inflectional affixes were added to the experimental noun set, RS's performance on repetition (and to a lesser degree on reading) deteriorated compared to that on the original trials. A more straightforward way of ascertaining whether the use of morphologically complex forms had a detrimental effect on RS's production skills would have been for him to read and repeat the same set of verbs without the –ing inflection. However, 32 out of the 40 verb targets would then have been ambiguous in terms of their word class (e.g. rake; swing, peel, yawn, kiss).

RS's apparent disadvantage for regularly inflected forms was similar to that of SJD (Badecker & Caramazza 1991), supporting the AAM model. That is, he demonstrated a difficulty with processing morphologically complex forms which affected regularly inflected forms (for which stems and affixes must be accessed separately and combined), more than irregular forms (which require the retrieval of a single whole unit). However, unlike SJD, who appeared to have a specific difficulty with accessing the affixes themselves, RS generally produced the affix correctly. This suggests that the processing cost of accessing two separate bits of information, the word stem and the affix, was too great. The regular affix, being high frequency (and also perhaps more readily produced repeatedly by an individual found to be prone to perseveration), may actually be more easily accessed than the stem, which was more vulnerable to retrieval difficulties.

8.3.4: Discussion of RS and word class effects

The main questions to address with regards to RS's word class differences were why his performance on verbs was *better* than on nouns in the naming task, and why it was *worse* than on nouns in the reading and repetition tasks (section 8.3). In order to explore the first question, the semantic hypothesis of word class differences was examined (section 8.3.1). There was no clear-cut evidence that a dissociation between sensory and functional information (i.e. a relative sparing of functional/relational information) was behind RS's advantage for verbs. The abstract/concrete variable was not fully explored, but in informal observation, there was no evidence of the advantage for abstract terms which may be associated with an advantage for verbs (Marshall et al. 1996b).

There was more support for the hypothesis that verb representations benefited from syntactic activation (section 8.3.2). When verb targets in reading and repetition tasks were given additional semantic/syntactic information, RS's performance was enhanced (section

8.3.2.2). There was more compelling evidence for this in repetition, where with the provision of a lead-in sentence, his performance was boosted to a level equal to that on repetition in nouns. In reading, two tasks which used pictures instead of words to convey a context did appear to succeed in boosting his performance to a small degree.

An advantage for verbs which appeared to stem from syntactic processing could be accommodated into either a model with an intermediary lexical or lemma level (e.g. Dell 1986; Levelt et al. 1999) or an Independent Network model (e.g. Caramazza 1997). Both models allow for a bidirectional flow of activation between the lexical representation and syntactic information, so it is plausible that syntactic activation to the lexical representation of a verb could boost its chances of being successfully selected (Druks & Carroll 2005). Caramazza and his colleagues cite cases of output modality-specific deficits as one of the motivating factors behind the Independent Network Model (e.g. Caramazza & Hillis 1991; Hillis & Caramazza 1995; Shapiro et al. 2000). It would have been interesting to investigate whether there was a dissociation in the word class effect between RS's spoken and written output. Unfortunately, his limited writing skills precluded assessment of this modality.

The second question concerns RS's diminished performance on verbs compared with nouns on reading and repetition (8.3.3). While a length effect may have been a factor (section 8.3.3.1), there was evidence (at least in repetition) that the use of morphologically complex forms was at least partially responsible for this. This is compatible with the AAM model (e.g. Caramazza et al. 1988), in which regularly inflected forms, such as those used in these experiments, are disadvantaged because the word stem and affix must be accessed separately and then combined. RS was able to reproduce the target affix with relative ease, with the word stem being more vulnerable. It was therefore speculated that the deficit lay in the linguistic burden of processing a complex form, with the high frequency component, the inflectional affix, being accessed at the expense of the lower frequency and less predictable word stem (section 8.3.3.5).

8.4: Summary and discussion of word class effects

An interesting contrast has been demonstrated in the performances of the two individuals with regards to word class differences: TK showed the more commonly observed pattern of an advantage for nouns in naming, although this was not significant. His advantage for verbs in repetition was more note-worthy. It was hypothesised that this was due to a reduced role of lexical-semantic activation and the reliance instead on more intact processing, the sub-lexical route. When repetition tests using semantic contexts were carried out, some support was found for the prediction that TK's performance would be diminished. It was speculated that verbs may have been processed sub-lexically because their morphological complexity caused problems at the auditory input level, although this hypothesis was not investigated. The word class effect in the early trials of repetition paralleled the inverse frequency effect in the same trials, which was also tentatively explained by the advantageous use of sub-lexical routes, avoiding impaired lexical-semantic processing.

RS, on the other hand, while appearing to be hampered by the inflectional affix in reading and repetition, showed a significant advantage for verbs compared with nouns in the naming task. This was suggested to be due to activation from syntactic processing, supported by the finding that his performance on verb targets in reading and repetition tasks could also be boosted by the provision of a semantic/syntactic frame.

Although the main focus in this section has been on RS, a major point of interest with regards to TK both here and in the previous chapter on frequency effects is the contrast between TK's performance on the earlier and later trials. The following section will examine change over time in greater detail.

Chapter 9: Change over time

It was observed in Chapter 3 that while RS did not show signs of improving over time, TK showed improvements in the numbers of correct responses in all tasks between the early and later pairs of trials. This was significant in repeating nouns and naming verbs. Other features of TK's performance, the inverse frequency effect and his advantage for verbs in repetition, diminished alongside this general improvement. There was also anecdotal evidence of an improvement in TK's language skills, as reported by his family and by other health care professionals.

Changes were also observed in connected speech samples collected over the course of the study. The original sample presented in Chapter 2 (Introduction to the participants) is reproduced below, followed by two further speech samples, the first taken approximately 18 months after the original, and the second after a further year.

Original speech sample: description of a picture of a canal scene:

"Here it's a bark (pointing to a dog) with a hole which is a talk (pointing to the man walking the dog) and he catches a cork with two barks along a road where a large chard (pointing to a tree stump) and leeks (pointing to reeds) with one two three four five six seven eight nine ten /rɑf/ and bits of /hɒmz/ (counting reed plants). We're still here as /ˈɡɜkɪŋ/ boat (pointing to canal boat) 'cos we like along here, and going round, we see the reed of the rude where the lockers rowed one two three four five six seven (counting windows on the boat) eight, no, seven parts with a plan there (pointing to the decorative panel on the side of the boat) and the /ˈpɪtʃɪn/ (pointing to man on boat) about his /ˈʌləpɜt/ you see. Over there (pointing to canoeist) you turned round with a pounders (pointing to paddle) with two teats and wheats (pointing to blades on paddle), and you say go on."

There were a total of 110 words and non-words in this sample, of which 15 (14%) were different words appearing to represent nouns (whether or not they were appropriate or target-related). There were also 4 non-words appearing to represent nouns: /rɑf/; /hɒmz/; /pɪtʃɪn/; /ʌləpɜt/. Another non-word appeared to represent an adjective, /gɜkɪŋ/. Although it is difficult to judge perseveration in a connected speech sample using the same criteria used for the experimental tasks (section 6.2.1), there were 4 clear examples of perseverative sequences in this sample (bark, talk, cork, barks, /rɑf/; road, chard; reed, rude, road; parts, plan; teats, wheats). This sample also demonstrates his fluency, with no indications of awareness of his difficulties, such as false starts or hesitations.

Second sample: TK was describing a sketch he had done of a Punch and Judy Show:

"I think you'd like that, wouldn't you? That's called a /kɜ/... /kɜ/... no, it's like a game. It's a game at school, isn't it? 'Cos there is... you can see them...see the cow, and I got a /kæm/. That would go into there. I'm waiting the /ˈkɑlɑ/" (therapist: "This is Punch and Judy, isn't it?") "That's right. Now this is got from a... let me see... I don't think... /duˈwɜti/, and that one... I think... alright, alright, I'll better that and make a better string there are sing there and wing that there... make 'em completely /ˈliəd/, you know, tell big ferns. So I don't ...erm... I suppose... I think you've got there. I think you must have done. You see all of these with... that's quite right. You've got... I don't know, I'm not... Now I can get back and... and I took that and I got this and summer. I want to the /ˈjætsɑl/ and sully, but I want sully to put that."

This sample is less fluent and demonstrates more awareness and attempts at self-correction with 8 clear examples of hesitancy or false starts (e.g. a /kɜ/... /kɜ/... no; a... let me see... I don't think...). There were 157 words or non-words, of which 8 (5%) were different words appearing to represent nouns. There were also 4 non-words appearing to represent nouns: /kæm/; /kɑlɑ/; /duwɜti/; /jætsɑl/, and a further non-word appearing to represent an adjective, /liəd/. Perseveration was still a feature, with 3 clear examples (cow, /kæm/, /kɑlɑ/; string, sing, wing; summer, sully, sully).

Third sample: TK was in the day centre, talking about his sketch book:

"Something else I've tried to do... I can't say... /ˈblʌmi/... explains..." (wrote EXPLAN) "...ah... explain" (corrected written word to EXPLAIN) "... oh god... the word... oh god..." (therapist: "Is it about something else you're going to draw?") "No" (wrote HISYES) "...It's going to explain... I can't ... you know the words in the back of the book?" (therapist: "You mean the poetry in your old sketch book?") "Yes. There's a man..." (therapist: "A poet?") "Yes. He comes every year. And he's brilliant. I can't..." (therapist: "Is he helping you to write more poetry?") "Yes, he's going to do that. I can see all these things and say “look at that”. I can actually hit my word. I’m just... how can I try to... I don’t know... I can’t do it. And I’ve seen all sorts of things.” (SLT: So what are you going to do this morning?) “I shall sit here and... (pointed out of the window, at patio table with parasol, and gestured drawing)... umbrella.”

(His wife later confirmed that each week, an elderly poet came to the day centre, and TK enjoyed chatting to him and showing him his old poetry.)

There were 100 words and non-words in this sample, of which 6 (6%) were different words appearing to represent nouns. There was only a single non-word, /ˈblʌmi/ (possibly a blend of the two interjections, “blimey” and “lumme”). Perseveration was not noted at all. This sample was replete with pauses, false starts and comments on word-finding difficulties, for example “... oh god... the word... oh god...” and “I can actually hit my word. I’m just... how can I try to... I don’t know... I can’t do it” as well as attempts to use other forms of communication to get his message across, such as writing and gesture.

These samples suggest that changes had occurred in TK’s output. However, a decrease in fluency and diversity of output (as demonstrated by the smaller proportion of different words representing nouns on the later two samples compared with the first sample) and an increase in hesitancy and attempts at self-correction were more apparent than an increase in accuracy. A longitudinal study was developed in order to explore any change using more formal testing. Before this is discussed, the literature on different theories of jargon aphasia is examined with regard to the predictions that they make about recovery.

9.1: Literature on recovery in jargon aphasia

9.1.1: Prediction of recovery made by models of spoken word production

It has been said that aphasia is not a static disorder (Kertesz 1979, in Simmons & Buckingham 1992) and that longitudinal studies are the only way of truly understanding a deficit and adaptations to it (Butterworth, Panzeri, Semenza & Ferriri (unpub.), in Simmons & Buckingham 1992). This review will examine the general longitudinal patterns predicted by the different theories of non-word production in jargon aphasia, before discussing the evidence for these predictions.

Anomia theories of non-word production in jargon aphasia postulate that non-words are non-lexically generated in the event of total lexical retrieval failures. They predict that non-word production subsides over time to reveal the underlying anomia, manifested by hesitation and the use of circumlocution, indefinite pronouns, stereotypical words and cliches (Buckingham 1977, 1981, 1987, 1990; Butterworth 1985; Christman & Buckingham 1989; Simmons & Buckingham 1992). Buckingham (1981) argues that the anomia is present throughout, but is initially masked by non-words. Several authors have claimed that recovery involves a shift along a continuum from phonemic jargon to neologistic jargon, then to semantic jargon and finally to empty anomic speech (e.g. Kertesz & Benson 1970; Peuser & Temp 1981; Simmons & Buckingham 1992). Simmons and Buckingham (1992) envisage this process as being a peeling away of layers: more robust features such as syntactic processing and access to function words may emerge during recovery, until the most pervasive core deficit, the underlying lexical retrieval difficulty, is exposed. Anomia theories do not predict that non-words should show an increase in target relatedness because they are not derived from the target (Christman & Buckingham 1989; Kohn, Smith & Alexander 1996).

Dual impairment theories propose that non-words arise from semantic errors followed by phonemic distortion. These theories predict two possible recovery patterns: in the first, the semantic impairment recovers, leaving the phoneme level impairment, in which target relatedness should be apparent (see below for predictions made by conduction theory). In the second pattern, the phonemic distortion recovers, revealing the underlying semantic errors, so there should be no increase in target relatedness. This pattern may then give way to empty anomic speech (Buckingham & Kertesz 1976, in Robson 1997).

Conduction theories predict an increase in target relatedness as phonological encoding processes recover (Robson 1997). Presumably, a diminishment of the length and serial position effects would also be predicted. According to Buckingham (1987; 1990), there should not be any evidence of anomia because the word is successfully retrieved prior to being distorted in post-lexical processes. There should instead be a recovery from unrelated to related non-words, and then to error-free speech.

Partial lexical retrieval theories also predict an increase in target relatedness because as lexical access improves, more target phonology is available (e.g. Kohn & Smith 1994b). Interactive activation accounts accommodate a partial lexical retrieval theory to explain non-word production, and therefore they too predict an increased access to target phonology (Robson 1997). Schwartz and colleagues (1994) argue that if non-word production is attributable to globally weakened connections, recovery should reveal a shift from a "bad error pattern" (a high proportion of non-word errors relative to word errors and more perseverative errors relative to anticipatory errors) to a "good error pattern" (an increase in the proportion of word errors and a decrease in the number of perseverative errors, as well as an overall reduction in the number of errors). The increase in word errors should occur because an increase in activation through strengthened connections should increase feedback from the phoneme level to the lexical level, reinforcing word outcomes. The decrease in perseveration should occur because incoming activation is more likely to be strong enough to override residual activation. Harley and MacAndrew (1992) argue that strengthening the semantic-to-lexical connection weights may result in an increase in semantic errors and then in circumlocutory anomic speech, as activation levels to semantic competitors as well as targets are boosted.

9.1.2.: Evidence from recovery patterns

The predictions made by different theories of non-word production are based on evidence from various case studies, as examined below. The pattern of a recovery from non-words to semantic errors and then to empty anomic speech has been reported by several authors. Green (1969) interviewed an individual with jargon aphasia over a year and found that the number of non-words decreased from 48 in the initial interview to 0 in the eleventh interview. This was accompanied by an increase in the number of formal and semantic errors, and in the use of indefinite pronouns (from 18 in the initial interview to 238 in the eleventh). A decrease in the number of non-words was *not* accompanied by an increase in the number of correct responses (reported in Robson 1997). Peuser and Temp (1981) report on two individuals: Mr W, who initially presented with semantic jargon resolving to empty anomic speech over a 7 year period, and Mrs K, whose neologistic jargon was claimed to evolve into semantic jargon (although the example of "semantic jargon" given resembles empty anomic speech based around a stereotypical utterance (Robson 1977)). Simmons and Buckingham (1992) studied KS over a period of 8 years with subtests of PICA (Porch Index of Communicative Ability: Porch 1967), but they do not provide a breakdown of the actual scores on these subtests, instead presenting an overview in which they claim that initial phonemic jargon gave way to neologistic jargon, then to semantic jargon, and finally to anomic speech characterised by hesitations and circumlocutions.

Accounts of recovery in dual impairment theory are less common. Kertesz and Benson (1970) report a longitudinal study of ten cases of neologistic jargon aphasia (although they do not give details on how recovery was assessed). They found a pattern of evolution from neologistic to semantic jargon and then to anomic speech, and suggest that this is caused by a lexical retrieval disorder (resulting in semantic errors) followed by severe phonemic distortion. However, this pattern can also be accommodated into the anomia theory discussed above (Buckingham and Kertesz 1976, in Robson 1997).

An increase in access to target phonology predicted by conduction theory, partial lexical retrieval theory and interactive activation accounts has been supported by many cases. For example, Lecours and Joanette (1980) use an increase in target relatedness as evidence in support of a conduction theory. Their participant also showed signs of anomia, such as the repetition of articles and prepositions, the use of circumlocutions and repeated word finding attempts, which is contrary to Buckingham's (1987; 1990) argument that recovery towards increased target relatedness should not be accompanied by anomia.

Kohn and Smith (1994b) claim that their longitudinal study of VN supports a partial lexical retrieval theory of non-word production. In formal testing, his responses were more likely to be correct and his word and non-word errors both became more target-related after five months, but his spontaneous speech remained anomic. This is speculated to be due to a strategy to avoid lengthy and effortful lexical retrieval attempts. Kohn et al. (1996) found further support for their theory of two mechanisms of non-word production in the longitudinal study of four individuals. Two of these individuals, LW and RH, made some recovery, with more correct responses and increased target relatedness. They were therefore assumed to base non-words on partial lexical retrieval. The other two individuals, ELB and JMC, did not show any signs of recovery, and were therefore assumed to rely on non-lexical mechanisms of non-word construction. These authors also argued that the initial severity of the impairment is not a predictor of recovery, as one of the recoverers was initially more impaired than the non-recoverers. This also indicates that non-word production is not due to a single defect which varies in its severity. Stereotypy is argued to be a predictor of recovery: the two non-recoverers showed more stereotypy because they were said to have lost phonological information, and were therefore constructing non-words from a limited pool of phonological material.

Supporters of interactive activation accounts have also cited an increase in both the number of target words retrieved and in the target relatedness of errors as evidence. For example, in Robson's (1997) study, LT showed little improvement over two and a half years, but his performance in a therapy task is suggested to mirror the effects of recovery. This task entailed making a semantic decision and then naming the target with the additional provision of a written word stimulus. The increase in the number of correct responses is speculated to be due to the provision of additional activation from two different sources (semantics and the visual input system), converging at the lexical level and then increasing the activation of target phonology. An increase in the use of low frequency target phonemes was also noted in this therapy task. It was argued that high frequency phonemes were overused because in a system that allows spreading activation, they were more likely to be activated in error by several competing lexical nodes. Increased activation of target lexical nodes inhibits the activation of non-target phonemes and increases the chances of low frequency target phonemes being selected (Robson 1997; Robson et al. 2003).

Robson (1997) suggests that LT's primary impairment is a difficulty in activation between the lexical and phoneme level. Schwartz and colleagues' (1994) proposal of *globally* weakened connections, which predicts a recovery from a "bad error pattern" to a "good error pattern" (more word errors relative to non-word errors and a reduction in the number of perseverative errors) has not been tested by a longitudinal study of aphasic individuals. However, the authors claim that this shift was demonstrated by a group of 20 non brain-injured participants who were given time to practise tongue-twisters (practice being assumed to mimic recovery). The error corpus of an individual with jargon aphasia, FL, was also compared with a corpus of normal speech sound errors as further evidence of a dichotomy between a "bad" and "good" error pattern. This predicted pattern was not supported by Robson (1997): in the therapy task described above, there was not a significant increase in the proportion of word errors. Perseveration was not a feature of LT's output, so it was not possible to comment on any change in this.

Recovery may also entail the substitution of one adaptive strategy for another. Butterworth (1985) argues that recovery involves abandoning the use of non-words when they are found not to be communicatively effective. Panzeri, Semenza and Butterworth (1987) explore this in the case of PZ, whose recovery was charted by speech samples and measures of fluency and naming ability over a period of three years. His naming improved dramatically, and there was a decrease in the number of unrelated non-words (postulated to be device-generated in the event of a total failure of lexical recovery). However, there was also a decrease in vocabulary size and an increased use of stereotypical "fillers", with the result that he was no better at conveying referential meaning than at the outset. Panzeri et al. (1987) argue that PZ initially used non-words to avoid anomic gaps, but when this strategy failed, he adopted a different strategy, which at least made his speech sound more "normal" and socially acceptable. There are similarities between this case and that of VN (Kohn & Smith 1994b), in which despite an improvement in naming, recovery in spontaneous speech appears to involve the use of strategies to reduce the strain of communication.

One of the difficulties in evaluating the evidence for patterns of recovery is that studies have used different methods of plotting change. Some use formal tests while others use speech samples, and as discussed above, contradictory evidence has been found when the two methods are used to assess the same individual (Kohn & Smith 1994b; Panzeri et al. 1987). In other cases, the methodology is not made explicit, or results are so general as be little more than anecdotal (e.g. Kertesz & Benson 1970). In addition, there is some circularity in the predictions and corresponding evidence: for example, Kohn and Smith's (1994a & b; 1996) account of two sources of non-words, one of which predicts a recovery while the other does not, was formulated *because of* longitudinal data.

Furthermore, there are some similarities between the different accounts. All the predictions of recovery above agree that an increase in awareness and monitoring is an important factor (e.g. Schwartz et al. 1994; Robson 1997; Marshall et al. 1998). In anomic accounts, non-word errors previously not successfully inhibited are edited out because of increasing error-awareness (Buckingham 1977; 1990; Peuser & Temp 1981; Christman & Buckingham 1989). According to Ellis (1985) and Ellis, Miller and Sin (1983), partial lexical retrieval accounts also predict anomic characteristics as self-monitoring improves. In interactive activation accounts, monitoring is considered a function of feedback from lower to higher levels of representation. Increased activation to the lower levels increases feedback and hence increases the likelihood of errors being edited out, resulting in some traces of anomia (Robson 1997).

Despite these similarities, there are some salient differences in the predictions made by the different accounts. To summarise, anomia theories predict the appearance of anomic characteristics and no increase in target relatedness. Conduction, partial lexical retrieval and interactive activation accounts all predict an increase in the realisation of target words and in the target-relatedness of errors. Furthermore, interactive activation accounts may predict an increase in the use of low frequency target phonemes. Those which hypothesise globally weakened connections also predict a decrease in non-word errors relative to word errors and a reduction in perseveration. Having described the patterns of recovery predicted by the different models, TK's recovery will be examined in order to ascertain which of these predictions are borne out.

9.2: TK and change over time

It has already been noted that TK improved over the original four trials in terms of the number of correct responses on the different tasks. The diminishment of both the inverse frequency effect in repetition and the advantage for verbs over nouns in the same task was also noted and attributed to an increase in lexical-semantic activation. In order to examine change over time in more depth, a further four trials of each task were carried out over the period of ten months (September 2003-June 2004). As with the original set, there was an early trial period consisting of Trials 5 and 6 of each task, followed by six month interval, followed by Trials 7 and 8. The stimuli and procedure for each task were identical to those used for the original trials. The results are presented below in Table 9.1 (Nouns) and Table 9.2 (Verbs). These may be compared with the response breakdown for the original trials in Tables 3.11 and 3.12 (section 3.5.2).

Table 9.1: TK: Naming, reading and repeating nouns over 4 further trials

	Correct Responses			Error Responses					
Task	Total	HiF	LoF	Sem	DSem	Word	Nword	Other	All E
N5	12	5	7	1	-	18	11	3	33
N6	17	10	7	3	-	22	5	1	31
N7	18	10	8	7	1	5	2	8	23
N8	16	6	10	3	-	19	4	-	26
Total	63	31	32	14	1	64	22	12	113
RA5	34	19	15	-	-	6	8	-	14
RA6	34	18	16	-	-	10	2	4	16
RA7	39	20	19	-	-	2	1	-	3
RA8	38	19	19	-	-	6	2	-	8
Total	145	76	69	-	-	24	13	4	41
REP5	34	15	19	-	-	5	1	1	7
REP6	32	15	17	-	-	8	3	1	12
REP7	37	19	18	-	-	4	-	-	4
REP8	35	16	19	-	-	4	1	-	5
Total	138	65	73	-	-	21	5	2	28

Table 9.2: TK: Naming, reading and repeating verbs over 4 further trials

	Correct Responses			Error Responses					
Task	Total	HiF	LoF	Sem	DSem	Word	Nword	Other	All E
N5	6	3	3	3	1	21	11	3	39
N6	14	7	7	10	3	9	9	8	39
N7	9	5	4	11	-	12	3	11	37
N8	9	7	2	10	4	4	16	1	35
Total	38	22	16	34	8	46	39	23	150
RA5	30	16	14	-	-	7	9	3	19
RA6	35	18	17	-	-	3	8	5	16
RA7	37	17	20	1	-	3	5	2	11
RA8	28	14	14	-	-	13	8	-	21
Total	130	65	65	1	-	26	30	10	67
REP5	34	15	19	1	1	5	3	1	11
REP6	32	16	16	-	-	7	4	1	12
REP7	29	13	16	-	-	9	4	-	13
REP8	35	18	17	-	-	4	9	-	13
Total	130	62	68	1	1	25	20	2	49

Key:

N	Picture naming	Sem	Semantic errors
R	Reading	DSem	Errors derived from semantic competitor
REP	Repetition	Word	Word errors
Total	Total correct	NWord	Non-word errors
HiF	High frequency correct	Other	Other error type
LoF	Low frequency correct	All E	Total number of errors

Recovery can be evaluated in several ways. The primary measure is an increase in the number of correct responses in each task. A further measure of improvement that will be examined is an increase in target relatedness, as predicted by conduction, partial lexical retrieval and interactive activation accounts. Some additional predictions made by interactive activation accounts will also be examined. These are: the increase in the proportion of target low frequency phonemes predicted by the hypothesis of a *localised* difficulty accessing phonology from the lexical level (Robson 1997); the increase in the proportion of word errors relative to non-word errors and the decrease in the number of perseverative errors predicted by an account in which non-words result from *globally* weakened connections (Schwartz et al. 1994).

9.2.1: Number of correct responses

Figures 9.1 and 9.2 show that there was a trend to an increase in the number of correct responses over the course of time on all tasks of nouns and verbs.

Figure 9.1: TK: Change over Time on Noun Tasks

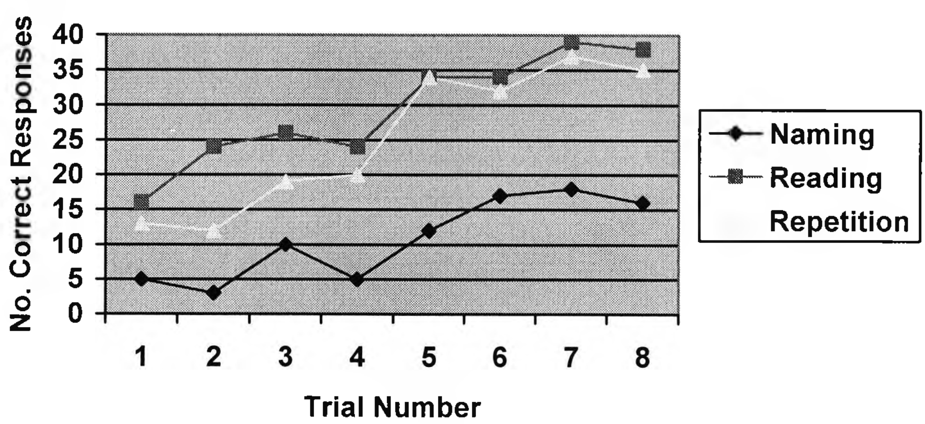
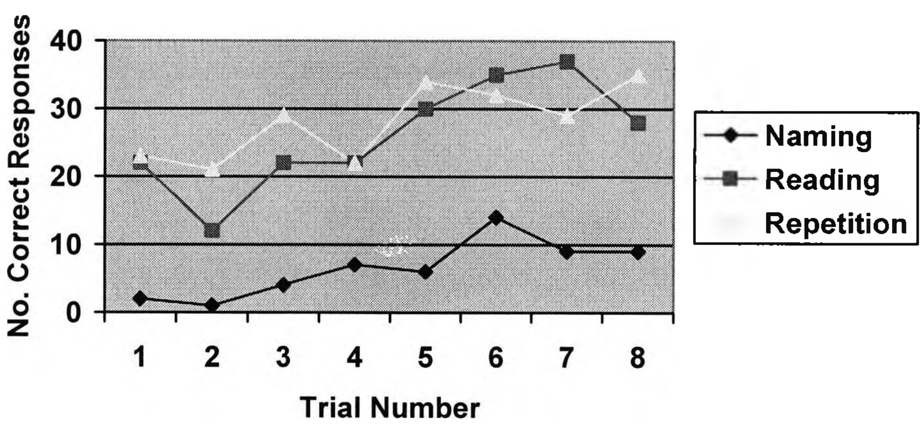


Figure 9.2: TK: Change over Time on Verb Tasks



Previously in this work, comparisons have primarily been made using a chi-square test of significance. However, with 8 trials of each task, an ANOVA is a more appropriate means of analysing patterns across the trials. A four-factor mixed ANOVA was carried out in which the trials 1-8 act as subjects. The variables were:

- Trial period (between subjects): 2 levels: original (trials 1-4) ; further (trials 5-8)
- Word class (within subjects): 2 levels: nouns; verbs
- Task (within subjects): 3 levels: naming; reading; repetition
- Frequency (within subjects): 2 levels: high frequency and low frequency

The full summaries of this and all other ANOVAs in this chapter are presented in Appendix 4. A significant effect of trial period ($F(1, 6) = 55.47$, $p < 0.001$) reflected an improvement in the second set of trials. The means for the trial periods are shown below in Table 9.3.

Table 9.3: TK: Means of number of correct responses by trial period

	Mean	Standard Deviation
First 4 trials	15.17	8.74
Second 4 trials	26.83	10.84

There was also a significant effect of task ($F(2, 12) = 321.07$, $p < 0.0001$). A Newman-Keuls unplanned comparison for levels of tasks showed that naming was significantly worse than reading ($p < 0.01$) and repetition ($p < 0.01$), with no significant difference between reading and repetition. While this does not pertain to change over time, it confirms the task differences noted in section 3.5.2.1. The means for the tasks are shown below in Table 9.4.

Table 9.4: TK: Means of number of correct responses by task

	Mean	Standard deviation
Naming	8.63	5.45
Reading	27.69	8.04
Repetition	26.69	8.14

In addition, there were 4 significant two-way interactions. The first was between trial period and word class ($F (1, 6) = 7.19$, $p < 0.05$). This shows that there were stronger improvements in nouns than verbs over time. An analysis of the simple main effects showed that both nouns ($F (1, 12) = 60.72$, $p < 0.001$) and verbs ($F (1, 12) = 26.19$, $p < 0.001$) improved over time. However, at the second assessment, nouns had a significant advantage over verbs ($F (1, 6) = 48.00$, $p < 0.05$). The means for each trial period in each word class are shown below in Table 9.5.

Table 9.5: TK: Means of number of correct responses by trial period and word class

Trial period	Word class	Mean	Standard Deviation
Original	Nouns	14.75	8.01
Original	Verbs	15.58	9.76
Further	Nouns	28.83	9.94
Further	Verbs	24.83	11.75

The second significant two-way interaction was between trial period and task ($F(2, 12) = 7.04$, $p < 0.01$). This appears to show a stronger improvement on reading and repetition than on naming, although an analysis of simple main effects showed that all tasks improved significantly. In fact, although in *absolute* terms, reading and repetition improved more, in *relative* terms, the most striking improvement was made in naming. The means for each trial period by task are shown below in Table 9.6.

Table 9.6: TK: Means of number of correct responses by trial period and task

Trial period	Task	Mean	Standard deviation
Original	Naming	4.63	2.88
Original	Reading	21.00	4.66
Original	Repetition	19.88	5.46
Further	Naming	12.63	4.34
Further	Reading	34.36	3.82
Further	Repetition	33.50	2.45

The other two significant two-way interactions do not pertain to change over time, but appear to confirm findings from previous chapters. There was a significant interaction between word class and task ($F(2,12) = 5.66$, $p < 0.05$). The simple main effects showed that nouns had an advantage over verbs that was significant in naming ($F(1,18) = 36.12$, $p = 0.01$) and nearly significant in reading. The reverse was true in repetition, with verbs having an advantage over nouns, although this was not quite significant. This confirms the word class effects discussed in section 8.2. The means for this interaction are shown below in Table 9.7.

Table 9.7: TK: Means of number of correct responses by word class and task

Trial period	Task	Mean	Standard deviation
Nouns	Naming	10.75	5.95
Nouns	Reading	29.38	8.09
Nouns	Repetition	25.25	10.33
Verbs	Naming	6.50	4.24
Verbs	Reading	26.00	8.16
Verbs	Repetition	28.13	5.52

The final significant two-way interaction was between task and frequency ($F (2, 12) = 8.71$, $p < 0.01$). Simple main effects showed that there was no frequency effect in naming and reading, but there was a significant advantage for *low* frequency targets in repetition ($F 1, 18) = 13.16$, $p < 0.01$), confirming the findings in Chapter 7. The means for this interaction are shown below in Table 9.8. However, it is surprising that there was not a significant three-way interaction between task, frequency and time ($F < 1$) to confirm the diminishing of the inverse frequency effect predicted by the apparent reduction in the inverse frequency effect over the original four trials.

Table 9.8: TK: Means of number of correct responses by task and frequency group

Task	Frequency group	Mean	Standard deviation
Naming	High	4.75	2.98
Naming	Low	3.88	2.96
Reading	High	13.94	4.54
Reading	Low	13.75	3.77
Repetition	High	12.19	4.78
Repetition	Low	14.50	3.67

9.2.2: Increase in target relatedness

According to some models, an increase in the number of correct responses is assumed to involve an increase in activation through the system, which predicts an increase in the amount of target phonology in error responses. In order to test this prediction, the number of target phonemes in errors from the original trials of each task was compared with the number of target phonemes in the further trials. Nouns and verbs were examined separately because of the finding in Section 9.2.1 that nouns improved more than verbs in terms of the number of correct responses. The numbers of shared phonemes as proportions of the total number of phonemes in each group of errors are shown below in Table 9.9.

Table 9.9: TK: Proportion of phonemes shared by targets and errors in original and further trials

	Word errors		Non-word errors	
	Trials 1-4	Trials 5-8	Trials 1-4	Trials 5-8
Naming Nouns	38/156 (24%)	53/181 (29%)	40/234 (17%)	21/89 (24%)
Naming Verbs	32/134 (24%)	27/129 (21%)	49/219 (22%)	24/108 (22%)
Reading Nouns	52/118 (44%)	40/62 (65%)	108/186 (58%)	36/54 (67%)
Reading Verbs	56/121 (46%)	43/71 (61%)	77/145 (53%)	57/89 (64%)
Repetition Nouns	48/211 (23%)	33/69 (48%)	34/87 (39%)	6/12 (50%)
Repetition Verbs	36/106 (34%)	27/62 (44%)	40/83 (48%)	29/54 (54%)

A comparison was made between the original and further trials using another four-factor ANOVA, with the variables of trial period (original and further); word class (nouns and verbs); task (naming, reading and repetition) and error type (word and non-word errors). There was no significant effect of trial period. In other words, although there was a tendency towards an increase in target relatedness in the further trials (with a mean of 44% of phonemes being shared with the target in the further trials, compared with a mean of 36% on the original trials), this was not significant. While there were significant effects of other variables, these will not be commented on as they do not concern change over time. There were no significant interactions between the variables.

9.2.3: Increase in the proportion of low frequency target phonemes

Robson's (1997) account predicts that an increase in activation entails an increase in the availability of low frequency phonemes, where previously high frequency phonemes were more readily available as "gap-fills". In order to test this, the numbers of target consonants from the ten lowest frequency consonants in the CELEX database (Baayen et al. 1995) in word and non-word errors were found (including only the consonants targeted in the stimuli, /b f h ŋ j ʃ g tʃ dʒ θ/). Only initial responses were taken, with exclusions as before. Totals of nouns and verbs on the original trials and the further trials of each task were combined and the proportions (of the total number of consonants in the error set) were compared. The results are presented below in Table 9.10.

Table 9.10: TK: Proportion of low frequency target consonants in error responses in original and further trials

	Word errors		Non-word errors	
	Trials 1-4	Trials 5-8	Trials 1-4	Trials 5-8
Naming Nouns	9/185 (5%)	6/184 (3%)	10/234 (4%)	2/89 (2%)
Naming Verbs	0/139 (0%)	2/125 (2%)	2/218 (1%)	1/104 (1%)
Reading Nouns	15/121 (12%)	3/65 (5%)	13/189 (7%)	6/53 (11%)
Reading Verbs	5/122 (4%)	5/71 (7%)	4/146 (3%)	5/84 (6%)
Repetition Nouns	10/212 (5%)	2/69 (3%)	7/86 (8%)	0/12 (0%)
Repetition Verbs	4/109 (4%)	0/58 (0%)	4/83 (5%)	2/54 (4%)

A further four-factor ANOVA (with the same variables as the target relatedness analysis in Section 9.2.2 above) revealed no significant increase in the use of low frequency target phonemes and no interaction between trial period and word class, task type or error type.

9.2.4: Increase in the proportion of word errors

The prediction made by the recovery to a "good error pattern" is that there should be an *increase* in the proportion of word errors relative to non-word errors. In order to assess this, the proportions of word errors in the further trials of each task (of the sum of word and non-word errors) were compared with the proportion on the original trials. This is presented below in Table 9.11.

Table 9.11: TK: Number of word errors in original and further trials

Task	Trials 1-4	Trials 5-8
Nouns Naming	61/119 (51%)	54/74 (73%)
Nouns Reading	35/83 (42%)	17/28 (61%)
Nouns Repetition	67/95 (71%)	19/23 (83%)
Verbs Naming	42/94 (45%)	39/66 (59%)
Verbs Reading	39/82 (48%)	23/48 (48%)
Verbs Repetition	39/64 (61%)	18/34 (53%)

A three-factor ANOVA was carried out, with the variables of trial period, word class and task type. There was a significant increase in the proportion of word errors over the two trial periods ($F(1, 6) = 11.27$, $p < 0.05$). Table 9.12 shows the means for this.

Table 9.12: TK: Means of percentage of word errors by trial period

	Mean	Standard Deviation
First 4 trials	53%	15.09
Second 4 trials	63%	20.02

The ANOVA also showed a significant effect of task ($F(2, 12) = 7.50$, $p < 0.01$), with a Newman-Keuls test revealing significantly higher proportions of word errors on repetition than on naming ($p < 0.05$) and reading ($p < 0.01$). This confirms the findings from section 3.5.2.1 and 4.2.1 of an unusually high ratio of word errors in this task. There were no significant interactions between the variables.

9.2.5: Reduction in perseveration

A further prediction made by the theory of a shift to a good error pattern is of a reduction in the amount of perseveration. In order to analyse this, the numbers of total and blended perseverations in each noun task of the further trials were found, using the same procedure as outlined in Chapter 6. The findings are shown below in Table 9.13, along with the numbers of perseverative responses in the original trials for comparison.

Table 9.13: TK: Number of total and blended perseverations in the original and further trials

	Trials 1-4			Trials 5-8		
	Naming	Reading	Repetition	Naming	Reading	Repetition
TP & BP	111/138 (80%)	53/81 (65%)	78/100 (78%)	58/102 (57%)	19/32 (59%)	20/24 (83%)

A two-factor ANOVA with the variables of trial period and task type showed no significant reduction in the amount of perseveration over time. Furthermore, there was no effect of task or interaction between trial period and task type.

9.3: Summary and discussion of change over time

TK showed an improvement in his spoken word production in that he produced more correct responses on the further trials of the tasks than on the original trials (section 9.2.1). Noun trials improved more than verb trials, and reading and repetition more than naming (ibid.).

There was a tendency for error responses on the further trials to be more target related than on the original trials, although this was not significant (section 9.2.2). There was no significant increase in the realisation of low frequency target phonemes (section 9.2.3). The increased activation through the system suggested by the increase in the number of correct responses predicts an increase in the chances of target phonemes being selected, as error phonemes are more effectively inhibited. It is therefore disappointing that there was not more evidence of an increase in target phonology in errors in general and low frequency target phonology in particular. One possible reason for this is that the set of low frequency consonants included /h/, which was found to be TK's most favoured consonant in the original trials (section 6.3.2). The over-representation of /h/ in the original trials may have inflated the rate of low frequency target consonants. This consonant actually accounted for 27% of the total number of low frequency target consonants in the original trials (with all tasks combined), but only 11% in the further trials. However, when the proportions of low frequency target consonants in the original and further trials were recalculated with /h/ removed, there was a negligible difference, possibly because of the small numbers of items involved.

There was a significant increase in the proportion of word errors relative to non-word errors (section 9.2.4). This is evidence of a shift to a "good error pattern" (Schwartz et al. 1994), occurring because as activation from the lexical level to the phoneme level increases, feedback to the lexical level should also increase, reinforcing lexical errors. A second prediction of this shift is a decrease in the proportion of perseverative errors, as a stronger flow of incoming activation should be more likely to override residual activation. This prediction was not supported by the data (section 9.2.5). Again, this is disappointing, given that TK's spontaneous speech indicated a striking reduction in perseveration, seen in the third speech sample presented in the introduction to this chapter.

It was also noted that TK's spontaneous speech appeared to become empty and anomic, despite an improvement in the number of correct responses in formal testing. This is similar to the pattern demonstrated by VN (Kohn and Smith 1994b), whose pauses, gaps and fillers are suggested to be strategies to avoid difficult lexical retrievals. It is also consistent with both serial and interactive activation accounts in which recovery entails increased monitoring and hence the editing out of erroneous responses. Even if there has been some improvement in lexical retrieval, this may not be able to "catch up" in connected speech, leaving word-finding gaps and fillers. The hypothesis of an improvement in monitoring is supported by an increase in the number of no responses and false starts in the experimental data: there were 35 such examples across all tasks in the further trials compared with just 3 in the original trials.

In summary, TK showed some improvement over the course of time, characterised by an increase in the number of correct responses. There was also evidence of an increase in word errors and a tendency towards an increase in the use of target phonology, although this was not significant. This partially meets the predictions of an interactive activation account of spoken word production in which recovery entails the strengthening of connections throughout the system and hence an increase in the flow of activation, boosting the retrieval of target phonology and the reinforcement of lexical errors by feedback activation. It is acknowledged that this evidence is limited, and the hypothesis would be more convincing if there had been more evidence of an increase of target phonology in error responses and a significant reduction in the amount of perseveration predicted by an increase in the flow of target activation. There was less support in the experimental data for an anomia theory of non-word production, which predicts no increase in target relatedness and remains silent on an increase in word error relative to non-word errors, although TK's connected speech became more anomic in character. It can only be concluded that TK's data does not completely fit any of the patterns of recovery predicted by the different models.

Chapter 10: General discussion and further directions

This account of the spoken output of two individuals with a clinical presentation of neologistic jargon aphasia has examined their performances on basic single word production tasks and then explored some of the more striking features of their production in further depth. These features will be summarised below, followed by a discussion as to which model of spoken word production can most comfortably accommodate them. Finally, problems and questions will be examined, along with suggestions for further study and the clinical usefulness of such research.

10.1: Summary of findings

10.1.1: Task effects

RS and TK both had severe difficulties with object and action naming. This indicates that semantic-lexical processing (upon which picture naming relies) was severely impaired. They were both better at reading (inconsistently in the case of RS) and at repetition. This suggests the availability of non-semantic routes for these processes.

RS had some sub-lexical repetition skills, as demonstrated by his performance on non-word repetition (section 2.1.4.2). His sub-lexical reading skills were more impoverished, as demonstrated by his performance on non-word reading (section 2.1.4.3). Auditory input generally appeared to be stronger than visual input, as demonstrated by spoken word/written word comprehension (section 2.1.2). These impressions from the preliminary tests were confirmed by the experimental tasks, in which RS performed significantly better on repetition than on reading (section 3.5.1.1).

For TK, on the other hand, reading was stronger than repetition in the experimental tasks (section 3.5.2.1). The finding that his reading comprehension for single words was better than his auditory comprehension (section 2.2.2) suggests superior visual input compared with auditory input. However, he demonstrated relatively good sub-lexical repetition skills, as shown by his non-word repetition (section 2.2.4.2). His performance on non-word *reading,* on the other hand, was poor when first tested (section 2.2.4.3) but improved to a level equal to that of non-word repetition when repeated after the first pair of trials (section 7.4). It was not clear whether this represented a genuine improvement in sub-lexical reading, or whether the poor performance on the first test was due to non-linguistic factors (for example a reluctance to attempt the task).

10.1.2: Word and non-word errors

Both participants were said to have neologistic jargon aphasia because they produced numbers of non-words at strikingly higher rates than the relatively unselected aphasic control participants (section 3.6.5). However, both also produced substantial numbers of word errors. There was some evidence that these errors should be regarded as genuine lexical retrievals and not jargon homophones. On one hand, both RS and TK tended to produce shorter word errors than non-word errors (section 4.2.4), which according to Franklin (1989, in Nickels & Howard 1995) may suggest that they were more likely to be jargon homophones. However, their real word CVC errors were produced at rates significantly higher than chance as defined by Gagnon et al. (1997) in all tasks, with the exception of repetition for RS (section 4.2.5). In addition, word errors tended to conform to the word class of the target (section 4.2.3). However, there was no evidence that word errors were higher frequency than their targets (section 4.2.2) or that word errors were less target related than non-word errors (section 5.2.3).

10.1.3: Target relatedness

There was evidence that word and non-word errors had phonological relationships with their targets at levels exceeding chance on all tasks for TK and all tasks with the exception of naming for RS (section 5.2.1). This suggests that for RS, semantic processing was so severely impaired that very little target information was available at the phoneme level. Even in the case of TK, evidence of target relatedness was less strong in naming than in reading and repetition.

Where it existed, target relatedness was found to be a general characteristic across all responses, not a bias resulting from a small number of highly target related items (section 5.2.2). An additional check demonstrated that even minimal phonological overlaps between targets and corresponding errors occurred at rates above chance (ibid.). The finding of target relatedness demonstrates that errors in jargon aphasia may be less disordered and dissimilar to the errors produced by individuals with other forms of aphasia than is often assumed. (Although not formally analysed, the non-semantic errors of aphasic control participants tended to be clearly target related.)

10.1.4: Perseveration

Both participants produced large numbers of perseverative errors (section 6.2.1). Although somewhat liberal criteria were used for identifying blended perseverations, they still appeared at higher rates in RS and TK's data than in the data of the aphasic control participants (ibid.). There were two features of the participants' perseveration which were difficult to explain. Firstly, there were often lengthy gaps between perseverative responses and their sources (section 6.2.2). This causes problems for explanations in which perseveration is simply the result of residual activation from a previous response. Secondly, a small number of total perseverations were non-words (6.2.5.6). This cannot be explained by residual activation at the lexical level, which can only account for total perseverations which are words.

An examination of the phoneme frequency distributions of both participants revealed a correlation with the English phoneme frequency distribution (section 6.2.5.1), but with certain consonants being over-represented across trials and tasks: /k/ and /l/ in the case of RS and /h/ in the case of TK (section 6.2.5.2). These consonants were more likely to occur in perseverative than non-perseverative responses (section 6.2.5.3). Furthermore, they were more likely to occur than other higher frequency consonants (section 6.2.5.5). These consonants were therefore regarded as default phonemes, readily available to fill gaps in the absence of target phonology. It was speculated that such default phonemes may arise in an impaired system because of changes in their resting levels of activation (ibid.).

Total perseverations were hypothesised to arise at the phoneme level rather than the lexical level, an explanation which accounts for the occasional non-word total perseveration (section 6.2.5.6). They were explained as resulting from the reassembling of units of perseverative material into previously used combinations. This hypothesis fits well with the default phoneme theory outlined above: the reliance on a small number of phonemes is more likely to result in the reproduction of a whole response. Furthermore, combinations which corresponded to words were reinforced by feedback to the lexical level and hence more likely to recur than non-word combinations.

10.1.5: Frequency effects

RS and the aphasic control participants tended to show an advantage for high frequency words over low frequency words (section 7.2). However, TK showed a striking advantage for low frequency words in the early trials of repetition of nouns and verbs, in terms of the number of items successfully retrieved (section 7.2) and in the target relatedness of errors (section 7.3.1). This inverse frequency effect diminished on the second pair of the original trials because of an increase in the number of high frequency words which were correctly repeated, the success rate on low frequency words remaining static. It was also striking that at the time of the early trials, non-words were repeated more successfully than words, particularly high frequency words (section 7.3.3). Like low frequency words, the success rate on non-word repetition did not improve over time.

This led to a hypothesis in which low frequency words were treated as if they were non-words. This required them to be rejected as words at the auditory input level. It was speculated that this may have been due to neighbourhood effects: if high frequency words have denser phonological neighbourhoods, then in the event of weak activation, a high frequency word may have been more likely to activate an erroneous lexical representation from the same neighbourhood. A low frequency word, from a sparser neighbourhood, would be more likely to fail to activate any lexical representation. It would therefore have been processed sub-lexically as a non-word (section 7.3.3). This was supported by evidence of a higher proportion of word errors to high frequency than low frequency targets, in keeping with the hypothesis that they were in fact lexical selection errors at the input level (ibid.). However, the analysis of all 8 trials showed that contrary to the prediction of a continued reduction in the inverse frequency effect, there was no overall reduction in this effect over time (Section 9.2.1). TK's performance on low frequency words may have improved because of a step-wise improvement in sub-lexical processing.

10.1.6: Word class effects

Whereas the control aphasic participants as a group showed no tendency to favour one word class over another, the experimental participants showed markedly different word class effects across the three tasks. These were investigated separately in greater detail. TK had an advantage for nouns over verbs in naming and reading. However, he had an advantage for verbs over nouns in the early trials of repetition (section 8.2). As with the inverse frequency effect in the early trials of this task, it was hypothesised that verbs were processed sub-lexically, thus by-passing lexical-semantic damage (section 8.2.1). This was supported by evidence that if he was encouraged to process verbs via semantics, his performance diminished. This was in contrast to the provision of additional semantic/syntactic information for noun targets, which *facilitated* his performance. A possible reason for verbs being processed sub-lexically was not explored, but it was speculated that it may have been the burden of processing a morphologically complex word at the input level which led to its being processed via a different route (section 8.2.2).

RS on the other hand showed an advantage for nouns in reading and repetition but an advantage for verbs in naming (section 8.3). The possibility that this reflected a categorical distinction between functional and perceptual semantic information was considered but rejected (section 8.3.1). It was hypothesised that in action naming, he benefited from additional syntactic information (8.3.2). This was supported by evidence that when given a semantic/syntactic context in repetition tasks, his performance improved (section 8.3.2.2). His diminished performance on reading and repeating verbs was hypothesised to be due to their morphological complexity (8.3.3). This was supported by evidence that he repeated verbs better with irregular inflections than with regular inflections, and that his performance on repeating nouns was also diminished when regular inflections were added. Rather than being unable to process the inflectional affix, he tended to reproduce this part successfully at the expense of the word stem (section 8.3.3.5).

10.1.7: Change over time

As TK's performance was noted to have improved over the original trials of the three tasks, a further four trials were carried out in order to investigate patterns of recovery. It was found that he produced more correct responses on these further trials, with this improvement being stronger in nouns than in verbs (9.2.1). There was limited evidence of an increase in the target relatedness of errors (9.2.2) and no evidence of an increase in the realisation of low frequency target phonemes (section 9.2.3). Support for a shift to a "good error pattern" was found from the increase in the proportion of word errors relative to non-word errors (section 9.2.4), but this would also predict a reduction in perseveration, which was not seen (9.2.5).

10.2: What model of spoken word production?

It will be argued that RS and TK's spoken word production can be accommodated most comfortably into a model in which there is feedback from the phoneme level to the lexical level, but not necessarily from the lexical to the semantic level. The Restricted Interaction Account (RIA) described by Rapp and Goldrick (2000) and Goldrick and Rapp (2002) is an example of such a model. As outlined in section 1.5, it has a semantic level (consisting of semantic feature nodes), a lexical level (which is linked to a system of syntactic features such as word class, number, tense etc.), and a phoneme level (consisting of the individual phoneme units). The following sections will attempt to describe the processing mechanisms of each task and to explain how the various features of production can be accounted for by an account of this kind.

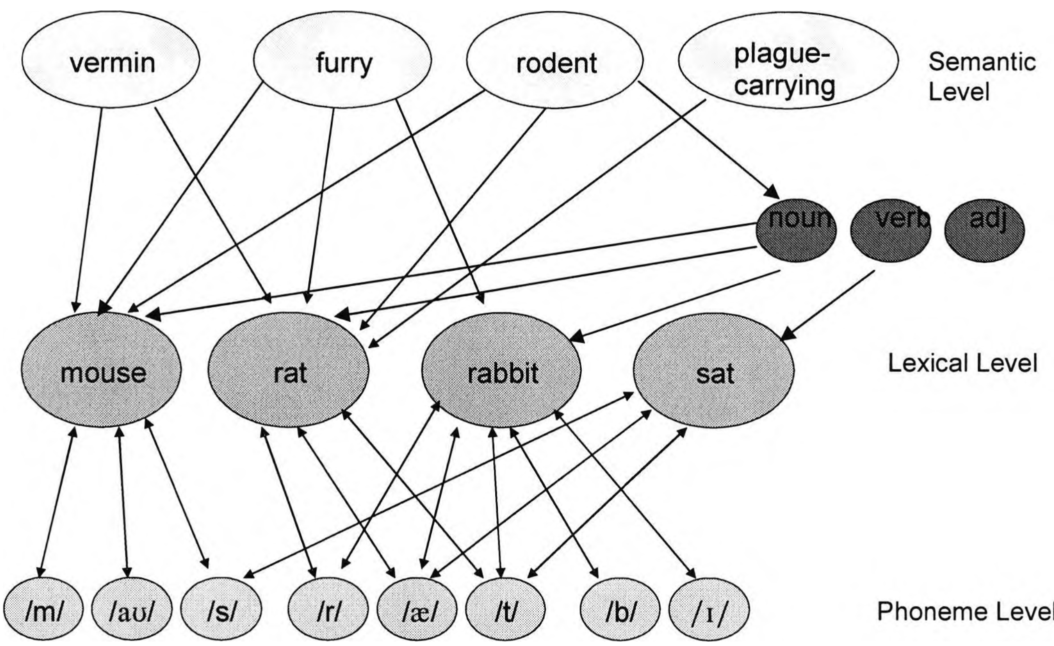
10.2.1: Naming

Figure 10.1 shows the model with respect to naming. Supposing that the target word is "rat", semantic features such as "rodent"; "furry" "vermin" and "plague-carrying" may be activated. At the lexical level (equivalent to the speech output lexicon in Figure 1.1), "rat" is activated, as are its semantic neighbours such as "mouse", "rabbit" and "cat". "Rat" passes its activation to its phonemes at the phoneme level so /r/ /æ/ and /t/ become activated. The semantic neighbours also pass on their activation to their phonemes, so /m/ /aʊ/ and /s/ become activated for "mouse", as does /k/, along with /æ/ and /t/ for "cat" and /b/ and /ɪ/, along with /r/ /æ/ and /t/ for "rabbit".

In the normal system, "rat" is more activated than its semantic neighbours and is therefore selected at the lexical level. Its phonemes are then more strongly activated at the phoneme level, and they are therefore selected for articulation. However, in an impaired system with weak incoming activation and random noise, the target lexical node may not be activated enough to be selected. In this case, a semantic neighbour may become activated to a higher degree and therefore it will be selected instead of the target. This accounts for semantic errors such as mouse, cat, or rabbit.

Figure 10.1: Partially interactive model of spoken word production for naming

(adapted from Rapp and Goldrick 2002)



However, if no lexical node is activated sufficiently to be selected, a blend of target and competitor phonemes may be selected at the phoneme level, forming an error phoneme string. This explains why there is a continuum of target relatedness, depending on how much phonemic content is derived from the target (chapter 5). This model is therefore preferable to models in which no target relatedness beyond chance is predicted (e.g. anomia theories, in which errors are non-lexically generated: section 5.1). The more target activation there is, the more target-related errors will be. Recovery entails an increase in activation throughout the system and hence an increase in the likelihood of the target node being selected at the lexical level. This is supported by the increase in the number of correct responses in the further trials (section 9.2.1).

Phoneme strings which happen to correspond to a real word are reinforced because they feed back to a lexical node (for example /m/ /æ/ /t/ feeds back to the lexical node "mat", /s/ /ɪ/ /t/ feeds back to "sit". Phoneme strings which do not correspond to words (e.g. /t/ /aʊ/ /b/ or /r/ /æ/ /s/) do not get reinforced by the feedback to the lexical level, because they do not have a corresponding lexical node. This is supported by the finding of word errors occurring at above chance levels (section 4.2.5) and by the higher levels of total perseveration of words than non-words (section 6.2.5.6). There may be such high numbers of non-word errors despite the availability of feedback because random noise in the system fluctuates dramatically, resulting in a greater or lesser flow of activation for this feedback to occur. An increase in activation at the phoneme level entails more feedback and hence an increase in the proportion of word errors, as seen in TK's recovery data (section 9.2.4).

It may also be questioned why word errors should tend to belong to the same word class as their targets (section 4.2.3) if they arise from the phoneme level and not from a higher level which is sensitive to syntactic processing. In the model described by Rapp and Goldrick (2000) and Goldrick and Rapp (2002), there are unidirectional connections from semantics to syntactic features and bidirectional connections between syntactic features and the lexical level. This means that syntactic features may be activated directly from semantics or indirectly from the lexical level. If they are activated from semantics, they have influence at the lexical level. For example, if the representation of an object is activated, the syntactic feature for the word class of nouns will be activated and pass activation on to noun nodes at the lexical level. Feedback from the phoneme level will be stronger to words that are already activated at the lexical level, so words from the target word class are more likely to be selected (Goldrick & Rapp 2002). Thus for the target "rat", feedback from /r/ /æ/ /m/ to "ram" and from /m/ /æ/ /t/ to "mat" will be stronger than from /s/ /æ/ /t/ to "sat" and from /r/ /aɪ/ /t/ to "write". This is supported by the finding (also in section 4.2.3) that the word class constraint was stronger in naming (the task reliant on processing via semantics and syntactic features) than on reading and repetition, which appeared to utilise non-semantic sources of activation, as described below in section 10.2.2.

Also at the phoneme level, phonemes from previous responses remain active, and this residual activation may be stronger than weak incoming activation. This gives rise to perseveration (chapter 6). When there is very little target activation, errors may be mostly composed of perseverative phonology rather than target phonology, explaining the existence of non-target related errors. In addition, it is hypothesised that there may be default phonemes which are readily selected in the event of weak incoming activation because they have higher resting levels of activation. Evidence for this comes from the finding that the participants' over-represented consonants were more likely to occur in perseverative than non-perseverative responses (section 6.2.5.3). This supports theories in which phonemes have varying resting levels of frequency, according to the phoneme frequency distribution of the language in question in the non-impaired system (Robson 1997; Robson et al. 2003). These resting levels may be idiosyncratically altered in an impaired system (Moses et al. 2004b).

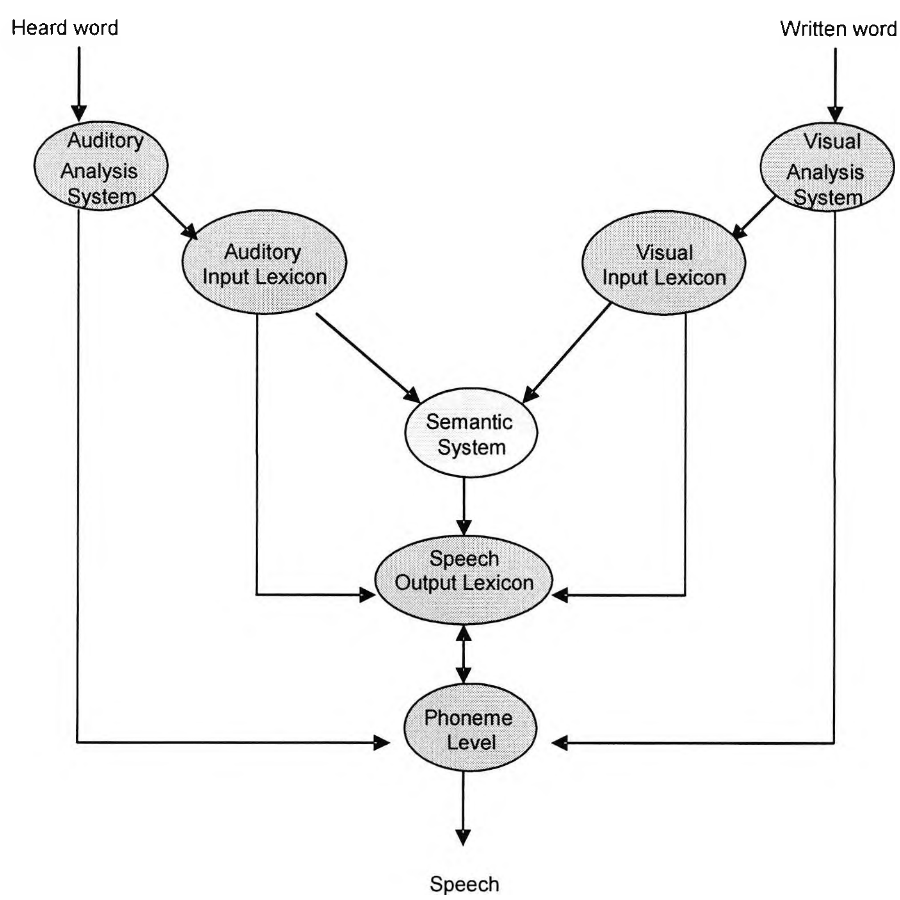
To return to syntactic processing, an advantage for verbs can be explained if activation from syntactic features can boost activation at the lexical level. For example, it was found that RS named actions more successfully than objects. It was hypothesised that this was because the act of processing an action picture, with its verb argument structure, facilitated verb retrieval because of the additional syntactic information (section 8.3.2.3). However, TK's action naming was not boosted by syntactic activation. Instead, it was worse than his object naming, possibly because of the burden of processing a more semantically complex representation (section 8.2.2).

10.2.2: Reading and repetition

Unfortunately, the restricted interaction account described by Rapp and Goldrick (2000) and Goldrick and Rapp (2002) describes only naming, and does not therefore include a model of input processes. In order to account for the effects noted in reading and repetition, the model outlined in Section 1.2.1.5 can used. The figure presented previously (Figure 1.1) has been adapted here (Figure 10.2) to show the feedback from the phoneme level to the speech output lexicon (lexical level).

As described in Section 1.2.1.5, there is a semantic route, from auditory or visual input to the semantic system, from where processing continues in the same way as for naming. For both participants, reading and repetition were found to be superior to naming in terms of the number of correct responses and also in terms of target relatedness. This suggests the availability of processing routes additional to semantic processing, which supply extra activation. These routes are the sub-lexical route (in which activation is passed directly from the auditory or visual analysis system directly to the output phonemic level) and the direct lexical route (in which activation passes from the auditory or visual input lexical level to the speech output lexicon, or lexical level). Activation from these three routes converges at the phonemic level where it is summated (Martin & Saffran 2002).

Figure 10.2: Partially interactive model of spoken word production for reading and repetition



It has already been noted that RS's naming was severely impaired because it relied on a damaged semantic system. His reading was better, suggesting that there was a contribution from the direct lexical and/or sub-lexical routes. This may have been inconsistently available because of a poor input signal and fluctuating noise, explaining why his performance on reading was inconsistent (Table 3.3). Repetition was clearly his strongest task. It is hypothesised that there was better spoken word than written word input to semantics (as demonstrated by his superior performance on spoken word to picture matching compared to written word to picture matching, section 2.1.2). In addition, more sub-lexical activation was available for repetition, as demonstrated by his non-word repetition compared to his non-word reading (section 2.1.4.2).

A reduced reliance on semantic processing may explain why RS's reading and repetition did not benefit from syntactic activation. When this was harnessed in tasks designed to encourage semantic/syntactic processing in repetition, his performance improved (section 8.3.2). Finally, RS had difficulties with the burden of processing morphologically complex words, for which the word stem and affix are hypothesised to be assembled at the word form level (e.g. Caramazza et al. 1988), or the phoneme level in this model. He was able to produce the affix more readily than the word stem, perhaps because it was high frequency and also because it harnessed his perseverative tendencies (section 8.3.3.5).

TK's reading and repetition are more challenging to explain. It is hypothesised that he was able to read via semantics and also via the direct lexical route, the additional route explaining his superior performance on reading compared with naming (section 3.5.2.1).

His sub-lexical reading skills were more inconsistent and may not have been available at the time of the early trials (section 2.2.4.3). Sub-lexical *repetition* on the other hand was a relative strength for TK. It was hypothesised that when he relied on this, he was more successful than when he relied on lexical processing. This was said to account for his superior performance on both low frequency targets and verb targets. High frequency targets and noun targets were processed via lexical-semantic routes which were more impaired (section 7.3.3; 8.2.2). It should be noted that in the Restricted Interaction Account, lexical frequency is encoded at the output lexical level (Rapp & Goldrick 2000; Goldrick & Rapp 2002). However, the inverse frequency effect in repetition was hypothesised to be due to neighbourhood density effects at the *input* lexical level. Furthermore, Goldrick and Rapp (2002) state that units in their *output* lexical level may be modality-specific or modality-neutral. Units in the input lexical level envisioned here are hypothesised to be modality-specific, in order to explain the phonological neighbourhood effects suggested to account for the inverse frequency effect in repetition.

10.3: Difficulties and omissions

While many aspects of the participants' data are consistent with the model described above, others are not. This section will mention these aspects, before examining some of the larger conundrums in the data in more detail and discussing some short-comings of the research.

It is argued above that word errors occur because of feedback from the phoneme level to the lexical level, provided that there is sufficient activation to drive it. This suggests that word errors should be more target related than non-word errors, because word errors arise when there is more activation at the phoneme level. This prediction was not supported by the data (section 5.2.3). For the same reason, word to non-word ratios are predicted to be greater on stronger tasks. This was not supported by RS and TK's data (section 3.5.1.1; 3.5.2.1). Similarly, there should be less evidence of perseveration on stronger tasks because of stronger incoming activation. Again, this was not the case (section 6.2.1). There were also several features in TK's recovery data which did not meet the predictions of an increase of activation in the model: there was neither a significant increase in the target relatedness of errors (section 9.2.2.), nor an increase in the retrieval of low frequency target phonemes (section 9.2.2), nor a decrease in perseveration (section 9.2.5).

Other somewhat weightier difficulties with the explanations for features of the data remain. For example, the hypotheses for the different word class effects observed in the data of both participants invoked morphological complexity. In both cases, this could have been investigated further if reading and/or repetition tasks had been carried out without the inflectional affix (–ing). In the case of RS, it was hypothesised that verbs were disadvantaged by the cost of processing a morphologically complex word. It is therefore predicted that the removal of the affix would reduce this disadvantage (section 8.3.3.5). In the case of TK, the hypothesis that the burden of processing the inflectional affix caused verbs to be processed sub-lexically would predict that removing the inflection would lower the advantage for verbs, as this would encourage processing via the damaged lexical route (section 8.2.2). Unfortunately, TK's advantage for verbs over nouns in the early repetition trials remained elusive because the effect had diminished by the time it was investigated.

Similarly, it has been noted that TK's inverse frequency effect in repetition was not fully investigated at the time when it was most strongly apparent (section 7.4). For example, the finding of an advantage for non-words over words in repetition could have been verified by further testing (section 7.4). The speculative explanation for the effect was flawed, particularly because of the absence of a (normal) frequency effect in the auditory lexical decision task (PALPA 5) which *was* carried out in the early stages of the research (section 7.3.3). As the hypothesis hinges on neighbourhood effects at the input level, a more appropriate test would have been an auditory lexical decision task designed to test for neighbourhood effects, as suggested in section 7.4. In addition, this hypothesis assumes that low frequency words have sparser phonological neighbourhoods than high frequency words. This is mentioned as a possibility by Marshall et al. (2001) in their phonological hypothesis for JP's inverse frequency effect but not supported by evidence. Other authors have found more complex interactions between lexical frequency and phonological neighbourhood size (Andrews 1989; Woolf 2004). In the current study, such a neighbourhood effect cannot have occurred as a result of high frequency words tending to be shorter (and therefore have larger neighbourhoods) than low frequency words, because the experimental stimuli were matched for length across the two frequency groups.

A more general point needs to be made about the investigation of frequency. Firstly, lexical frequency values throughout the research were taken from Francis and Kuçera (1982). These values are based on *written* word frequencies of *American* English. It may have been more appropriate to have used values taken from the CELEX lexical database (Baayen et al. 1995), which are based on the spoken word frequencies of British English (Cuetos, Aguado, Izura & Ellis 2002). However, as noted in section 3.2, the stimuli were based on the high and low frequency groups from PALPA 54, as these were readily available in the clinical setting. It may also be argued that the variable of age of acquisition should have been used instead of frequency or at least been more explicitly controlled because recent research has suggested that this may be a more important variable than frequency in picture naming (e.g. Cuetos et al. 2002; Johnston & Barry 2005). However, while stimuli in the two frequency groups were not matched pair-wise for age of acquisition, an attempt was made to ensure that the groups as a whole were closely matched for this variable.

It is also acknowledged that other areas of the participants' production were not explored. For example, several investigations of the features of RS and TK's production discussed the role of semantics (for example the semantic neighbourhood hypothesis for TK's inverse frequency effect in repetition (section 7.3.2); the semantic hypothesis for RS's advantage for verbs in naming (section 8.3.1)). More in-depth investigations of the participants' semantic processing (for example synonym judgements) may have shed further light on these hypotheses. It may also have been useful to investigate writing, to draw further support for theories of patterns of integrity and impairment of their language systems. RS did not demonstrate any spared ability to write, but TK frequently used writing as a strategy to aid communication. His written output was similar to his spoken output, being characterised by a mixture of words and non-words with varying degrees of target-relatedness. Perseveration was also a feature. However it was not possible within this study to compare it more formally with his spoken output. The model outlined above also makes some assumptions which were not explicitly examined in this research. For example, the absence of feedback activation from the lexical level to the semantic level could have been explored by examining patterns of mixed errors.

A wider question remains: if the various features of the participants' production can be explained in a single model, why are these effects not more commonly seen in people with aphasia? For example, reduced activation at the auditory input level may be assumed to be a frequently occurring impairment in aphasia, yet the inverse frequency effect observed in TK's repetition, argued to arise from this impairment, appears to be extremely rare (or at least very under-reported). Was TK's processing unusually sensitive to neighbourhood effects at this level? It could be argued that individuals with jargon aphasia have more abnormally fluctuating levels of random noise than people with other forms of aphasia, and that this may account for the idiosyncratic patterns that are observed. However, the question as to why a reduced flow of activation through the system causes jargon aphasia in some individuals and non-fluent forms of aphasia in others remains unanswered.

10.4: Further directions

There were certain features of the phenomenon of perseveration which may merit further exploration. For example, there was anecdotal evidence that RS's stereotypical utterances changed over time. In the initial stages of the research, plosive clusters dominated as word or non-word initials (e.g. /klædʒɑd/; /kræstɪmən/; /plumən/). In the later stages, /s/ clusters emerged as stereotypical initials (e.g. /smæg/; /skəʊp/; /sləʊl/). There was also anecdotal evidence that he became more perseverative in his spontaneous speech and in therapy tasks after the experimental trials had been completed. During this time, he suffered further infarction. It may be that his system got progressively more clogged up with default material as target activation from higher semantic-lexical levels progressively diminished. There may have been a similarity between RS and FM, the participant followed by Graham, Patterson and Hodges (2001) in a longitudinal study of jargon agraphia, whose written responses became progressively less target related and more perseverative. However, it was felt that a longitudinal study of RS's possible deterioration, contrasting with TK's apparent improvement, was not appropriate for ethical reasons.

In addition, further analysis of the phoneme frequency distribution could examine vowels as well as consonants. This may lead in turn to an investigation of over-used syllable patterns. Finally on perseveration, it was speculated that there may be a relationship between default phonemes and stereotypical utterances (section 6.3). Further examination of this may shed light on whether default phonemes are the building-blocks of stereotypical utterances or whether it is the stereotypical utterances which come first, their over-use raising the resting levels of activation of their phonemes so that they become more available as default segments.

Further work may involve exploring predictors of recovery in jargon aphasia. Kohn and her colleagues researched the patterns shown by recoverers and non-recoverers using a serial model of spoken word production (Kohn et al. 1996). What predictions would be made by the partially interactive model described above? For example, TK, who was argued to show evidence of recovery (chapter 9), produced higher proportions of word errors than RS, who did not appear to improve. Furthermore, it was TK who showed evidence of target relatedness on naming, the one task which relied on activation via semantic processing (chapter 5). RS, on the other hand, showed more convincing evidence of a reliance on default phonemes than TK (chapter 6).

Finally, this research has not addressed therapy or the clinical implications of the findings. Perhaps only a very general assertion can be made on the subject here, and it is one that has often been made before: that jargon aphasia is not a unitary disorder. Each person said have jargon aphasia is likely to have a highly individual pattern of language breakdown and integrity resulting in a unique set of features. This has positive and negative implications. On the positive side, clinicians should not be afraid of experimenting with different therapies and should not feel disheartened when their planned therapy does not appear to have the desired results. It may be that in a system which is unusually sensitive to different variables, finely tuning the therapy task or approaching the therapy from a slightly different angle may have more positive results. On the negative side, it implies that we are still not in a position to state with confidence exactly where a breakdown may lie and to plan tailor-made therapies informed by a proven model of spoken word production.

Appendix 1: Noun and verb stimuli

Noun stimuli

High frequency	Low frequency
Window	cannon
Watch	stool
Train	clown
Table	camel
Key	axe
House	broom
Horse	flute
Heart	glove
Hair	frog
Hand	harp
Glass	snail
door	sock
Church	grapes
Book	comb
Bottle	hammer
Ball	leaf
Arm	owl
Knife	thumb
Telephone	butterfly
Gun	nut

Verb stimuli

High frequency	Low frequency
Drawing	begging
Eating	skipping
Walking	licking
Running	barking
Playing	combing
Dropping	typing
Watching	peeling
Writing	knitting
Swinging	bleeding
Cutting	posting
Kissing	dripping
Catching	sewing
Smiling	skating
Riding	juggling
Driving	raking
Building	tickling
Carrying	diving
Sitting	kicking
Shooting	ironing
Reading	yawning

Appendix 2: Task position effects in basic naming, reading and repetition tasks

As noted in section 3.2, a post hoc analysis of task position effects was undertaken on the data of both individuals to check that maintaining the same order of stimuli in each trial of each task did not bias the results (in other words, that stimuli appearing early in a task were neither advantaged or disadvantaged compared to stimuli appearing later in the same task). The stimuli in each task were divided into four parts according to their position (i.e. the first 10 stimuli in a specific task, the second 10 stimuli, the third 10 stimuli and the fourth 10 stimuli). For each trial, the number of correct responses in each quarter was recorded. Scores from each trial of a task were totalled. The results are presented below.

RS: Number of correct responses in naming, reading and repetition of nouns and verbs quarter by quarter (all trials combined)

	Naming				Reading				Repetition			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Nouns	5	1	0	3	4	8	7	10	29	30	19	30
Verbs	4	6	7	6	3	1	4	6	27	26	23	12

Key:

1st = first 10 stimuli; 2nd = second 10 stimuli etc.

TK: Number of correct responses in naming, reading and repetition of nouns and verbs quarter by quarter (all trials combined)

	Naming				Reading				Repetition			
	1st	2^{nd}	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Nouns	8	4	5	6	23	27	20	18	16	11	18	17
Verbs	3	2	2	6	19	14	27	18	21	18	25	24

There were no striking task position effects in the performances of either RS or TK. It was not the case that items presented early in a task had an advantage over later items (as the result of a fatigue effect) or vice versa (as a result of "warming up" into the task). This provides evidence that maintaining the same order of stimuli in each trial did not bias the results.

Appendix 3: Data on control participants

Performance of 10 non-brain injured control participants in naming, reading and repeating nouns and verbs: total numbers of correct responses and error types

	Correct Responses			Error Responses					
Task	Total	Hi F	Lo F	Sem	DSem	Word	Nword	Other	All E
NN	386	197	189	18	-	-	-	-	18
NR	400	200	200	-	-	1	-	-	1
NREP	396	200	196	-	-	5	-	-	5
VN	396	197	199	13	-	-	-	-	13
VR	399	200	199	-	-	1	1	-	2
VREP	399	200	199	-	-	3	-	-	3

Key:

Correct: Total number of correct responses

HiF: High frequency targets

LoF: Low frequency targets

Sem: Semantic/visual errors

Sem/Ph: Semantic + phonemic errors

Word: Non-semantic word errors

NWord: Non-word errors

Other: Other error types

All E: Total number of errors

NN: Nouns naming

NR: Nouns reading

NREP: Nouns repetition

VN: Verbs naming

VR: Verbs reading

VREP: Verbs repetition

In the object naming task, acceptable alternative targets were: locomotive for train (produced by 2 participants); engine for train (1 participant); bungalow for house (6 participants); forearm for arm (1 participant); revolver for gun (4 participants); pistol for gun (2 participants); chopper for axe (2 participants); hatchet for axe (2 participants). In the action naming task acceptable alternative targets were machining for sewing (produced by 3 participants) and grinning for smiling produced by one participant.

Performance of 10 aphasic control participants in naming, reading and repeating nouns and verbs: Total numbers of correct responses and error types

PB

	Correct Responses			Error Responses					
Task	Total	Hi F	Lo F	Sem	DSem	Word	Nword	Other	All E
NN	22	15	7	16	4	17	3	4	44
NR	32	14	18	1	-	24	8	1	34
NREP	36	19	17	-	-	3	7	1	11
VN	27	13	14	14	-	4	6	5	29
VR	33	16	17	-	-	14	7	1	22
VREP	35	19	16	-	-	7	7	-	14

KC

	Correct Responses			Error Responses					
Task	Total	Hi F	Lo F	Sem	DSem	Word	Nword	Other	All E
NN	37	20	17	2	-	1	-	1	4
NR	39	20	19	-	-	1	-	-	1
NREP	39	20	19	-	-	1	-	-	1
VN	36	16	20	6	-	1	-	-	7
VR	38	20	18	-	-	2	-	-	2
VREP	40	20	20	-	-	-	-	5	5

JD

	Correct Responses			Error Responses					
Task	Total	Hi F	Lo F	Sem	DSem	Word	Nword	Other	All E
NN	31	16	15	6	-	-	-	5	11
NR	40	20	20	-	-	-	-	2	2
NREP	38	19	19	-	-	3	1	-	4
VN	33	19	14	3	-	1	-	7	11
VR	40	20	20	-	-	1	-	-	1
VREP	40	20	20	-	-	-	-	-	-

KL

	Correct Responses			Error Responses					
Task	Total	Hi F	Lo F	Sem	DSem	Word	Nword	Other	All E
NN	28	16	12	6	-	18	7	-	31
NR	22	11	11	1	1	16	12	-	30
NREP	35	18	17	-	-	5	1	-	6
VN	24	10	14	10	-	4	3	10	27
VR	34	17	17	-	-	10	6	3	19
VREP	34	18	16	-	-	5	2	-	7

DM

	Correct Responses			Error Responses					
Task	Total	Hi F	Lo F	Sem	DSem	Word	Nword	Other	All E
NN	17	12	5	10	4	7	4	8	33
NR	21	14	7	-	-	13	8	-	21
NREP	27	18	9	-	-	8	6	-	14
VN	12	8	4	14	-	3	12	9	38
VR	3	-	3	2	-	30	9	2	43
VREP	23	11	12	-	-	7	11	-	18

BN

	Correct Responses			Error Responses					
Task	Total	Hi F	Lo F	Sem	DSem	Word	Nword	Other	All E
NN	25	14	11	11	4	26	30	-	71
NR	40	20	20	-	-	-	1	-	1
NREP	25	13	12	-	-	9	11	-	20
VN	20	11	9	2	4	33	6	2	66
VR	40	20	20	-	-	-	-	-	-
VREP	16	10	6	1	-	18	19	-	38

MO'C

	Correct Responses			Error Responses					
Task	Total	Hi F	Lo F	Sem	DSem	Word	Nword	Other	All E
NN	19	13	6	8	-	10	2	12	32
NR	26	16	10	1	-	5	-	12	18
NREP	34	20	14	-	-	4	1	3	8
VN	18	9	9	19	2	9	4	13	47
VR	22	13	9	-	-	16	2	6	24
VREP	29	17	12	1	-	4	1	8	14

BT

	Correct Responses			Error Responses					
Task	Total	Hi F	Lo F	Sem	DSem	Word	Nword	Other	All E
NN	35	20	15	3	-	1	2	2	8
NR	35	18	17	-	-	2	3	-	5
NREP	35	18	17	-	-	4	1	-	5
VN	31	15	16	4	1	2	-	3	10
VR	22	10	12	-	-	6	12	-	18
VREP	34	19	15	-	-	4	2	-	6

VV

	Correct Responses			Error Responses					
Task	Total	Hi F	Lo F	Sem	DSem	Word	Nword	Other	All E
NN	33	18	15	6	1	9	-	1	17
NR	39	20	19	-	-	1	-	-	1
NREP	40	20	19	-	-	1	-	-	1
VN	34	18	16	1	-	1	-	4	6
VR	28	16	12	-	-	14	2	-	16
VREP	39	19	20	-	-	-	1	-	1

PW

	Correct Responses			Error Responses					
Task	Total	Hi F	Lo F	Sem	DSem	Word	Nword	Other	All E
NN	38	20	18	1	-	2	-	-	3
NR	39	20	19	-	-	2	3	-	5
NREP	29	17	12	-	-	8	3	-	11
VN	38	19	19	3	-	-	-	-	3
VR	39	20	19	-	-	2	-	-	2
VREP	38	19	19	-	-	2	2	-	4

Appendix 4: TK: ANOVA tables across 8 trials of noun and verb tasks

In Chapter 9 (Change over time), a number of ANOVAs were used in order to analyse patterns over a total of 8 trials. Significant findings were presented in the text. The full ANOVA tables are presented below

Summary of ANOVA table for number of correct responses

Source of Variance	Sum of Squares	df	Mean Squares	F	P
A (trial period)	816.667	1	816.667	55.472	0.0003
B (word class)	15.042	1	15.042	3.085	0.1295
C (task)	1841.688	2	920.844	321.069	0.0000
D (frequency)	4.167	1	4.167	0.909	0.3772
AB	35.042	1	35.042	7.188	0.0365
AC	40.396	2	20.198	7.042	0.0095
AD	2.667	1	2.667	0.582	0.4745
BC	60.396	2	30.198	5.662	0.0185
BD	0.375	1	0.375	0.084	0.7822
CD	45.021	2	22.510	8.714	0.0046
ABC	20.771	2	10.385	1.947	0.1852
ABD	0.042	1	0.042	0.009	0.9264
ACD	4.146	2	2.073	0.892	0.4709
BCD	8.062	2	4.031	1.929	0.1878
ABCD	1.021	2	0.510	0.244	0.7871
Between Error	88.333	6	14.722		
(Error BxS)	29.250	6	4.875		
(Error CxS)	34.417	12	2.868		
(Error DxS)	27.500	6	4.583		
(Error BCxS)	64.000	12	5.333		
(Error BDxS)	26.917	6	4.486		
(Error CDxS)	31.000	12	2.583		
(Error BCDxS)	25.083	12	2.090		

Summary of ANOVA table for proportion of target phonemes in errors

Source of Variance	Sum of Squares	df	Mean Squares	F	p
A (trial period)	1497.840	1	1497.840	3.128	0.1274
B (word class)	724.900	1	724.900	3.435	0.1133
C (task)	16452.975	2	8226.488	41.207	0.0000
D (error type)	295.402	1	295.402	2.254	0.1839
AB	59.220	1	59.220	0.281	0.6153
AC	526.821	2	263.410	1.319	0.3034
AD	294.000	1	294.000	2.244	0.1848
BC	354.375	2	177.188	1.132	0.3545
BD	20.720	1	20.720	0.223	0.6537
CD	742.919	2	371.459	1.550	0.2519
ABC	74.094	2	37.047	0.237	0.7928
ABD	111.370	1	111.370	1.196	0.3160
ACD	446.779	2	223.390	0.932	0.4204
BCD	357.091	2	178.546	0.691	0.5198
ABCD	31.675	2	15.838	0.061	0.9408
Between Error	2872.947	6	478.824		
(Error BxS)	1266.183	6	211.030		
(Error CxS)	2395.661	12	199.638		
(Error DxS)	786.198	6	131.033		
(Error BCxS)	1877.937	12	156.495		
(Error BDxS)	558.526	6	93.088		
(Error CDxS)	2875.722	12	239.643		
(Error BCDxS)	3099.197	12	258.266		

Summary of ANOVA table for proportion of low frequency target phonemes

Source of Variance	Sum of Squares	df	Mean Squares	F	p
A (trial period)	36.878	1	36.878	1.900	0.2173
B (word class)	210.338	1	210.338	26.478	0.0021
C (task)	339.285	2	169.643	10.545	0.0023
D (error type)	6.050	1	6.050	0.462	0.5220
AB	45.238	1	45.238	5.695	0.0543
AC	72.221	2	36.111	2.245	0.1485
AD	17.425	1	17.425	1.331	0.2925
BC	81.541	2	40.771	6.108	0.0148
BD	0.338	1	0.338	0.029	0.8710
CD	20.088	2	10.044	0.449	0.6486
ABC	0.870	2	0.435	0.065	0.9372
ABD	0.650	1	0.650	0.055	0.8221
ACD	155.794	2	77.897	3.482	0.0642
BCD	8.068	2	4.034	0.259	0.7759
ABCD	104.785	2	52.393	3.367	0.0691
Between Error	116.477	6	19.413		
(Error BxS)	47.662	6	7.944		
(Error CxS)	193.048	12	16.087		
(Error DxS)	78.546	6	13.091		
(Error BCxS)	80.093	12	6.674		
(Error BDxS)	70.692	6	11.782		
(Error CDxS)	268.420	12	22.368		
(Error BCDxS)	186.738	12	15.562		

Summary of ANOVA table for proportion of word errors

Source of Variance	Sum of Squares	df	Mean Squares	F	p
A (trial period)	1124.235	1	1124.235	11.278	0.0153
B (task)	2846.791	2	1423.396	7.507	0.0077
C (word class)	1328.255	1	1328.255	2.610	0.1573
AB	314.738	2	157.369	0.830	0.4596
AC	609.900	1	609.900	1.199	0.3156
BC	205.588	2	102.794	0.399	0.6797
ABC	130.628	2	65.314	0.253	0.7802
Between Error	598.090	6	99.682		
(Error BxS)	2275.214	12	189.601		
(Error CxS)	3053.276	6	508.879		
(Error BCxS)	3092.608	12	257.717		

Summary of ANOVA table for proportion of perseverative errors

Source of Variance	Sum of Squares	df	Mean Squares	F	p
A (trial period)	266.667	1	266.667	1.961	0.2109
B (task)	1399.867	2	699.934	3.136	0.0802
AB	1108.156	2	554.078	2.483	0.1252
Between Error	815.913	6	135.986		
(Error BxS)	2678.077	12	223.173		

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