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Non-Fluent Primary Progressive Aphasia: A Case Study

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1. ABSTRACT

This single case study of a patient with non-fluent Primary Progressive Aphasia, JB, aimed at presenting a comprehensive picture of his abilities in linguistic and cognitive domains. The study followed the progression of the disorder over a period of three years, presenting a comprehensive neuropsychological report as well as investigations into phonology, syntax, morphology and comprehension and production of language. This case of NFPPA was especially interesting because the patient was bilingual (Hungarian – L1/English – L2) and, whenever possible, his abilities were investigated in both languages. The phonological investigation tested JB's ability in reading and repetition of single words in two testing periods (Time 1 and Time 2), controlling for syllable length and complexity. The results of the study in general showed that JB's performance was not different from other reported cases of NFPPA and that JB's abilities for most areas of interest appeared to be more preserved in L1. The results of the phonological experiment indicated that the pattern of errors appears to be similar across languages, the frequency of particular error types and the effect of complexity remain reasonably stable over time, even though performance was poorer overall at Time 2 than Time 1, and the length effect (increased level of impairment for longer targets) is more pronounced at Time 2 than Time 1. Overall results of the study are discussed in relation to similar reports and findings.

2. INTRODUCTION

Primary Progressive Aphasia (PPA) is a degenerative language disorder that has only been recently described. It was not until Mesulam (1982) described six cases of slowly progressing aphasia without signs of dementia that the disorder was defined and its systematic investigation began. Cases of progressive language disorder have been published before 1982 (Pick, 1892; Serieux, 1893; Rosenfeld, 1909; Mingazzini, 1914), but these were few and made no attempt to describe the disorder in great detail. Since 1982, interest in the disorder that has come to be known as PPA has been increasing and many reports of patients and reviews of cases have been published.

PPA usually manifests in two forms: a non-fluent type (NFPPA) and a fluent one, also termed 'semantic dementia' (SD). Mixed types of progressive aphasia have also been reported (Karbe, Kertesz & Polk, 1993). SD, the fluent type of PPA, clinically resembles Wernicke's aphasia and is associated with comprehension deficits and normal fluency (Lambon-Ralph, McClelland, Patterson, Galton & Hodges, 2001; Clark, Charuvastra, Miller, Shapira & Mendez., 2005). Any observed non-fluency in SD, which is due to frequent pausing as a result of impaired word-finding difficulties, should be distinguished from non-fluency in NFPPA which is due to phonological breakdown, and non-fluency in FTD which is due to an apathetic, amotivational state (Grossman & Ash, 2004). Patients with SD present with circumlocutory spontaneous speech that is devoid of meaningful content and is marred with frequent paraphasias. A breakdown of semantic knowledge is at the centre of semantic dementia, involving the gradual loss of the semantic features of words and objects (Garrard & Hodges, 2000; Gorno-Tempini, Dronkers, Rankin, Ogar, Phengrasamy, Rosen, Johnson, Weiner & Miller, 2004; Grossman & Ash, 2004). This results in difficulties in tasks requiring semantic memory (such as word definition and confrontation naming). The analysis of naming errors in confrontation naming tasks show that SD patients often make errors of confusion between targets and their coordinates or superordinates,, and that as the disorder progresses semantic paraphasias become increasingly less related to the target (Hodges, Graham & Patterson 1995; Lambon Ralph et al., 2001). Skills in syntax, phonology and articulation, however, remain well preserved (Hodges & Patterson, 1996). Surface dyslexia and dysgraphia with a tendency towards regularisation errors has also been observed (Warrington, 1975; Patterson, Graham&

Hodges, 1994; Noble, Glosser & Grossman, 2000). Scans show that the temporal lobes are affected (Edwards-Lee, Miller, Benson, Cummings, Russell, Boone, & Mena., 1997; Hodges & Miller, 2001), with a predominance of left temporal lobe atrophy (Mummery, Patterson, Price, Ashburner, Frackowiak & Hodges, 2000).

NFPPA, according to Clark et al. (2005), resembles Broca's aphasia in that it is characterised by reduced phrase length, agrammatism, and effortful and halting speech. Some of the patients in Mesulam's (1982) study had progressive loss of speech output and impaired repetition, despite relatively preserved verbal comprehension of single words. According to Béland and Paradis (1997), NFPPA patients show deficits in rate of speech, prosody and quality of articulatory gestures, and a tendency towards mutism. Neuroimaging studies usually indicate atrophy of the left inferior frontal region (Abe, Ukita & Yanagihara, 1997; Rosen, Kramer, Gorno-Tempini, Schuff, Weiner & Miller, 2002), and reduced metabolic activity of the anterior insula (Nestor, Graham, Fryer, Williams, Patterson & Hodges, 2003; Gorno-Tempini et al., 2004).

Hodges and Patterson (1996) compared the performance of two patients with NFPPA to that of a group of five SD patients in a longitudinal study. The patients were tested on a range of neuropsychological and language tests and the results indicated that there were differences, as well as some similarities between the groups. Both groups performed well on tests of visuoperceptual and spatial ability (Judgement of Line Orientation test, Complex Figure and Object Matching), but in contrast to the SD patients, the NFPPA participants were unimpaired on the object decision task. Digit span was impaired in NFPPA but not in SD. A dissociation was observed in verbal fluency tasks, where the NFPPA participants were more impaired on the initial-letter-fluency task whereas SD participants were more impaired on the category fluency task. Naming was impaired in both groups but the SD patients were more severely impaired. One of the major differences in the groups reported in this study is the patients' performance on single word comprehension tasks. Whereas the NFPPA participants showed preserved single word comprehension (Semantic Test Battery – Hodges, Salmon & Butters, 1992) and conceptual semantic knowledge for objects (Pyramids and Palm Trees), the performance of the SD participants was grossly impaired. On the Test of the Reception of Grammar (TROG), the NFPPA participants' performance was impaired, as opposed to SD participants who obtained a score just outside the normal range. According to Hodges and Patterson (1996), it is the tests of lexical and syntactic comprehension that distinguish between the two subgroups of PPA, with the NFPPA patients showing spared comprehension even for low frequency items and marked impairment on tests of syntactic comprehension, and SD patients showing the opposite pattern.

Agrammatism, associated with the omission of free and bound grammatical morphemes, has been reported on many occasions in the literature in NFPPA cases (Tyrrell, Warrington, Frackowiak & Rossor, 1990; Kempler, Metter, Riege, Jackson, Benson & Hanson, 1990; Caselli & Jack, 1992; Ackermann, Scharf, Hertrich & Daum, 1997). Thompson, Ballard, Tait, Weintraub and Mesulam (1997) carried out a study of four patients with NFPPA for up to 11 years post-onset in order to explore aspects of expressive language decline: mean length of utterance (MLU), the proportion of grammatical sentences, the proportion of verbs produced with correct morphology, the complexity of verb morphology, the proportion of verbs produced with correct argument structure, open- to-closed-class word ratio, and noun-to-verb ratio. For each of these variables, the performance of the NFPPA patients was compared to that of agrammatic Broca's aphasic and non-brain-damaged individuals. In terms of MLU, all four patients exhibited similar patterns of decline, below the range of non-damaged controls and similar to that of the agrammatic controls, at some point in the course of the disease. Three of the four participants produced a low proportion of grammatical sentences, falling within the mean of the agrammatic controls, whereas the fourth participant was only slightly below the mean of the non-brain-damaged controls, with no sings of marked deterioration. The authors analysed the use of bound and free-standing morphemes. Regarding accuracy, performance was similar to the production of grammatical sentences: three participants were within the agrammatic range, whereas one participant was within the norm. For complexity of verb morphology, however, all patients' performance was close to that of the agrammatic patients. The proportion of verbs produced with correct argument structure was reduced to close to or below the agrammatic mean for three participants, whereas one participant performed better. The same participant showed an open- to closed-class word ratio that was similar to controls, in contrast to the other three participants whose performance was comparable to that of the agrammatic patients.

Finally, in terms of noun-to-verb ratio, three participants exhibited a higher noun-to-verb ratio, with marked difficulty in verb production and similar to the agrammatic performance, while the fourth participant produced fewer nouns than verbs. Thompson et al. (1997) concluded that within the subgroup of NFPPA, the language processing system may be affected in different ways, similar to what is seen in patients with focal lesions. The authors state that at least two patterns of language decline are evident from this study: one pattern is similar to the deficits seen in agrammatism (impairment in the retrieval of verbs and closed-class items with a concomitant deficit in the processes that govern sentence structures), whereas the other is characterised by word-retrieval difficulties with relatively little grammatical impairment. Weintraub, Rubin and Mesulam (1990), in another study of three patients with NFPPA, reported on the patients' gradual decline in fluency and an increase in the number of grammatical errors and phonemic paraphasic substitutions. Karbe et al. (1993) describe ten cases of PPA where speech fluency, oral expression, repetition and confrontation naming appeared to be declining with the same rate. The two NFPPA patients examined by Hodges and Patterson (1996) were impaired in reversible sentence comprehension that requires the appreciation of grammatical relationships in sentences, in addition to impairments in confrontation naming, repetition and phoneme discrimination.

Other researchers such as Kartsounis, Crellin, Crewes and Toone (1991) and Croot, Patterson and Hodges (1998) argue that the deficit in NFPPA specifically affects the phonological properties of words. According to Grossman and Ash (2004), this impairment can clinically manifest as dysarthria or phonemic paraphasia. Indeed, slow, dysprosodic and hypophonic speech marred by impaired articulation, non-fluency and phonemic paraphasias is almost always reported in NFPPA (Kempler et al., 1990; Delecluse, Andersen, Waldemar, Thompson, Kjaer, Lassen & Postiglione 1990; Tyrrell et al., 1990; Caselli & Jack, 1992; Hodges and Patterson, 1996; Ackermann et al., 1997; Thompson et al., 1997; Croot et al., 1998; Clark et al., 2005). Thompson et al. (1997), in their attempt to analyse the speech errors of their NFPPA patients, describe a disorder characterised by progressive loss of articulatory agility and melodic line, progressive slowing of speech rate and prolonged pauses, and reduced intelligibility.

Croot et al. (1998), in a comprehensive study of single word production in NFPPA, examined the phonological decline of the two patients described by Hodges and Patterson (1996) in single word production. In their first experiment they compared the participants' single word production in repetition, reading aloud and picture naming. The participants were required to produce the same 180 concrete words of one, two and three syllables in each task. The largest category of error was phonologically related neologisms, with longer words being harder to produce. Both participants produced only few semantically-related errors. Another analysis described the severity of disruption of the participants' attempts by examining the proportion of simple errors (those differing from the target in one phoneme only) and complex errors (those involving more than one altered phoneme). The results showed that the proportion of phonologically complex errors was higher than simple errors in both participants, with more complex errors occurring on longer words. The main finding of the first experiment was that patients were more likely to arrive to a reasonable approximation to the target in the tasks where the stimulus provided information about the required phonological output – in reading and repetition. Although there was an impairment in all three tasks (with naming being the most impaired), results showed an small advantage in reading over repetition, suggesting that the orthographic input level is better preserved than the auditory-phonological input level. The impairment in naming indicates that in these patients the semantic route of speech production is not as efficient as the direct route (cf. McCarthy & Warrington, 1984), and that production of a phonological target is more likely to be successful if it is processed through the phonological rather than the semantic level of the lexical network (cf. Dell, 1986). The fact however that there was an impairment in all three modalities rules out a task-specific deficit and suggests that a processing level common to all three tasks (phonological encoding and/or articulatory implementation) is the underlying cause of the impairment.

In a second experiment, in which only one participant took part, Croot et al. (1998) tested the hypothesis that the patients' success in speech production will depend on the strength of the correlation between input and output forms. Input and output are said to be highly correlated when they are in the same modality – written or spoken. Repetition and copying written words are highly correlated while reading and writing to dictation are not. The number of correct responses in tasks with the same input and output modality (copying and repeating) was higher than that in tasks where input and output were different (reading and writing to dictation). However, difficulties were observed in the repetition task, and the explanation was that it arises from the demands for phonological processing at both input and output stages of the task. The main conclusion from this study was that the lack of phonological support in picture naming is the cause of greater difficulty in naming than in reading and repetition, and that there is a length effect in NFPPA whereby longer words yield more errors because of an increased opportunity to produce an error.

Patients with NFPPA also exhibit difficulties in word-finding which seem to increase with the progression of the illness (Weintraub et al., 1990; Grossman, Mickanin, Onishi, Hughes, Morrison, D'Esposito, Robinson, Alavi & Reivich 1996; Hodges & Patterson, 1996; Thompson et al., 1997). Moore, Dennis and Grossman (2003) found that 24% of the NFPPA patients in their study had a confrontation naming impairment early on in the course of their disorder. This difficulty with confrontation naming was associated with a limitation in lexical retrieval, compared to similar difficulties in SD patients which were associated with both lexical retrieval and semantic memory. Grossman and Ash (2004) suggest that the naming deficit in NFPPA is due to impairment at the level of phonetic assembly of the word form, as evidenced by phonemic paraphasic errors and not semantic errors. (Weintraub et al., 1990; Grossman et al., 1996; Moore et al., 2003).

Hillis, Tuffiash and Caramazza (2002) reported naming difficulties in NFPPA that are specific to verbs. Their participants were tested on oral and written naming and word-picture verification over a period of time. The experimental corpus consisted of 30 pictures of actions, 30 pictures of objects with verbal labels matched for surface frequency, and 30 pictures of objects with verbal labels matched for cumulative frequency with the verbs. Results showed that in general all patients were better at oral naming of objects than actions until the late stages of their disorder when marked deterioration was observed for both categories. Different errors were made in object and action naming; in action naming there were many semantic errors while in object naming there were predominantly phonological errors. In contrast to oral naming however, written naming of both objects and actions in all patients was relatively more preserved for a longer period of time, and word-picture verification remained unaffected for both nouns and verbs at all stages of the investigation. Hillis et al. (2002) offer a number of possible explanations for the discrepancy between oral and written naming; they state that the earlier deterioration of verbs in the oral modality compared to nouns could be due to an impairment of a lexical-phonological mechanism that is critical to the production of verbs but not to nouns. To explain the relative preservation of written verb naming as opposed to oral verb naming, they suggest that the lexical-phonological access to verbs is impaired but lexical-orthographic access to them is spared. The authors also state that the fact that in all patients the oral naming of verbs (and eventually the oral naming of nouns) deteriorated before the written naming of both nouns and verbs is an indication that the neural processes subserving the lexical-phonological representation of nouns and verbs are adjacent and thus damage in this progressive type of disorder has spread from the affected verb mechanisms to the equivalent noun mechanisms. Alternatively it could be that there is a mechanism common to the oral naming of both nouns and verbs (for example motor speech programming or articulation of speech), which was affected before the equivalent mechanism common to the written naming of these grammatical categories. The authors also state that although the patients were 100% accurate on word-picture verification, the possibility of a subtle semantic deficit cannot be completely ruled-out, since picture naming requires more intact semantic information than word-picture verification. Other authors like Bak and Hodges (1999) and Bak, O'Donovan, Xuereb, Boniface and Hodges (2001) have speculated that the action naming deficit in NFPPA patients could be due to histopathologic distributions of disease in the motor association cortex. Bak and colleagues examined NFPPA patients with concomitant motor neuron disease and argued that degradation of sensory-motor semantic features associated with verbs that are stored in the motor association cortex is the underlying reason of impaired verb naming.

In conclusion, NFPPA affects speech output, making it non-fluent with speech rate deficits, deficits in prosody and articulatory gestures. It also affects the phonological representation of words, leading to frequent phonological paraphasic errors with a preponderance of complex rather than simple phonological errors, and phoneme discrimination impairments. Comprehension of single words appears to be well preserved in NFPPA, but grammatical comprehension is comprised, often leading to agrammatic comprehension. Naming difficulties are present in many cases, possibly, affecting verbs more than nouns. Reading and repetition are also affected, although the degree of impairment appears to depend on the individual case. In relation to cognition, visuoperceptual abilities and memory are well relatively preserved, but digit span is impaired.

Although there have been many studies on NFPPA in the past and some have explored in detail certain aspects of the disorder, no single study has attempted an exploration of a patient's abilities in several linguistic and cognitive domains. The present study follows the progression of the disorder over a period of three years, exploring the abilities and impairments of a single individual in cognition and language. A detailed neuropsychological profile is presented as well as investigations in phonology, syntax, morphology and comprehension and production of language. The fact that the patient described is bilingual introduces an additional interesting parameter to this investigation. It will be most interesting to observe performance in similar tasks in both languages, and any discrepancy found between the two languages may provide important insights into the organisation of language in the brain.

3. METHOD

Clinical background

JB is a 66-year-old, right-handed, bilingual man who came to the attention of the researchers in 2002, at which point his speech output was already impaired. History of his condition spans a period of almost eight years prior to initial examination by the present researchers.

JB's first language is Hungarian. He received eight years of education in Hungary before permanently moving to England at the age of 14. He is married and has two children with whom he speaks English, and has worked as a car painter sprayer until retirement. According to reports from his wife, his level of English pre-morbidly was excellent. His contact with Hungary and the Hungarian language, although maintained, was sporadic. The decision to test JB in both languages stemmed from reports that he was better at expressing himself in Hungarian.

An MRI scan in 2001 showed sulcal widening, somewhat more prominent in the left hemisphere. The latest MRI scan in May 2003 has shown evidence of a mild degree of generalized volume loss, profound perisylvian atrophy with a left sided predominance, and relative preservation of mesial temporal and posterior cortical structures (see Appendix 1). Initial psychometry in 2001 showed a verbal IQ of 83 and a performance IQ of 99. Subsequent psychometry in February 2002 showed a marked deterioration in both IQ categories (verbal IQ 61, performance IQ 74). Verbal ability, digit span, praxis and calculation were all impaired but memory function was relatively spared and he appeared well oriented in time and space.

JB's wife reports that she first noticed a tendency towards logopenia and word finding and naming difficulties in English in 1999. His writing had been affected about the same time. JB's verbal output has progressed from sparse attempts at dysfluent speech characterised by frequent phonemic errors, to effortful production of a restricted set of single phonemes. His comprehension was initially unaffected and he was able to understand conversations and engage in everyday activities. Comprehension however is now impaired and JB is having difficulty understanding new information and following instructions.

Cognitive testing explored JB's abilities in visual and spatial perception, conceptual knowledge, memory, executive function and problem solving. Testing took place during 2002-2003, 2004 and 2005 (see following section). He was tested on the Visual Object and Space Perception Battery (VOSP – Warrington & James, 1991) where he performed well on all the subtests not involving speech production in all testing periods. JB was also tested on face recognition in the Camden Recognition Memory Test (Warrington, 1996) in 2005. His performance was within the norm (22/25 correct). In terms of conceptual knowledge, JB's performance appears to vary widely according to the test; on the Pyramids and Palm Trees test he performed well within the norm on all occasions he was tested (50/52, 49/52, 49/52), whereas on the Kissing and Dancing test his performance deteriorated as time progressed (49/52, 43/52 – testing in 2002-2003 and 2004 respectively). This may indicate that his conceptual knowledge of objects is well preserved but similar knowledge for actions is impaired.

JB's performance on tests of executive function and problem-solving ability was tested only in 2005 and found to be impaired. He fell below the norm on the Butt Non-Verbal Reasoning Test (Butt & Bucks, 2004 - 7/10 correct), which is a test of problem solving, and was below the norm in the Trailmaking test (Reitan & Wolfson, 1985), which is a test believed to tap executive function. In the Brixton test, JB was unable to deduce any rule from the patterns presented. Similarly, his performance on the matrices of the Wechsler Abbreviated Scale of Intelligence show impairment (raw score 13).

Experimental investigations – Language tests

Testing was carried out during two periods in order to monitor the progression of language deterioration. Period 1 testing took place in 2002-2003 and Period 2 testing took place in 2004. Additional, though limited testing also took place in 2005. Where appropriate, the tests were administered in English and Hungarian, but due to technical reasons not all tests could be carried out during all testing periods.

3.1.Phonology:

JB's phonological abilities were tested in reading and repetition of single words in English and Hungarian. The test for each language consisted of seven lists of words for reading and repetition, with 50 words in each list for the English and 80 words in each list for the Hungarian test. In both languages the stimulus words were selected according to syllable length and phonological complexity. The words ranged from one syllable to three syllables to account for length. Complexity was controlled by the presence/absence of consonant clusters in word-initial, word-medial and word-final positions, and the presence of more than one clusters in a single word. The task was administered in both languages in Time 1 and Time 2. Order of task presentation was counterbalanced; JB was asked first to read all the words in half the lists, and then repeat the words in the rest of the lists, and vice versa. His attempts were recorded, transcribed and analysed. Due to unfortunate circumstances during testing in Hungarian in Time 1, data on the recording media were corrupted and, as a result, the reading and repetition data of some lists were lost. During testing in Hungarian in Time 2, it was decided to test JB only on lists one through to four because it proved too tiresome for him to read and repeat all seven lists. For this reason, the data in both languages were reorganised in order to make them comparable (see analysis 3, section 3.1.3). The data for each language are analysed for the following features:

(1) correct responses

(2) error analysis:

- (a) substitutions, additions, omissions
- (b) consonant substitutions
    - (i) substitutions in different place of articulation
    - (ii) substitutions in same place of articulation
- (c) vowel substitutions
    - (i) central vowel substitutions
    - (ii) schwa substitutions
    - (iii) schwa insertions
- (d) processes affecting the duration of phonemes
- (e) pause insertions

(3) word complexity:

- (a) processes affecting clusters

(b) correct responses as a function of target word length, presence/absence of clusters and position of clusters in targets

(4) stammering behaviour

The complete set of lists, JB's attempts at reading and repeating and their analysis can be found on the CD accompanying this report. Instructions how to use the CD can be found in Appendix 2.

3.1.1 Analysis 1 – ***English***

3.1.1.1 Correct responses

In terms of syllable length and number of correct responses, JB is more successful on 1-syllable targets than 2-syllable or 3-syllable ones (Table 1). For 1- and 2-syllable words, performance is better by almost 33% in repetition compared to reading in both Time 1 and Time 2. This shows that JB is performing better in repetition than in reading. Between periods of testing (Time 1 vs. Time 2), it is clear that the number of correct 1- and 2-syllable responses is reduced by almost 50% in both modes of presentation in Time 2, indicating that performance was negatively affected as time progressed. The number of correct 3-syllable responses is minimal, with only one correct response overall, indicating that performance was severely affected by word length.

Table 1: Numbers and percentages of correct responses of 1-, 2- and 3-syllable targets for reading and repetition in Time 1 and Time 2

	2003		2004	
	Reading	**Repetition**	**Reading**	**Repetition**
1-syllable (n=184)	69 (37.5%)	94 (51%)	33 (17.9%)	46 (25%)
2-syllable (n=111)	19 (17.1%)	34 (30.6%)	4 (3.6%)	7 (6.3%)
3-syllable (n=57)	0	1 (1.7%)	0	0

3.1.1.2 Error analysis

JB's phonological errors were placed in the broad categories of substitutions, additions and omissions (Table 2). In Time 1, the proportion of substitution errors is higher in repetition than in reading, whereas the proportions of addition and omission errors are higher for reading. The numbers for the three categories of error are similar for reading in Time 1, but for repetition JB appears to be substituting more than adding or omitting phonemes. For reading and repeating in Time 2, the highest proportion of errors is addition errors, with a higher percentage for reading than repetition. The number of substitution and omission errors appears to increase for repetition in Time 2.

Table 2: Numbers and percentages of substitution, addition and omission errors for reading and repetition in Time 1 and Time 2

	2003		2004	
	Reading	**Repetition**	**Reading**	**Repetition**
Substitution	194 (31%)	174 (52.9%)	218 (28.5%)	231 (34.4%)
Addition	240 (38.5%)	85 (25.8%)	439 (57.5%)	292 (43.5%)
Omission	190 (30.4%)	70 (21.3%)	107 (14%)	149 (22.2%)
TOTAL ERRORS	**624**	**329**	**764**	**672**

The error analysis in Table 3 is based on different criteria and shows JB's attempts in reading and repetition, analysed for the following categories of errors: processes affecting clusters (cluster simplification and substitution), insertion of pauses, and processes affecting the perceived duration of phonemes (consonant and vowel shortening or lengthening). The data were also analysed for the presence of Apraxia of Speech (AOS) because certain apraxic behaviours were noted during transcription. Therefore the data were also analysed for substitutions of consonants and vowels with other phonemes of the same category. For reading and repetition in Time 1, the biggest category of errors is consonant substitutions (more than 1/3 of the total errors), followed by vowel substitutions (around 1/4 of total errors), decreases in vowel duration and cluster simplifications. In Time 2 and for both modes of presentation, the percentages for vowel and consonant substitutions do not differ substantially, followed by decreases in vowel duration as the next biggest category of error, and cluster simplifications.

Consonant substitution errors were further analysed for place of articulation – same (for example [leɪʃən] for 'nation') or different ([greɪg] for 'grave'). Vowel substitutions were analysed for features of AOS such as central vowel substitutions ([nɜvəl] for 'novel'), schwa insertions ([zəʊnə] for 'zone') and substitutions of other vowels with schwa (schwa substitutions - [mʌdəɒ] for 'modern'). From Table 4 it appears that JB is substituting consonants in a different place of articulation more than in the same place of articulation. For both consonant substitution processes however, the percentages are very similar across modes of presentation and periods of testing, indicating that performance was not affected by these two variables. In terms of vowel substitutions, there appear to be more central vowel substitutions for reading in Time 1, whereas for repetition in the same testing period JB is substituting for central vowels and schwas with the same rate. In Time 2, the highest proportion of errors in both modes of presentation are schwa insertions, followed by a higher number of schwa substitutions than central vowel substitutions for reading, but similar percentages for repetition.

Table 3: Number and percentages of errors in different categories, for reading and repetition in Time 1 and Time 2

	2003		2004	
	Reading	**Repetition**	**Reading**	**Repetition**
Cluster Simplif.	24 (10%)	18 (8.6%)	25 (7.7%)	28 (7.6%)
Cluster Substit.	12 (5%)	8 (3.8%)	14 (4.3%)	15 (4%)
Consonant Sub.	88 (36.6%)	85 (40.5%)	96 (29.5%)	132 (35.9%)
Vowel Sub.	61 (25.4%)	58 (27.6%)	107 (32.9%)	119 (32.3%)
Pause-insertions	15 (6.25%)	3 (1.4%)	26 (8%)	10 (2.7%)
Vowel short.	33 (13.75%)	30 (14.3%)	38 (11.7%)	41 (11.1%)
Vowel length.	4 (1.6%)	4 (1.9%)	13 (4%)	22 (6%)
Consonant length.	4 (1.6%)	4 (1.9%)	6 (1.8%)	1 (0.3%)
ERROR TOTAL	**240**	**210**	**325**	**368**

Table 4: Numbers of errors for the features of C-sub/same place of articulation, C-sub/different place of articulation, central V-sub, schwa-sub, schwa-insertions and pause-insertions, for reading and repetition in Time 1 and Time 2

	2003		2004	
	Reading	**Repetition**	**Reading**	**Repetition**
C-sub/same place	35 (40%)	33 (38.8%)	36 (37.5%)	44 (33.3%)
C-sub/diff. place	53 (60%)	52 (61.2%)	60 (62.5%)	88 (66.6%)
TOTAL CONS. SUB. ERRORS	**88**	**85**	**96**	**132**
Central V-subst.	29 (47.5%)	24 (41.4%)	26 (24.3%)	29 (24.4%)
Schwa-subst.	17 (27.9%)	24 (41.4%)	18 (16.8%)	31 (26%)
Schwa-insertions	15 (24.6%)	10 (17.2%)	63 (58.9%)	59 (49.6%)
TOTAL VOWEL SUB. ERRORS	**61**	**58**	**107**	**119**

3.1.1.3 Word complexity

Word complexity, which was measured in terms of presence or absence of clusters in various positions in the words, showed that errors took the form of either cluster simplifications (where one of the cluster components was missing) or cluster substitutions (where the target cluster was substituted for an altogether different cluster). The results showed that in general JB is simplifying clusters more than substituting them (Table 2). For Time 1, there appear to be slightly more instances of cluster simplification and substitution for reading than repetition, whereas for Time 2, the percentages for these error categories of errors are comparable.

An additional analysis focused on the number of correct responses as a function of target word length, the presence/absence of consonant clusters and their position in the target words (Table 5). JB's performance in general appears to be most successful on 1-syllable targets that contain no clusters, in both modes of presentation and during both testing periods.

Reading: Slightly more than half of the total correct responses in Time 1 are on 1-syllable targets without clusters. The next successful attempts were for 2-syllable targets without a cluster, although the success rate is considerably smaller than that of 1-syllable/no cluster attempts. JB is also better on 1-syllable targets with an initial cluster than on targets of the same length with a final cluster. In the same testing period, his performance on 2-syllable targets with a cluster is impaired, with a very low rate of success. JB's success at 3-syllable targets of any complexity is at floor level, indicating that irrespective of complexity, longer targets of more than two syllables pose a great difficulty for him. Performance in Time 2 is worse than in Time 1, and again with more success on 1-syllable/no cluster targets, where the number of correct responses constitutes 2/3 of the total number of correct responses. In time 2, reading of 1-syllable targets with clusters is affected negatively, with fewer correct responses than in Time 1. Similarly, longer than one syllable words are starting to pose great difficulty for JB, as on 2-syllable targets he was only able to produce four correct words on targets without clusters. He is at floor level with targets of two syllables that contained clusters at any position, indicating that as time progressed, the presence of clusters in words longer than one syllable impairs performance. Performance on 3-syllable targets of any complexity was identical to Time 1.

Repetition: JB was better in repetition than in reading in Time 1, again with more success on 1-syllable targets without clusters. He was however more successful in repeating than in reading 1-syllable targets with word initial and word final clusters, and was able to repeat correctly both 1-syllable targets containing two clusters. For 2-syllable words, JB's performance is better on targets without clusters, followed by a higher success rate on targets with word initial clusters than targets with word final clusters. Success on 3-syllable targets is minimal, with only one correct response on one clusterless target. In Time 2, the number of correct 1-syllable responses is less than half of those at Time 1, but once again with more success on targets without clusters. For 1-syllable words with clusters, JB's performance was better with targets containing a word-final cluster. The pattern for 2-syllable words is similar to Time 1, with more successful responses on clusterless targets. Targets that contained clusters proved to be more difficult. Performance on 3-syllable targets is at floor level. The latter observations indicate that for both reading and repetition, performance was affected negatively by the increasing length of a word and the presence of clusters on longer targets, and more so as time progressed.

Table 5: Numbers and percentages of correct responses analysed for syllable length and presence and location of clusters for reading and repetition in Time 1 and Time 2

Task	**Time**	**Length**	**Complexity**	**Cluster Locus**	**Number of Correct Responses**	**Proportion of Total Correct Responses**
Reading	T1	1-Syllable	0 Clusters (n=110)		*46*	*52.3%*
			1 Cluster (n=72)	Initial (n=42)	*13*	*14.7%*
				Final (n=30)	*9*	*10.2%*
			2+ Clusters (n=2)		*1*	*1.1%*
				Total 1-Syllable (n=184)	***69***	
		2-Syllables	0 Clusters (n=74)		*16*	*18.2%*
			1 Cluster (n=35)	Initial (n=24)	*1*	*1.1%*
				Final (n=11)	*2*	*2.3%*
			2+ Clusters (n=2)		*0*	
				Total 2-Syllable (n=111)	***19***	
		3 Syllables	0 Clusters (n=16)		*0*	
			1 Cluster (n=27)	Initial (n=4)	*0*	
				Medial (n=21)	*0*	
				Final (n=2)	*0*	
			2+ Clusters (n=14)		*0*	
				Total 3-syllable (n=57)	*0*	
				TOTAL CORRECT RESPONSES FOR READING AT T1	***88***	

Reading	T2	1 Syllable	0 Clusters (n=110)		*24*	*66.6%*
			1 Cluster (n=72)	Initial (n=42)	*4*	*11.1%*
				Final (n=30)	*4*	*11.1%*
			2+ Clusters (n=2)		*0*	
				Total 1-Syllable (n=184)	***32***	
		2 Syllables	0 Clusters (n=74)		*4*	*11.1%*
			1 Cluster (n=35)	Initial (n=24)	*0*	
				Final (n=11)	*0*	
			2+ Clusters (n=2)		*0*	
				Total 2-Syllable (n=111)	***4***	
		3 Syllables	0 Clusters (n=16)		*0*	
			1 Cluster (n=27)	Initial (n=4)	*0*	
				Medial (n=21)	*0*	
				Final (n=2)	*0*	
			2+ Clusters (n=14)		*0*	
				Total 3-syllable (n=57)		
				TOTAL CORRECT RESPONSES FOR READING AT T2	***36***	
Repetition	T1	1 Syllable	0 Clusters (n=110)		*51*	*41.1%*
			1 Cluster (n=72)	Initial (n=42)	*19*	*15.3%*
				Final (n=30)	*15*	*12%*
			2+ Clusters (n=2)		*2*	*1.6%*
				Total 1-Syllable (n=184)	***87***	
		2 Syllables	0 Clusters (n=74)		*31*	*25%*
			1 Cluster (n=35)	Initial (n=24)	*4*	*3.2%*
				Final (n=11)	*1*	*0.8%*
			2+ Clusters (n=2)		*0*	
				Total 2-Syllable (n=111)	***36***	
		3 Syllables	0 Clusters (n=16)		*1*	*0.8%*
			1 Cluster (n=27)	Initial (n=4)	*0*	
				Medial (n=21)	*0*	
				Final (n=2)	*0*	
			2+ Clusters (n=14)		*0*	
				Total 3-syllable (n=57)	***1***	
				TOTAL CORRECT RESPONSES FOR REPETITION AT T1	***124***	
Repetition	T2	1 Syllable	0 Clusters (n=110)		*36*	*63.1%*
			1 Cluster (n=72)	Initial (n=42)	*2*	*3.5%*
				Final (n=30)	*9*	*15.7%*
			2+ Clusters (n=2)		*0*	
				Total 1-Syllable (n=184)	***47***	
		2 Syllables	0 Clusters (n=74)		*9*	*15.7%*
			1 Cluster (n=35)	Initial (n=24)	*1*	*1.7%*
				Final (n=11)	*0*	
			2+ Clusters (n=2)		*0*	
				Total 2-Syllable (n=111)	***10***	
		3 Syllables	0 Clusters (n=16)		*0*	
			1 Cluster (n=27)	Initial (n=4)	*0*	
				Medial (n=21)	*0*	
				Final (n=2)	*0*	
			2+ Clusters (n=14)		*0*	

				Total 3-syllable (n=57)	*0*	
				TOTAL CORRECT RESPONSES FOR REPETITION AT T2	*57*	

3.1.1.4 Stammering Behaviour

During testing, it was noted that JB's attempts at pronunciation were often disrupted in a manner that resembled stammering. His output was often characterised by repetitions of sounds and syllables in all positions in words. Therefore the data was also analysed for phoneme, segment and whole word repetitions in word initial (WI), medial (WM) and final (WF) positions in words. Table 6 shows that the vast majority of repetitions were segment repetitions, usually in WI and WM position. The table also shows that there are more instances of stammering behaviour in reading than repeating in both testing periods, with the numbers increasing in Time 2.

Table 6: Numbers of repetition instances for reading and repetition in Time 1 and Time 2

	2003		**2004**	
	Reading	**Repetition**	**Reading**	**Repetition**
Phoneme Repet. WI	7 (7.8%)	3 (8.6%)	11 (8%)	1 (1.5%)
Phoneme Repet. WM	0	3 (8.6%)	0	0
Phoneme Repet. WF	0	2 (5.7%)	5 (3.6%)	0
Segment Repet. WI	33 (37.5%)	5 (14.3%)	41 (30%)	22 (32.8%)
Segment Repet . WM	32 (36.4%)	15 (42.8%)	56 (40.8%)	24 (35.8%)
Segment Repet. WF	12 (13.6%)	7 (20%)	25 (18.2%)	20 (29.8%)
Whole Word Repet. WI	2 (2.3%)	0	2 (1.4%)	0
Whole Word Repet. WM	0	0	0	0
Whole Word Repet. WF	2 (2.3%)	0	2 (1.4%)	0
TOTAL ERRORS	**88**	**35**	**137**	**67**

Summary of performance in English:

The analysis of the English data has shown that JB performs better on 1-syllable targets and is better in repetition than reading in both periods of testing. He is most successful on clusterless targets in both modes of presentation and both testing periods, especially clusterless targets of one syllable in length. In general, his level of performance decreases in Time 2 and is worst on longer targets (>2-syllables) of any complexity. In terms of errors, there were more substitution errors in Time 1 for repetition, but more addition and omission errors for reading. In Time 2 JB was making more errors of addition for both modes of presentation. The number of errors in general increases in Time 2. In addition, there were more consonant than vowel substitutions for both modes of presentation in Time 1, but the proportion of errors for both processes was similar in Time 2 for both reading and repetition. The analysis of consonant and vowel substitutions showed that there were more substitution of consonants in a different place of articulation for both modes and both testing periods, and more central vowel substitutions for reading in Time 1, but more schwa insertions in Time 2 for both modes. In terms of processes affecting clusters, there were more cluster simplifications than substitutions in both times and for both reading and repetition. Analysis of stammering-like errors showed that there were more segment repetition errors in word initial and medial positions than any other type and position, with a higher number of errors of this type for reading and Time 2 in general.

*3.1.2 Analysis 2 – **Hungarian***

Data for reading and repetition in Time 1 is available only from three lists from each mode of presentation, different for each mode. Data for reading and repetition in Time 2 is available from four lists, which are the same for both modes of presentation.

3.1.2.1 Correct responses

The number of correct responses as a function of syllable length has shown that, like in English, JB is more successful on 1-syllable targets than 2- or 3-syllable ones (Table 7). However, whereas the number of correct 1-syllable responses in both reading and repetition remains almost the same for both testing periods, the same does not apply for correct 2-syllable responses where the number decreases considerably in Time 2. Performance on 3-syllable targets is minimal, with correct responses only in Time 1.

Table 7: Numbers and percentages of correct responses of 1-, 2- and 3-syllable targets for reading and repetition in Time 1 and Time 2

	2003		2004	
	Reading (3 Lists)	**Repetition (3 Lists)**	**Reading (4 Lists)**	**Repetition (4 Lists)**
1-syllable (n=282)	72 (25.5%)	63 (22.3%)	60 (21.2%)	60 (21.2%)
2-syllable (n=149)	18 (12%)	13 (8.7%)	2 (1.3%)	3 (2%)
3-syllable (n=53)	2 (3.8%)	1 (1.9%)	0	0

3.1.2.2 Error analysis

Table 8 shows JB's errors of substitution, addition and omission. In Time 1 JB's errors of substitution constituted almost half the amount of errors in both reading and repetition, followed by a bigger number of addition than omission errors. In Time 2 the total number of errors increased considerably compared to Time 1, with a higher percentage of errors of addition in reading and errors of substitution in repetition.

Table 8: Numbers and percentages of substitution, addition and omission errors for reading and repetition in Time 1 and Time 2

	2003		**2004**	
	Reading (3 Lists)	**Repetition (3 Lists)**	**Reading (4 Lists)**	**Repetition (4 Lists)**
Substitution	199 (48.6%)	178 (51.9%)	248 (34%)	240 (42.7%)
Addition	158 (38.6%)	120 (35%)	378 (51.8%)	191 (34%)
Omission	52 (12.7%)	45 (13.1%)	103 (14.1%)	131 (23.3%)
TOTAL ERRORS	**409**	**343**	**729**	**562**

Table 9 shows the error analysis for processes affecting clusters, substitutions of consonants and vowels, insertion of pauses and processes affecting the perceived duration of phonemes. The biggest category of errors in both modes of presentation and in both periods of testing is consonant substitutions, which constitute more than a third of the total errors on each occasion. Like in English, the next biggest category of error is vowel substitutions, followed by decreases in vowel duration as the third biggest category of error. In Time 1, it appears that there are more instances of consonant substitutions for reading but more vowel substitutions for repetition. It also appears that the number of vowel lengthening instances increases significantly in repetition, whereas the number of the other processes affecting phoneme length remains comparable between the two modes of presentation. In Time 2, the proportion of consonant substitutions is higher for repetition, whereas the proportion of vowel substitutions is similar in both modes of presentation. In terms of processes affecting the duration of phonemes in Time 2, it appears that there is a higher instance of vowel duration decreases in reading, whereas instances of the other two processes is similar for both modes of presentation.

Analysis of consonant and vowel substitutions is shown in Table 10 where it appears that, similar to English, JB is substituting more consonants in a different place of articulation, with numbers being slightly higher for reading in Time 1, but similar between modes of presentation in Time 2. In terms of vowel substitutions, the proportion of schwa substitutions is higher in both reading and repetition in Time 1, followed by a high proportion of schwa insertions. In Time 2, there is a higher proportion of schwa insertions for reading than schwa and central vowel substitutions, whereas for repetition the proportions are similar between schwa substitutions and insertions.

Table 9: Number and percentages of errors in different categories, for reading and repetition in Time 1 and Time 2

	2003		2004	
	Reading (3 Lists)	**Repetition (3 Lists)**	**Reading (4 Lists)**	**Repetition (4 Lists)**
Cluster Simplif.	20 (9.2%)	13 (5.5%)	19 (6.6%)	27 (9.5%)
Cluster Substit.	11 (5%)	11 (4.6%)	18 (6.3%)	16 (5.6%)
Consonant Sub.	92 (42.4%)	85 (35.7%)	107 (37.4%)	131 (46%)
Vowel Sub.	38 (17.5%)	57 (24%)	50 (17.5%)	43 (15.1%)
Pause-insertions	10 (4.6%)	4 (1.7%)	20 (7%)	11 (3.8%)
Vowel short.	34 (15.7%)	33 (13.9%)	40 (14%)	28 (9.8%)
Vowel length.	3 (1.4%)	26 (11%)	20 (7%)	19 (6.7%)
Consonant short.	9 (4.1%)	9 (3.8%)	12 (4.2%)	10 (3.5%)
ERROR TOTAL	**217**	**238**	**286**	**285**

Table 10: Numbers of errors for the features of C-sub/same place of articulation, C-sub/different place of articulation, central V-sub, schwa-sub, schwa-insertions and pause-insertions, for reading and repetition in Time 1 and Time 2

	2003		2004	
	Reading (3 Lists)	**Repetition (3 Lists)**	**Reading (4 Lists)**	**Repetition (4 Lists)**
C-sub/same place	26 (27.9%)	27 (32.5%)	40 (36.7%)	44 (33.6%)
C-sub/diff. place	67 (72%)	56 (67.5%)	69 (63.3%)	87 (66.4%)
TOTAL CONS. SUB. ERRORS	**93**	**83**	**109**	**131**
Central V-subst.	23 (22.1%)	8 (10.8%)	37 (22.1%)	29 (23.6%)
Schwa-subst.	47 (45.2%)	40 (54%)	55 (33%)	49 (39.8%)
Schwa-insertions	34 (32.7%)	26 (35.1%)	75 (44.9%)	45 (36.6%)
TOTAL VOWEL SUB. ERRORS	**104**	**74**	**167**	**123**

3.1.2.3 Word complexity

Like in English, errors of cluster simplification and substitution were present in the Hungarian data as well, with numbers similar to the English data (Table 9). In general, it appears that JB is simplifying clusters more than substituting them, with slightly more cluster simplifications for reading in Time 1, but more simplifications for repetition in Time 2. The proportion of cluster substitutions remains comparable across modes of presentation and periods of testing.

Table 11 below shows an analysis of correct responses as a function of target word length, the presence/absence of consonant clusters and their position in the target words in Hungarian. Much like the English data, the majority of correct responses for both times were on 1-syllable targets that contained no clusters, with the next most successful attempts on 1-syllable targets with word final clusters.

Reading: Like in English, more than half of the total correct responses in Time 1 are on 1-syllable targets without clusters. The next successful attempts were for 2-syllable targets without clusters, although the proportion of this is comparable to the proportion of 1-syllable targets with a final cluster. 1-syllable targets with word initial, word medial and more than one cluster pose a difficulty for JB, as do 2-syllable targets with a cluster at any position. Similar to English, JB's success at 3-syllable targets of any complexity is minimal, with only two successful attempts for clusterless targets, indicating that irrespective of complexity and language, longer targets of more than two syllables impair performance at this period of testing. Performance in Time 2 is more impaired than Time 1 with the biggest rate of success on 1-syllable/no cluster targets. The number of correct 1-syllable responses with a word final cluster is comparable to Time 1, but the number of correct 2-syllable/no cluster responses is significantly reduced. Performance on 3-syllable targets of any complexity was identical to Time 1.

Repetition: JB's performance in repetition in Time 1 was more impaired overall than in reading, but again with more success on 1-syllable targets without clusters, which constitute half of the total number of correct responses. The proportion of correct 1-syllable/word final cluster words is higher than the proportion for 2-syllable/no cluster targets, whereas performance on targets of one syllable with word initial and medial clusters and targets of two syllables with any cluster is minimal. Like in English, success on 3-syllable targets is at floor level, with only one correct response on a target with a word medial cluster. In Time 2, the number of correct 1-syllable responses of all measures of complexity is similar and comparable to performance in reading in the same testing period. The number of correct 2-syllable words is significantly reduced, with only three correct responses on clusterless targets.

Table 11: Numbers and percentages of correct responses analysed for syllable length and presence and location of clusters for reading and repetition in Time 1 and Time 2 (*Total number of words are for 6 lists – data from List 5 was lost in Time 1 and the list was not attempted in Time 2)

Task	Time	Length	Complexity*	Cluster Locus*	Number of Correct Responses	Proportion of Total Correct Responses
Reading	T1	1-Syllable	0 Clusters (n=173)		*53*	*57.6%*
(3 Lists)			1 Cluster (n=102)	Initial (n=7)	*1*	*1%*
				Medial (n=1)	*0*	
				Final (n=94)	*15*	*16.3%*
			2+ Clusters (n=7)		*2*	*2.2%*
				Total 1-Syllable (n=282)	***71***	
		2-Syllables	0 Clusters (n=123)		*17*	*18.5%*
			1 Cluster (n=26)	Initial (n=2)	*0*	
				Medial (n=21)	*1*	*1%*
				Final (n=3)	*1*	*1%*
			2+ Clusters (n=0)		*0*	
				Total 2-Syllable (n=149)	***19***	
		3 Syllables	0 Clusters (n=17)		*2*	*2.2%*
			1 Cluster (n=19)	Initial (n=0)	*0*	
				Medial (n=18)	*0*	
				Final (n=1)	*0*	
			2+ Clusters (n=17)		*0*	
				Total 3-syllable (n=53)	***2***	
				TOTAL CORRECT RESPONSES FOR READING AT T1	***92***	
Reading	T2	1 Syllable	0 Clusters (n=173)		*40*	*69%*
(4 Lists)			1 Cluster (n=102)	Initial (n=7)	*0*	
				Medial (n=1)	*0*	
				Final (n=94)	*17*	*29.3%*
			2+ Clusters (n=7)		*0*	
				Total 1-Syllable (n=282)	***57***	
		2 Syllables	0 Clusters (n=123)		*1*	*1.7%*
			1 Cluster (n=26)	Initial (n=2)	*0*	
				Medial (n=21)	*0*	
				Final (n=3)	*0*	
			2+ Clusters (n=0)		*0*	
				Total 2-Syllable (n=149)	***1***	
		3 Syllables	0 Clusters (n=17)		*0*	
			1 Cluster (n=19)	Initial (n=0)	*0*	

				Medial (n=18)	*0*	
				Final (n=1)	*0*	
			2+ Clusters (n=17)		*0*	
				Total 3-syllable (n=53)	***0***	
				TOTAL CORRECT RESPONSES FOR READING AT T2	***58***	
Repetition	T1	1 Syllable	0 Clusters (n=173)		*39*	*50.6%*
(3 Lists)			1 Cluster (n=102)	Initial (n=7)	*2*	*2.6%*
				Medial (n=1)	*1*	*1.3%*
				Final (n=94)	*19*	*24.7%*
			2+ Clusters (n=7)		*1*	*1.3%*
				Total 1-Syllable (n=282)	***62***	
		2 Syllables	0 Clusters (n=123)		*13*	*16.9%*
			1 Cluster (n=26)	Initial (n=2)	*0*	
				Medial (n=21)	*1*	*1.3%*
				Final (n=3)	*0*	
			2+ Clusters (n=0)		*0*	
				Total 2-Syllable (n=149)	***14***	
		3 Syllables	0 Clusters (n=17)		*0*	
			1 Cluster (n=19)	Initial (n=0)	*0*	
				Medial (n=18)	*1*	*1.3%*
				Final (n=1)	*0*	
			2+ Clusters (n=17)		*0*	
				Total 3-syllable (n=53)	***1***	
				TOTAL CORRECT RESPONSES FOR REPETITION AT T1	*77*	
Repetition	T2	1 Syllable	0 Clusters (n=173)		*41*	*65%*
(4 Lists)			1 Cluster (n=102)	Initial (n=7)	*0*	
				Medial (n=1)	*0*	
				Final (n=94)	*18*	*28.6%*
			2+ Clusters (n=7)		*1*	*1.6%*
				Total 1-Syllable (n=282)	***60***	
		2 Syllables	0 Clusters (n=123)		*3*	*4.8%*
			1 Cluster (n=26)	Initial (n=2)	*0*	
				Medial (n=21)	*0*	
				Final (n=3)	*0*	
			2+ Clusters (n=0)		*0*	
				Total 2-Syllable (n=149)	***3***	
		3 Syllables	0 Clusters (n=17)		*0*	
			1 Cluster (n=19)	Initial (n=0)	*0*	
				Medial (n=18)	*0*	
				Final (n=1)	*0*	
			2+ Clusters (n=17)		*0*	
				Total 3-syllable (n=53)	***0***	
				TOTAL CORRECT RESPONSES FOR REPETITION AT T2	***63***	

3.1.2.4 Stammering Behaviour

Stammering behaviour was also noted in Hungarian and the data were analysed similarly to English. The numbers showed that, like English, the majority of repetitions were segment repetitions, especially in word initial and medial positions. From Table 12, it appears that the numbers of word initial segment repetitions are similar for both reading and repetition in both testing periods, whereas for word medial segment repetitions, the numbers are greater for reading than repetition in both Time 1 and Time 2. In general, the proportion of repetitions increases in Time 2 for both modes of presentation.

Table 12: Numbers and percentages of repetition instances for reading and repetition in Time 1 and Time 2

	2003		**2004**	
	Reading (3 Lists)	**Repetition (3 Lists)**	**Reading (4 Lists)**	**Repetition (4 Lists)**
Phoneme Repet. WI	0	1 (4.3%)	4 (2.4%)	1 (1.2%)
Phoneme Repet. WM	0	0	2 (1.2%)	0
Phoneme Repet. WF	0	0	0	0
Segment Repet. WI	11 (20.4%)	10 (43.5%)	37 (22.7%)	31 (38.3%)
Segment Repet . WM	29 (53.7%)	7 (30.4%)	75 (46%)	20 (24.7%)
Segment Repet. WF	12 (22.2%)	4 (17.4%)	45 (27.6%)	29 (35.8%)
Whole Word Repet. WI	0	0	0	0
Whole Word Repet. WM	0	0	0	0
Whole Word Repet. WF	2 (3.7%)	1 (4.3%)	1 (0.6%)	0
TOTAL ERRORS	**54**	**23**	**163**	**81**

<u>Summary of performance in Hungarian:</u>

Analysis of the Hungarian data has shown that JB performs better on 1-syllable targets, with similar percentages of success between modes of presentation and periods of testing. The success rate is highest for clusterless targets in both modes of presentation and both testing periods, especially of 1-syllable words. The numbers of correct 2-syllable responses decreases considerably in Time 2 for both reading and repetition. JB's performance is most impaired on longer targets (>2-syllables) of any complexity. In terms of errors, the proportion of substitution errors compared to other types is higher in Time 1 for both modes of presentation, and there are more errors of any type in Time 2 in general, with more additions for reading and more substitutions for repetition. The proportion of cluster simplification errors is higher than cluster substitutions. In addition, there are more consonant substitutions for reading in Time 1 but more vowel substitutions for repetition in the same period, whereas in Time 2 there are more consonant substitutions for repetition but similar numbers of vowel substitutions for both modes of presentation. The instances of vowel lengthening were the highest of the processes affecting phoneme duration, with more for repetition in Time 1 but more for reading in Time 2. Analysis of consonant substitution errors showed that the highest proportion was for substitutions in a different place of articulation, with more instances for reading in Time 1 and similar numbers for both modes of presentation in Time 2. Analysis of vowel substitutions showed that there were more schwa substitutions and insertions for both modes in Time 1 but more schwa insertions for reading in Time 2. In terms of stammering-like repetitions, there are more segment repetitions in general, especially in word initial and medial positions, with increasing numbers in Time 2 for both modes of presentation.

3.1.3 Analysis 3 – ***English vs. Hungarian***

Due to the incomparability of the lists in the two languages, the data were reorganised. Three lists were selected for each testing period and for each mode of presentation for either language. For Time 1, the three equivalent English lists were selected to match the remaining Hungarian lists for reading and repetition. For Time 2, the same process was employed but the lists in Hungarian were reduced to three to make comparison with Time 1 possible. In addition, the number of words in the Hungarian lists had to be reduced to 50 to match the number of words in the English lists. For this reason, 30 words from each Hungarian list used in this analysis were randomly removed. The reduction of lists and words was possible because the lists in each language were similarly controlled for length and complexity.

For this analysis, the focus was on the effects of length and complexity on word production in reading and repetition in English and Hungarian in both testing periods. Responses on 3-syllable targets are not included because, after the reorganisation of the data, no correct responses for this syllable length were present. The results are presented in Tables 13 and 14.

Table 13: Number of correct responses in reading and repeating words in English, organised according to syllable length and the presence and location of clusters

Task	Time	Length	Complexity	Cluster Locus	Number of Correct Responses	Proportion of Total Correct Responses
Reading	T1	1-Syllable	0 Clusters (n=93)		*22*	*48.9%*
(3 Lists)			1 Cluster (n=62)	Initial (n=35)	*7*	*15.5%*
				Final (n=27)	*2*	*4.4%*
			2+ Clusters (n=1)		*1*	*2.2%*
				Total 1-Syllable (n=156)	***32***	
		2-Syllables	0 Clusters (n=66)		*11*	*24.4%*
			1 Cluster (n=27)	Initial (n=18)	*1*	*2.2%*
				Final (n=9)	*1*	*2.2%*
			2+ Clusters (n=2)		*0*	
				Total 2-Syllable (n=95)	***13***	
				TOTAL CORRECT RESPONSES FOR READING AT T1	***45***	
Reading	T2	1 Syllable	0 Clusters (n=93)		*13*	*68.4%*
(3 Lists)			1 Cluster (n=62)	Initial (n=35)	*1*	*5.3%*
				Final (n=27)	*2*	*10.5%*
			2+ Clusters (n=1)		*0*	
				Total 1-Syllable (n=156)	***16***	
		2 Syllables	0 Clusters (n=66)		*3*	*15.8%*
			1 Cluster (n=27)	Initial (n=18)	*0*	
				Final (n=9)	*0*	
			2+ Clusters (n=2)		*0*	
				Total 2-Syllable (n=95)	***3***	
				TOTAL CORRECT RESPONSES FOR READING AT T2	***19***	
Repetition	T1	1 Syllable	0 Clusters (n=93)		*21*	*46.7%*
(3 Lists)			1 Cluster (n=62)	Initial (n=35)	*7*	*15.5%*
				Final (n=27)	*7*	*15.5%*
			2+ Clusters (n=1)		*0*	
				Total 1-Syllable (n=156)	***35***	
		2 Syllables	0 Clusters (n=66)		*10*	*22.2%*
			1 Cluster (n=27)	Initial (n=18)	*0*	
				Final (n=9)	*0*	
			2+ Clusters (n=2)		*0*	
				Total 2-Syllable (n=95)	***10***	
				TOTAL CORRECT RESPONSES FOR REPETITION AT T1	***45***	
Repetition	T2	1 Syllable	0 Clusters (n=93)		*17*	*70.8%*
(3 Lists)			1 Cluster (n=62)	Initial (n=35)	*1*	*4.2%*
				Final (n=27)	*3*	*12.5%*
			2+ Clusters (n=1)		*0*	
				Total 1-Syllable (n=156)	***21***	
		2 Syllables	0 Clusters (n=66)		*3*	*12.5%*
			1 Cluster (n=27)	Initial (n=18)	*0*	
				Final (n=9)	*0*	

			2+ Clusters (n=2)		*0*	
				Total 2-Syllable (n=95)	***3***	
				TOTAL CORRECT RESPONSES FOR REPETITION AT T2	***24***	

Table 14: Number of correct responses in reading and repeating words in Hungarian, organised according to syllable length and the presence and location of clusters

Task	**Time**	**Length**	**Complexity**	**Cluster Locus**	**Number of Correct Responses**	**Proportion of Total Correct Responses**
Reading	T1	1-Syllable	0 Clusters (n=104)		*31*	*56.7%*
(3 Lists)			1 Cluster (n=68)	Initial (n=5)	*1*	*1.8%*
				Final (n=63)	*9*	*16.4%*
			2+ Clusters (n=6)		*2*	*3.6%*
				Total 1-Syllable (n=178)	***43***	
		2-Syllables	0 Clusters (n=82)		*11*	*20%*
			1 Cluster (n=12)	Initial (n=2)	*0*	
				Medial (n=9)	*1*	*1.8%*
				Final (n=1)	*0*	
			2+ Clusters (n=1)		*0*	
				Total 2-Syllable (n=95)	***12***	
				TOTAL CORRECT RESPONSES FOR READING AT T1	***55***	
Reading	T2	1 Syllable	0 Clusters (n=104)		*21*	*72.4%*
(3 Lists)			1 Cluster (n=68)	Initial (n=5)	*0*	
				Final (n=63)	*7*	*24.1%*
			2+ Clusters (n=6)		*0*	
				Total 1-Syllable (n=178)	***28***	
		2 Syllables	0 Clusters (n=82)		*1*	*3.4%*
			1 Cluster (n=12)	Initial (n=2)	*0*	
				Medial (n=9)	*0*	
				Final (n=1)	*0*	
			2+ Clusters (n=1)		*0*	
				Total 2-Syllable (n=95)	***1***	
				TOTAL CORRECT RESPONSES FOR READING AT T2	***29***	
Repetition	T1	1 Syllable	0 Clusters (n=104)		*25*	*59.5%*
(3 Lists)			1 Cluster (n=68)	Initial (n=5)	*1*	*2.4%*
				Final (n=63)	*9*	*21.4%*
			2+ Clusters (n=6)		*1*	*2.4%*
				Total 1-Syllable (n=178)	***36***	
		2 Syllables	0 Clusters (n=82)		*6*	*14.3%*
			1 Cluster (n=12)	Initial (n=2)	*0*	
				Medial (n=9)	*0*	
				Final (n=1)	*0*	
			2+ Clusters (n=1)		*0*	
				Total 2-Syllable (n=95)	***6***	

				TOTAL CORRECT RESPONSES FOR REPETITION AT T1	***42***	
Repetition	T2	1 Syllable	0 Clusters (n=104)		*22*	*66.6%*
(3 Lists)			1 Cluster (n=68)	Initial (n=5)	*0*	
				Final (n=63)	*8*	*24.2%*
			2+ Clusters (n=6)		*1*	*3%*
				Total 1-Syllable (n=178)	***31***	
		2 Syllables	0 Clusters (n=82)		*2*	*6%*
			1 Cluster (n=12)	Initial (n=2)	*0*	
				Medial (n=9)	*0*	
				Final (n=1)	*0*	
			2+ Clusters (n=1)		*0*	
				Total 2-Syllable (n=95)	***2***	
				TOTAL CORRECT RESPONSES FOR REPETITION AT T2	***33***	

Reading: In Time 1, although the highest proportion of correct answers for both languages is for 1-syllable words without a cluster, the proportion is higher in Hungarian than in English. The results show that there is a high percentage of correct answers for 1-syllable targets with a word final cluster in Hungarian, and a similar percentage in English for targets with word initial cluster. The numbers for correct 2-syllable responses are very similar in both languages. In Time 2, the total number of correct responses for both English and Hungarian is considerably decreased, with the highest percentage of success being on 1-syllable targets without a cluster for both languages. For 1-syllable targets with a cluster, the most successful attempts in both languages were for targets with a word final cluster. For 2-syllable targets, although there are correct responses only for clusterless targets, the proportion of success is much higher in English than in Hungarian.

Repetition: The results for repetition in Time 1 show that, as with reading, the highest proportion of correct responses for both languages is for 1-syllable targets without a cluster. For 1-syllable targets with a cluster, JB is performing equally well on targets with an initial and final cluster in English, but is more successful on targets with a word final cluster in Hungarian. For 2-syllable targets, the success rate is higher in English than in Hungarian, with correct responses confined only to clusterless targets for both languages. The results in Time 2 are similar to Time 1 in that the highest proportion of success is for 1-syllable/no cluster targets. JB is performing better in

Hungarian on 1-syllable words with a word final cluster, but for 2-syllable targets his success rate in English is twice that of Hungarian.

3.2 Picture Naming:

3.2.1 Boston Naming Test (Kaplan, Goodglass & Weintraub, 1983) – English and Hungarian

Items in the Boston Naming Test (BNT) range from very frequent words such as *bed* to very infrequent words like *abacus*. The BNT has been adopted for Hungarian by replacing some items that were inappropriate for the Hungarian language. JB was tested three times on the Boston Naming test in Hungarian. The majority of his non-responses for all sessions were on low frequency items, whereas errors were mostly articulatory distortions and phonological approximations on multi-syllabic words and a few semantically-related errors. In English, the test was administered once. Most of the erroneous items were no responses and phonological cues were successful for only four items. A summary of JB's naming can be found in Table 15.

3.2.2 Object and Action Naming Battery (OANB - Druks & Masterson, 2000) – English and Hungarian

The objective of the OANB is to compare object and action naming. The verbal labels of the pictures are matched pair-wise on printed word frequency, rated familiarity and rated age-of-acquisition. The battery contains 162 object items and 100 action items presented as line drawings.

In Hungarian in period 1, JB named 148/162 (91.35%) objects and 74/100 (74%) actions. In naming actions, he often responded with a whole sentence, including the subject and the object. His errors included phonological errors, a few circumlocutions and the production of superordinates. The articulation of longer words is more difficult for him. In Period 2, JB was tested using the computerised version of the OANB where objects and actions are matched for age of acquisition. JB named 56/100 objects and 54/100 actions, with errors being predominantly phonological approximations.

In English, during Period 1, JB named 52/162 nouns and an additional 20 nouns with a phonological cue prompt and 25/100 actions (and an additional 11 actions) with a phonological cue. His naming was often slow. Mild phonological distortions were accepted as correct responses. By Period 2, his naming abilities had deteriorated significantly. Due to his naming difficulties, he was only tested on 50 actions, out of which only seven were correct, 17 were circumlocutions, 23 were phonological errors and two were no responses. His performance in object naming was worse. He was tested only 25 items, out of which only two were correct, with the rest being phonological errors.

Table 15: Number of items correctly produced on the BNT and OANB tests

	HUNGARIAN		ENGLISH	
	Period 1	**Period 2**	**Period 1**	**Period 2**
BNT	30/60	(i) 25/60 (ii) 16/60	9/60	
OANB: **Actions:** **Objects:**	 74/100 148/162	 54/100 56/100	 36/100 72/162	 7/50 2/25

Summary of naming tests:

JB's naming performance is summarized in Table 5. His naming abilities appear to be better preserved in Hungarian than in English during both testing periods. His performance is worse on the BNT than on the OANB. This could be due to the fact that the BNT contains more low frequency/familiarity words. His impaired performance on action naming in Period 1 on the OANB could be due to the fact that verbs in Hungarian tend to be longer than nouns, making it more difficult for him to articulate the words. In addition, research has shown that action naming tends to be more difficult than object naming in NFPPA (Hillis et al., 2002). His performance during the second testing period on the BNT and OANB in both languages reflects a deterioration in naming as the disease progressed.

3.3 The comprehension of single words:

3.3.1 Written picture-to-word matching task - Hungarian

There are 50 items in the task. An item consists of a written word and four pictures: the target, a phonologically related word, a semantically related word and an unrelated word. During the first testing period, JB made 6/50 errors, out of which he self-corrected four, and during Period 2, he made 5/50 errors.

3.3.2 Word semantic association task (PALPA 51) - English

The test involves the selection of a word out of four written words that are close in meaning to the target. The test includes 15 high imageability and 15 low imageability words. During Period 1, JB was correct on 13/15 high imageability items and 11/15 on low imageability items. In Period 2, he was correct on 12/15 high imageability items and 7/15 correct on the low imageability items.

3.3.3 British Picture Vocabulary Scale (Dunn, Dunn, Whetton & Burley, 1997) - English

The British Picture Vocabulary Scale (BPVS) is a measure of receptive vocabulary. It consists of 168 test items, ranging from very frequent words like *ball* to very infrequent one like *tubular*. The target is presented verbally and the selection is from four pictures. JB was tested in English during Period 1 and achieved a raw score of 25.

3.3.4 Synonym judgement task – Hungarian

The task contains 50 noun, 50 verb and 32 adjective pairs, half similar in meaning and half dissimilar. The task is to decide whether or not the two words are close in meaning. In Period 1, he made 17/132 errors in total in roughly equal numbers on the three word classes (6/50 nouns, 7/50 verbs, 4/32 adjectives). In Period 2, JB made 28/132 errors (9/50 nouns, 14/50 verbs, 6/32 adjectives).

3.3.5 Auditory synonym judgement task (PALPA 49) – English

The auditory synonym judgement task (PALPA 49) consists of items of two spoken words that are either similar in meaning or dissimilar. In the test, there are 30 high imageability and 30 low imageability items. During Period 1, JB correctly judged 27/30 high imageability items and 24/30 low imageability items. During Period 2, JB made correct responses only to 4/30 high imageability and 7/30 low imageability items.

Table 16: Number of items (%) correct in the single word comprehension tests

	HUNGARIAN		ENGLISH	
	Period 1	**Period 2**	**Period 1**	**Period 2**
Written picture/word matching	44/50 (88%)	45/50 (90%)		
Synonym Judgement				
Nouns:	44/50 (88%)	41/50 (82%)		
Verbs:	43/50 (86%)	36/50 (72%)		
Adjectives:	28/32 (87.5%)	26/32 (81.25%)		
PALPA 51				
H Imag/ty:			13/15 (86.6%)	12/15 (80%)
L Imag/ty:			11/15 (73.3%)	7/15 (46.6%)
PALPA 49				
H Imag/ty:			27/30 (90%)	4/30 (13.3%)
L Imag/ty:			24/30 (80%)	7/30 (23.3%)
BPVS			25 raw score, AE: 3;6	

Summary of single word comprehension tests:

The single word comprehension tests are summarized in Table 16. JB's comprehension of single words, especially of concrete words, appears to be relatively well preserved, but he shows an imageability effect with performance being more impaired on low imageability items. During Period 1 testing, he is performing equally well on both languages but as the disorder progressed, his performance appears to be more impaired in English. The incomparabililty of the tests in the two languages should be taken into account however, as the comprehension tests in English are probably more difficult.

3.4 Grammatical Knowledge:

3.4.1 Test for the Reception of Grammar (Bishop, 1989) – English and Hungarian

The Test for the Reception of Grammar (TROG) tests the comprehension of 20 different grammatical constructions (such as active and passive sentences, prepositional sentences, double negatives, subject and object relatives, among others) using a sentence picture matching paradigm.

The test has been translated into Hungarian with some modifications. One block had to be omitted since there are no gender distinctions in Hungarian and the block on passive voice had to be modified because Hungarian has no passive voice. Instead of the passive, the active voice is used in which the direct object argument is moved to sentence initial position (OVS). In this sentence structure, the focus is on the theme argument, similarly to the English passive voice, but no passive morphology is involved. On some of the items JB responded with confidence. On items that he made errors, JB hesitated and asked for repetitions. In Period 1, he made a total of eight errors: one error on OVS structure, one on subject relatives, one on double negatives, one on object relatives, two on prepositional sentences and two on subject relatives with a modified object. During the second testing period his performance was worse and he made a total of 23 errors: two on OVS structures, seven on prepositional sentences, six on subject relatives with a modified object, one on double negatives, six on object relatives and one on comparative adjectives.

In English, during Period 1, JB made nine errors, all in blocks containing syntactically more complex structures. He required repetition of the target sentence on seven additional items. In Period 2 he made a total of 21 errors: three on active sentences, two on comparative adjectives, one on passive sentences, three on prepositional sentences, four on subject clefts, two on negative constructions, three on subject relatives with a modified object and four on double negatives.

3.4.2 Hungarian Syntactic Comprehension Test

The test was administered in Hungarian and consists of 24 sentences, in six categories. The test examines performance on subject and object relatives, reversible sentences in SVO and OVS order and SVO active sentences with coordinated subject and objects. JB was tested twice and in both occasions he made a total of five errors but with different error distributions. In Period 1 he made three mistakes on object relatives, one error on reversible actives in OVS order and one error on SVO actives with coordinated subjects. In Period 2 he made two errors on subject relatives, one on reversible actives in SVO order and one on actives in OVS order and one error on SVO actives with coordinated objects.

3.4.3 Syntactic Comprehension Test (Froud & Druks, unpublished) – English and Hungarian

This test of syntactic comprehension consists of 120 sentences examining a range of syntactical structures such as reversible actives and passives, plausible and impossible actives, plausible and impossible passives, truncated active and passive sentences and prepositional filler sentences. The test, which is a sentence-to-picture matching task, is administered in two sessions, each containing half the sentences from all the categories described above. All items in the test are reversible because the plausible and impossible sentences are accompanied by plausible and impossible pictures.

In the Hungarian version of the test, changes were made to accommodate for different syntactic structure. Reversible passives translate in Hungarian as OVS active constructions in which the subject is marked for the accusative. Truncated passives translate into Hungarian as OV order. JB made a total of 10 errors in Period 1: three on reversible actives, three on reversible passives, one on impossible actives, two on truncated actives and one on truncated passives. In Period 2 he made a total of five errors: two on reversible actives, one on reversible passives and two on truncated passives.

In the English version of the test, during Period 1, JB made nine errors, four on reversible passives, two on non-reversible actives, two non-reversible passives and one truncated actives. In Period 2, he performed on only half of test and he made a total of 19 errors, three on reversible actives, six on reversible passives, one on possible actives, two on impossible passives, two on truncated actives, three on truncated passives and two on prepositional filler sentences.

3.4.4 Anagram Task – Hungarian

The task contains ten simple non-reversible declarative sentences consisting of a subject NP, an object NP and a verb. Nine nouns are marked with accusative case and one with a locative case marker. The sentences are cut up into their constituents and in addition to the words required for constructing a sentence, three noun distractors (one nominative, one accusative and one marked with another case) are also added. JB was tested during Period 1 and made no errors, although he was slow.

3.4.5 Conjunctives test – English and Hungarian

The task involves presentation of ten written sentences in which a conjunction is missing. The patient is asked to choose the appropriate conjunction out of three choices from the following possibilities: *because, that, before, after, where, if,* *therefore, when.* JB made no errors in Hungarian in Period 1, and only one error in Period 2. In English, during Period 2 he gave 6/10 correct responses.

3.4.6 Grammaticality judgement task - Hungarian

The task consists of 10 verbally presented sentence pairs, one grammatical and one ungrammatical. The patient has to select the correct version. The errors in the sentences involved incorrect verb inflections and incorrect case markers. JB was tested during Periods 1 and 2 and made no errors.

3.4.7 Count and mass nouns judgement test - Hungarian

Numerals and quantifiers in Hungarian are followed by the singular form of count nouns [for example, *hat gyerek* (six child), *sok gyerek* (many child)]. The plural form of count nouns is only used when they appear without a numeral or quantifier specifier [for example, *gyerekek* (children), *kedves gyerekek* (nice children)]. Mass nouns, like in English, cannot have a numeral specifier and they remain in singular form following a quantifier. Mass nouns never appear in the plural. The test consists of 80 written items in which count and mass nouns are presented with either a numeral or a quantifier or an adjectival specifier, and were either in plural or singular form. The test has 26 correct forms and 54 ungrammatical forms and the phrases are presented in a written form. In Period 1 JB made no errors but in Period 2 he made 15/80 errors.

Table 17: Number of items incorrect on grammatical knowledge tests

	HUNGARIAN		ENGLISH	
	Period 1	**Period 2**	**Period 1**	**Period 2**
TROG	8 /80	23/80	9/80	21/80
Synt. Comp. Test (Froud & Druks)	10/120	5/120	9 /120	19/60
Conjunctions task	0/10	1/10		4/10
Hung. Synt, Comp. Test	5/24	5/24		
Count & Mass Nouns Task	0/80	15/80		
Anagram task	0/10			
Gramm/ty Judgement Task	0/10	0/10		

Summary of grammatical knowledge tests:

JB's performance on the grammatical knowledge tests presents a comparable picture in both languages. He scored similarly on the TROG for English and Hungarian in both periods, having more difficulty with syntactically complex structures. Reversible sentences with more complex syntactic structure appear to pose more difficulty for him, in contrast to non-reversible sentences on which he made no errors. In contrast, his performance on tests that distinguished between count and mass nouns and tests of grammaticality judgement (in Hungarian) was very good.

3.5 Inflectional Morphology:

3.5.1 Tense sorting task – English and Hungarian

This task, administered in Hungarian during Period 1, involved sorting 30 past tense and 29 present tense verb forms presented in written form on small cards and in random order in past tense and present tense piles. The verbs were in either singular or plural form and in all six persons. The past tense marker in Hungarian is always *–t*. There were five present tense verbs in the test which contain a word final *–t* in their stem, therefore, the task could not be performed by relying only on superficial cues. JB found the task difficult and he mistakenly placed seven present tense verbs in the past tense pile, and three past tense verbs in the present tense pile.

A similar test was administered in English. It consists of 102 pairs of words, the present and past tense forms of the same verbs. Half the items in the test are regular and half are irregular. The patient is asked to select the item that designates the past tense. In Period 1, JB gave 85/102 correct responses. All of his errors were on irregular items. In Period 2, he gave 75/102 correct responses, but his errors included both regular (8/27) and irregular items (19/27).

3.5.2 Verbal inflections test – English and Hungarian

Knowledge of verb affixation in Hungarian was tested with ten sentences in which a verb is missing. The ten sentences were presented verbally and the patient has to choose from four alternatives (visually similar, infinitival, incorrectly inflected and target). In Period 1, JB made no errors but on four occasions he spontaneously produced a different form than the target, all of which were acceptable alternatives. In Period 2, he made two errors and an additional two errors which he self-corrected.

Verb affixation was also tested in English during Period 2 in a task that required distinguishing between stem and third person singular in the present tense. The test consists 40 items. Each item includes two personal pronouns, a third person singular and any of the remaining pronouns, and a verb either in the stem or in the third person singular present tense form. The patient has to link the verb with the appropriate personal pronoun. JB scored 23/40 correct, which is chance performance.

3.5.3 Sentence Completion with Past Tense Forms test - English

This English test consists of 36 sentences in which the first part of the sentence makes a general statement including a verb in the present tense form while in the second part an adverbial necessitates the use of the past tense form of the same verb (for example, *Films usually start at 8:00 but yesterday the film ______ at 8:30*). In half the sentences the verbs are regular and in half irregular. The presentation is in the written modality and the patient has to select the correct verb form from the target verb and either the progressive –ing form or the third person singular form. In Period 1, JB gave 27/36 correct responses. There was no difference between regular and irregular forms and JB chose incorrectly the –ing and the third person singular response an equal number of times. His performance, although well above chance, is considered impaired since unimpaired individuals are expected to make no mistake in this task. In Period 2, JB attempted only 11 items and made 6 errors. His performance here is clearly impaired.

3.5.4 The recognition of written inflected words - Hungarian

In this task, each item consists of a spoken target word presented by the experimenter and three written words out of which the patient has choose the target word. There are 12 noun items differently inflected for case, and six verb items differently inflected for tense and agreement. There are also six noun and six verb items in which the selection had to be made among semantically and phonologically related words. JB made no errors in Period 1 and responded quickly and confidently. In Period 2, he made 4/30 errors (2 nouns, 2 verbs), self-corrected three times but needed several repetitions of the target words.

Table 18: Number of items incorrect on inflectional morphology tests

	HUNGARIAN		ENGLISH	
	Period 1	**Period 2**	**Period 1**	**Period 2**
Tense Sort.	10/30		17/102	27/102
Verb Infl. Test	0/10	2/10		17/40
Sentence Completion			9/36	6/36
Word Rec/tion				
Nouns:	0/12	2/12		
Verbs:	0/6	2/6		

Summary of inflectional morphology tests:

JB performed better in English on the tense sorting task. His errors were initially on irregular items but by the second testing period, impairment extended to regular items as well. In terms of verbal affixation, performance in English was only slightly above average, whereas in sentence completion with past tense forms he is clearly impaired. JB however appeared to have minimal difficulties with the recognition of written inflections, where his responses were quick and confident.

3.6 Summary of Language Tests:

JB's performance in Hungarian presents a varied picture. He can read and repeat one and two syllable words but longer, multisyllabic words present difficulties for him. His output is characterised by syllable-by-syllable production, repetitions of segments and sound distortions. Although he can name high frequency words, low frequency items are difficult for him. His comprehension of single words is relatively well preserved but he shows frequency and imageability effects. His knowledge of Hungarian grammar is well preserved in relation to nominal inflections – case assigning affixes, word order, grammaticality judgement, distinctions between mass and count nouns, the recognition of affixes and the selection of correct conjunctives, but he has difficulties in distinguishing with differently inflected verbs. In terms of comprehension of verbs in sentences, JB had difficulties with reversible sentences and sorting present and past tense verbs.

His performance is similar in English where he has problems reading and repeating longer, multisyllabic items with a breakdown profile similar to Hungarian. JB performed well on high imageability and high frequency items but had difficulties with items of low frequency and imageability. Naming of nouns and verbs posited a problem for him and on several occasions he needed to be prompted with a phonological cue in order to provide the correct answer. In terms of syntactic complexity, JB had difficulties with more complex structures and on both reversible and non-reversible items. Unlike in Hungarian, the comprehension of conjunctions and prepositions also presented difficulties for him, as evidenced by his above average performance. In terms of verb affixation, past tense sorting proved hard for JB where he made errors on irregular past tense and third person singular items.

During 2005, JB was tested on some English language tests which did not require any verbal output, like the comprehension subtests of the Verb and Sentence Test (Bastiaanse, Edwards & Rispens, 2002) where he was unable to follow instructions and the test was abandoned. He was also tested on a test of comprehension of prepositional sentences where his performance was slightly above average.

4. DISCUSSION

JB's cognitive profile is very similar to other reported cases of NFPPA. Hodges and Patterson (1996) report that for their two NFPPA patients, there was a discrepancy between verbal and performance IQ in favour of the latter, clear impairment on digit span and calculation, preserved memory ability and preserved visuospatial and visual perception abilities - a pattern identical to JB. McNeil and Duffy (2001) report that patients with PPA do not present with memory disturbances, are not disorientated, do not suffer from personality changes - except maybe depression due to frustration – and can continue with work and activities of daily living. This pattern of behaviour is again identical to that of JB at the initial stages of the disorder. As the disorder progressed, JB's cognitive and language profile deteriorated as well; examination in 2005, almost eleven years after the onset of the disorder, revealed marked impairment in areas of executive function and problem-solving ability. This finding is not surprising given the numerous accounts of increasing levels of cognitive impairment as the disorder progresses, which ultimately affect many areas of cognition (Green, Morris, Sandson, McKeel & Miller, 1990; Duffy & Petersen, 1992; Rogers & Alarcon, 1999).

Relatively intact comprehension abilities are a finding present in many studies on NFPPA (Mesulam, 1982; Weintraub et al., 1990; Duffy & Petersen, 1992; Hodges & Patterson, 1996). Hodges and Patterson (1996), in their comparison of the two NFPPA patients with a group of SD patients, found that non-verbal single word comprehension was well preserved in NFPPA, a finding that is in agreement with the current study as well. Indeed, JB's performance on the Pyramids and Palm Tress test, which is a test of conceptual knowledge for objects, remained within the normal limits throughout the testing periods. Conceptual knowledge for verbs however did not present with the same pattern, having deteriorated as time progressed. The finding that verbs are more impaired than nouns in NFPPA is not uncommon, with many studies reporting a deficit in verb production (Thompson et al., 1997; Bak & Hodges, 1999; Bak et al., 2001; Hillis et al., 2002). Although the Kissing and Dancing Test employed to investigate JB's conceptual knowledge of verbs does not involve production, it could be that comprehension and production of verbs are served by the same underlying mechanisms, which if damaged will affect both. In general, with progression of the disorder, performance on single word comprehension tests appeared to be more impaired in English but this could also be due to the fact that the English tests employed in this study were more difficult that the Hungarian ones. Testing also revealed an imageability effect, with low imageability items being more difficult, a finding which is not surprising since it is generally accepted that low imageability has an adverse effect on performance in aphasia (Bird, Howard & Franklin, 2003). In addition, and contrary to Hodges and Patterson (1996) who found that NFPPA patients have relatively spared comprehension even for low frequency items, JB's results on the Boston Naming Test for both languages suggests that low frequency has an effect on comprehension.

JB's performance on the naming tasks also confirms the above observation that abilities in noun naming are better preserved than verb naming, at least for Hungarian as the same could not be ascertained with certainty in English because naming in general in this language was impaired to a greater extent. The preservation of object naming as opposed to a deficit in action naming in agrammatic aphasia is well documented in the literature (Miceli, Silveri, Nocentini, & Caramazza, 1988; Zingerser & Berndt, 1990; Berndt, Mitchum, Haendiges, & Sandson, 1997; Kim & Thompson, 2000; see Druks, 2002 for a comprehensive review of noun/verb differences and performance in aphasia). Similarly, a number of studies have reported on the verb production deficit in Broca's aphasia (Jonkers, 1998; Kim & Thompson, 2000; Luzzatti, Zonca, Pistarini, Contardi, & Pinna, 2002, among others), with many arguing that availability is not determined only by grammatical category (verb or noun), but also by complexity within a category (more complex items being more difficult – Bastiaanse & van Zonneveld, 2004). The comparison with Broca's aphasia is appropriate in this case because NFPPA resembles Broca's aphasia on many aspects, including agrammatism (Clark et al., 2005), and because damage is in similar brain regions (Abe, Ukita & Yanagihara, 1997; Rosen et al., 2002). The cause of the impairment is the subject of debate and many views have been put forward. Druks and Shallice (2000) report on a patient whose performance in verb naming was considerably improved when actions were acted out in front of him or when they were carried out by him. Similarly, Campbell and Manning (1996) report on a patient who showed better naming of actions than objects in general and who on many occasions tended to gesture the actions. Druks (2002) states that the evidence from these two patients could suggest that verb production may be facilitated by the availability of action representations, which might not have been accessible in JB's case. Other researchers have argued that the differences between object and action naming could be due to loss/preservation of features, or functional/associative features (Marshall, Pring, Chiat & Robson, 1996a, 1996b; Bird, Howard & Franklin, 2000). Bastiaanse and van Zonneveld (2004) state that the locus of the deficit is located in or around the lemma representations (cf. speech production model, Levelt, 1989), as the lemmas themselves do not appear to be affected. The conclusion of the Bastiaanse and van Zonneveld (2004) study is that grammatical encoding is the cause of the verb production deficit for both single-word naming and verbs in sentence structure, since verbs in either context require grammatical encoding. This could also apply to JB as his performance on grammatical tasks is generally impaired, especially for tasks that require judgment on complex syntactical structure (for example reversible sentences with complex argument structure). Caramazza and Hillis (1991) state that if comprehension of verbs is spared but production is not, the deficit can be located at the level of the output lexicon, as impairment at higher levels would result in deficits of comprehension. In JB's case, comprehension and production of verbs are both impaired, suggesting that, in contrast to focal damage seen in acute cases of aphasia, the diffuse damage in NFPPA affects more than one level of single word comprehension and production. Alternatively – and given JB's difficulties with the pronunciation of longer words, it could be that JB's impaired performance in action naming, at least for Hungarian, is due to the fact that verbs in Hungarian tend to be longer than nouns, making them more difficult to articulate. JB's relatively preserved abilities in object naming also provide evidence for the widely accepted view that the processing of nouns and verbs employs different mechanisms.

JB's performance on tests of grammatical knowledge presents a picture that is comparable to other studies on grammatical ability in NFPPA and Broca's aphasia. The similar locus of damage in NFPPA and Broca's aphasia allows us to expect that there will be grammatical deficits to a greater extent than semantic deficits. Indeed, Hodges and Patterson (1996) report impairment on the TROG for both their participants, a finding which is similar to the current study. JB was impaired on all tests of syntactic comprehension in both languages, but his performance was better in Period 1 than in Period 2. His errors were mainly on syntactically complex sentences, especially reversible sentences. Problems with reversible sentences in agrammatic aphasia, in the face of intact single word comprehension and comprehension of non-reversible sentences, was termed 'asyntactic comprehension' by Caramazza and Zurif (1976). According to these authors, reversible sentences lack semantic or pragmatic cues to assist comprehension, and that the deficit is due an impaired syntactic processor that is responsible for both comprehension and production problems. Schwartz, Saffran and Marin (1980) found that when the syntactic form of the stimulus is varied to include more structures (actives, passives, object and subject clefts and relative clauses), patients' performance was impaired not only on reversible but also on active sentences. This was also true for JB, especially in Period 2. Schwartz et al. (1980) argued that the underlying deficit in their patients was not purely syntactic, but rather a problem of mapping grammatical categories onto thematic roles. This account could apply for JB, at least for Period 1, who showed that in various other syntactic tasks and especially in Hungarian (anagram task, grammaticality judgement, conjunctives task, count and mass nouns task) his performance was within normal limits. His overall grammatical ability was better in Hungarian, where he showed preserved skills on tasks that involved nominal inflections and case assigning affixes, word order, distinctions between mass and count nouns, the recognition of affixes and selection of conjunctives. English appeared to be more affected, as he made errors on non-reversible sentences as well, in addition to errors involving prepositions and conjunctions. For both languages however, performance on morphosyntactic tasks was more impaired. Verb affixation and sorting verbs into past and present tense in particular proved very difficult. This last observation may be taken as additional evidence in favour of the argument that in JB's case - and perhaps in NFPPA in general – the diffuse nature of the disorder affects not only the semantics of verbs, but also to the morphosyntactic processes that govern their formation.

The investigation into JB's phonological abilities in English and Hungarian has provided some interesting results which are in some ways similar to the findings from other studies. Croot et al. (1998) found that the nature of the stimulus (the mode of presentation in this study) influenced the success of single word production; in their experiments it was easier for the patients to arrive at a reasonable phonological approximation to the target when the stimulus itself provided phonological information (reading and repetition > naming), although the difference between success in any modality was minimal, suggesting that there is a processing level common to all three tasks. Despite the latter, they also state that since the spoken word in repetition provides more direct phonological information than the written word in reading, the expectation would be that performance in the repetition task would be better than in reading. JB was not tested in naming in the phonology experiment but his overall pattern of results in English supports the finding that the modality that offers the most phonological information (repetition) produced the biggest number of correct responses (which was on 1-syllable targets) in both periods of testing. The same however does not apply for Hungarian where the number of correct responses, although again on 1-syllable targets, remains almost constant across modes of presentation and periods of testing. The findings of the present study also support the view that impaired auditory-phonological and orthographic processing will result in a degraded form of the information provided by the spoken and the written word (cf. Croot et al., 1998).

The presence of a length effect suggests that the length of a target affects the probability that it will be correctly produced, with 1-syllable words presenting less difficulty than 2- and 3- syllable words. In both languages, JB was most successful on 1-syllable targets, followed by 2-syllable targets, whereas the numbers for correct 3-syllable attempts in both languages are very few in both periods of testing (Tables 2 and 8). Cohen and Bachoud-Levi (1995) state that an increase in error rate related to increased word length suggests that a deficit may exist in the 'phonological' or 'articulatory' output buffer, in a way that the phonological/articulatory plan for the intended unit exceeds the capacity of the buffer. Performance was better in Time 1 than in Time 2 for 1-syllable attempts in English, an expected finding since virtually all accounts of NFPPA make note of decreasing performance as the disorder progresses. However, his performance on targets of the same length in Hungarian that remained constant across modalities and periods of testing suggests that the two languages are differently organised in the brain, and the disorder is affecting L2 (English) more than L1 (Hungarian). The fact that his correct 1-syllable responses in Hungarian were at around 22% correct for both modes of presentation and periods of testing indicates that there is a level of impairment in L1, but it appears to be affecting reading and repetition in both Time 1 and Time 2 at the same extent, unlike in English where the impairment is more pronounced in reading and in Time 2. Nevertheless, despite JB's better performance overall on 1-syllable targets, it is his performance on 2-syllable words that is the best indication of decline between the two periods of testing; in both languages the number of correct 2-syllable attempts is decreased considerably in Time 2, indicating that as the disorder progresses, the phonological and articulatory demands of longer words (>1-syllable) significantly impair performance. This is very similar to Croot et al.'s (1998) conclusion that longer words would be more susceptible to error because words that require more phonological processing provide more opportunity for error (although these authors did not examine performance across different testing periods).

Complexity, which was controlled for by the presence and location of clusters in words, was another factor that was investigated in this study and has shown an effect. In both languages, there were more instances of cluster simplifications than substitutions, indicating that there probably is phonological planning for the intended cluster which is then simplified to facilitate production. In addition, and again in both languages, JB was most successful on targets without a cluster in both modes of presentation and in both testing periods (Tables 5 and 11). Targets of one syllable in length without a cluster produced the greatest number of correct responses, followed by clusterless targets of two syllables in length. Performance on 3-syllable words of any complexity was at floor level for both languages, modes of presentation and periods of testing. Although in general the number of targets of any length and complexity is reduced in Time 2, the reduction of 2-syllable clusterless targets is considerable. In terms of targets containing clusters, JB's performance varies with language: in English he is generally performing better on 1-syllable targets with word initial (WI) clusters whereas in Hungarian he is more successful on 1-syllable targets with a word final (WF) cluster. Longer targets with a cluster in any position are more difficult for him. These findings are not surprising in that it is expected that impaired patients will perform better on targets that are the least complex (without a cluster). This refers back to the point discussed earlier: words that require more phonological processing provide more opportunity for error, and although Croot et al. (1998) are discussing errors as a function of length, this argument can easily be applied to measures of complexity as well. The disparity between more success for targets with WI cluster in English and targets with WF cluster in Hungarian is in this author's point of view an experimental artefact and can be traced to the numbers of available targets in the experimental lists: only seven 1-syllable targets with WI cluster in Hungarian but ninety-four with WF cluster, whereas in English the numbers are forty-two and thirty for targets with WI and WF cluster respectively.

The data were also analysed for specific patterns of errors. The data were first analysed for phoneme substitutions, additions and omissions with somewhat different results for each language . In English, JB was making more substitution errors for repetition in Time 1 but more addition and omission errors for reading. In Time 2, the incidence of addition errors was higher for both modes of presentation (Table 1). In Hungarian, there are more errors of substitution in Time 1 for both modes of presentation, but more addition errors for reading and more substitution errors for repetition in Time 2 (Table 7). The proportion of errors of all types in general increased in Time 2 for both languages. The literature on speech errors usually categorises substitutions of sounds as phonemic errors (Klatt 1981; Canter, Trost & Burns, 1985; Blumstein, 1998), indicating that the cause of the impairment in JB's case is phonological and not articulatory. In English, it would appear that the orthographic input system in Time 1 is better preserved than in Hungarian as the incidence of substitutions in reading in L2 is lower than in repetition. Addition errors in this case of NFPPA are usually the result of phoneme and segment repetitions, and suggest a problem with what Van Riper (1971) coined as the main features of stammering behaviour:

> "[...] a temporal disruption of the successive and simultaneous programming of muscular movements required to produce one of the word's integrated sounds, or to emit one of the syllables appropriately or to accomplish the precise linking of sounds and syllables that constitutes its motor pattern" (p. 404)

Stammering-like behaviour was investigated in this study and the results showed that the vast majority of stammering-like errors were segment repetitions for both languages (Tables 6 and 12). The incidence of phoneme and whole word repetitions was very low, indicating that the problem, in relation to Van Riper's (1971) definition, may be due to inappropriate emission of syllables or imprecise linking of sounds and syllables. Processes affecting the perceived duration of phonemes were also examined and it was found that the majority of errors of this type were processes affecting the duration of vowels in both languages (Tables 3 and 9). This process is particularly important in Hungarian where the distinction of short and long vowels represents a phonological contrast. Problems affecting the duration of vowels in PPA have been reported by Ackermann et al. (1997) who examined a German-speaking PPA patient and found similar results.

During the course of analysing the transcription data it was noted that JB's output was characterised by apraxic behaviour. The analysis of errors therefore was extended to examine for features of Apraxia of Speech (AOS), a disorder which is characterised by the following types of errors (Darley, Aronson & Brown, 1975):

a) effortful groping of articulatory gestures
b) consonant phonemes more affected than vowels
c) inconsistent or variable errors across productions
d) errors that increase complexity of articulation across a word rather than simplify
e) errors that approximate the target within one or two features
f) errors that represent perseveration, anticipation or transposition of phonemes
g) schwa insertions in consonant clusters
h) awareness of errors

Although the full range of AOS characteristics was not examined in this study, some features were examined and suggest that AOS is present in this particular case of NFPPA. There were certainly more consonant than vowel substitutions in Period 1 in both languages and both modes of presentation, with numbers of the two processes being comparable in Time 2 as the disease progressed and worsened (Tables 3 and 9). Schwa insertions were also a feature of JB's output, as were the inconsistent and variable errors across productions. This last feature was not formally examined as JB was only required to produce each target once, but on many occasions he attempted targets more than once giving the researchers the opportunity to ascertain whether his output was variable and inconsistent. The overall impression from the testing process was that JB was aware of his errors and that these errors were approximations to the target, at least during Time 1.

One of the aims of this study was to investigate JB's abilities in the two languages he is proficient in. The findings are very interesting in that they present a similar picture to that presented in other studies of bilingualism in focal aphasia. Fabbro (2001) states that studies have shown that bilingual aphasics do not necessarily show the same language disorders with the same degree of severity in both languages. This is true for JB's case as well, where his performance in object and action naming, his comprehension of single words and his grammatical ability was better preserved in L1 (Hungarian) than in L2 (English). The notion that there is better preserved ability in L1 is not new: indeed, Pitres (1895 – cited in Fabbro, 2001) formulated a hypothesis (which came to be known as *'Pitres' rule'*) in which he suggested that patients tend to recover the language that is *most familiar* to them prior the onset of their aphasia. For JB it is not quite clear which of the two languages he speaks can be considered 'the most familiar' since he had grown up speaking Hungarian but has been using English (presumable more) for the past 50 years or so. Fabbro (2001) makes mention of a criticism of 'Pitres' rule' which has been compared and contrasted with *'Ribot's law'*, whereby patients tend to recover more of their *native language*. This last notion seems to apply better to JB's case, with performance in Hungarian – his native language – being better. However, it is very important at this point to mention that these two formulations describe a process of 'recovery' and they are referring to cases of acute aphasia, a fact which may not apply to the case of progressive aphasia where the damage is diffuse and progressive. Therefore, it could be that the native language is not recovering more as such, but rather is more resistant to damage than L2.

Paradis (2001), in a review of language recovery in polyglot aphasics, has shown that most bilingual patients show a similar impairment in both languages (parallel recovery), followed by a smaller number who show greater impairment in L2 and an even smaller proportion who show greater impairment in L1. Fabbro (2001), in a study investigating the language recovery in 20 Friulian-Italian bilingual aphasics, obtained very similar results, with 65% of patients showing parallel recovery, 20% showing impairment in L2 and 15% showing impairment in L1. JB's overall performance in the current study has shown that in general L1 is better preserved than L2. The results of the phonological experiment however showed that the pattern of performance is very similar for both languages. This discrepancy could be due to the diffuse nature of the disorder of PPA; it could be that - at least in JB's case - the disorder has affected L2 processes such as syntax, naming and comprehension more severely than the equivalent processes in L1. Along these lines, it could be that phonology for both languages is equally (or almost equally) affected. This speculation would also indicate that the organisation of the two languages in the brain is different. This notion however is still highly debated as studies have found that the native language, the most familiar to the patient before the onset of the aphasia, the most socially useful or the most affectively loaded does not recover first or best. It is also not a matter of whether the two languages were acquired and used in the same context as opposed to different contexts, at different times of development (Paradis, 1977, 1998, 2001).

5. CONCLUSIONS

The aim of this study was to investigate the effects of NFPPA on the cognitive and language abilities of one affected individual, and particularly the effects of the disorder over time. As the participant was also bilingual, this study aimed to compare his abilities in both languages and determine whether performance would be better in one than in the other.

The results of the study showed that this case of NFPPA was in general terms not different from other cases of NFPPA reported in the literature. The pattern of damage seen in JB is very similar to the pattern described elsewhere for this particular subtype of PPA, indicating that, even though individual differences between patients exist, in general this disorder seems to follow a prescribed path. The investigations into JB's abilities in the two languages showed that these appear to be more preserved in L1, although not for all the domains of language.

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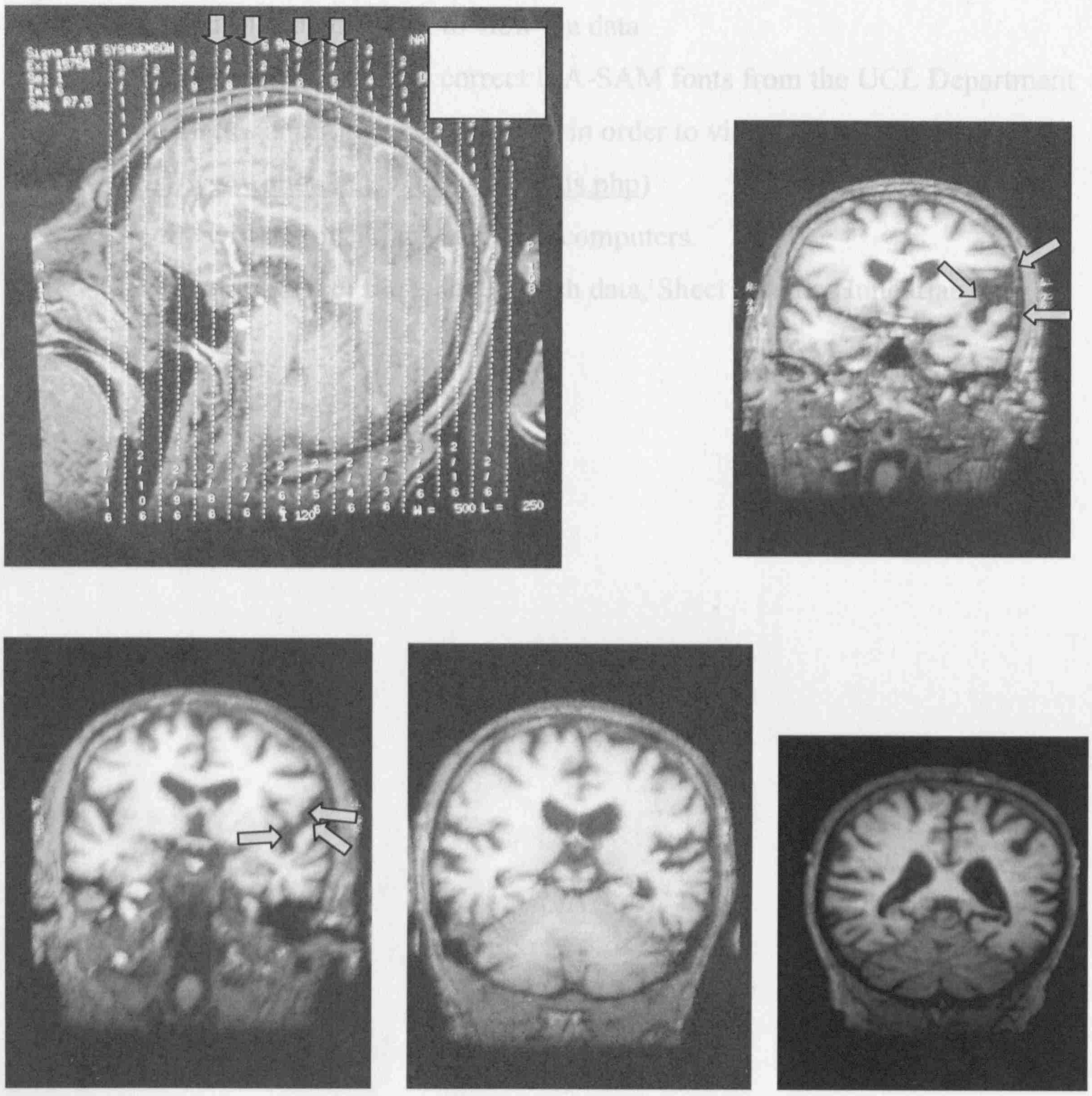
7. APPENDIX 1:

Selected slides from JB's latest MRI scan (May 2003) showing evidence of a mild degree of generalized volume loss, profound perisylvian atrophy with a left sided predominance, and relative preservation of mesial temporal and posterior cortical structures.



8. APPENDIX 2

1. Insert the CD into the CD-ROM drive.
2. If autorun is not initiated, double-click 'My Computer' icon on the desktop.
3. Double-click on the appropriate CD-ROM drive (if more than one)
4. Choose the 'Transcription Data' file.

NB: You need Microsoft Excel to view the data.

You need to download the correct IPA-SAM fonts from the UCL Department of Phonetics and Linguistics website in order to view the transcriptions: (http://www.phon.ucl.ac.uk/shop/fonts.php)

The file will not open on Macintosh computers.

Sheet 1 of the Excel file is the English data, Sheet 2 is the Hungarian data.