Apraxia of Speech in a Bilingual Speaker: Perceptual Characteristics and Generalisation of non-language Specific Treatment

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ABSTRACT

Speech production in a second (or third) language in the case of late bilingualism (or multilingualism) is probably motorically more complex than in the first language and greater demands are placed on the speech sensorimotor control system. In the case of defective speech motor planning due to brain damage, this will be particularly true, but to date no studies have been done on bilingual apraxia of speech. In this study the perceptual speech characteristics of a first-language Afrikaans-speaking apraxic person were studied in both Afrikaans and English and also generalisation of improvement after the application of non-language specific treatment aimed at improving speech motor planning abilities. The results indicated that similar perceptual characteristics occurred in both languages, but the problem in the second language was more severe. Improvement occurred in both languages indicating generalisation to the second language. The theoretical and clinical implications of the results are discussed.

KEY WORDS: apraxia of speech, bilingual, perceptual characteristics, treatment.

INTRODUCTION

The study of apraxia of speech (AOS) in the bilingual speaker provides an unique opportunity to explore the nature of this complex and much debated disorder. Bilingual speakers know that speech production in a second language (L2) which was acquired later than the first language (L1), is not as automatic as speech in the mother tongue and that it requires more conscious effort to attain the correct accent of L2. Speech production in the second language in the case of so-called late bilingualism (Paradis, 1995) would therefore probably place additional demands on the speech control system of the apraxic speaker. A most relevant question would be if the perceptual characteristics in the first and second language are similar in nature and severity. Another related question is whether the re-acquisition of motor planning skills will be generalised to more than one language. If motor planning ability is truly re-developed, generalisation to more than one language should occur and there would be a general decrease in the number of speech errors and a higher incidence of error-free speech.

Both of these issues were addressed in this study as these are most relevant questions in a society where bilingualism or even multilingualism is almost the rule. Due to differences between the language preferences or abilities of clinicians and clients in this country and the high incidence of bilingualism and multilingualism amongst clients, there is a clinical need for a non-language specific treatment programme which facilitates speech planning ability and the benefits of which will generalise to more than one language. The treatment programme that was used in this study was the Speech Motor Learning (SML) Program (Van der Merwe, 1985) which is widely used (Van der Merwe, 1985; Van der Merwe, 1990) in South Africa, but the effect of its application on the second language of apraxic speakers has not yet been tested. The current study is exploratory in nature and addresses these issues which appear to be quite novel in the field of apraxia of speech.

Language use in a second language is widely studied, but no literature could be found on the topic of speech production by a second-language speaker. Several factors will probably influence the process and the nature of sensorimotor control of speech in late bilingualism (or late multilingualism). The age of acquisition of L2 (or L3) and the extent to which the production of the language specific phonemes were automatised will probably be the most important factors in the ease of production of L2. The number of corresponding phonemes in the two languages, the auditory perceptual abilities and the motivation of the speaker to reach the critical acoustic configuration of the novel phonemes of L2 as produced by the mother tongue speaker, will also influence speech motor control in L2.

The four-level framework of speech sensorimotor control (Van der Merwe, 1997) depicts speech production as being context-sensitive. It was hypothesised in this framework that contextual factors such as familiarity, length of the utterance, rate, syllable structure, motor complexity and level of automaticity (see framework for theoretical motivations and references) "affect the dynamics of motor control by exerting an influence on the mode of coalition of neural structures involved during a particular phase and on the skill required from the planning, programming, and execution mechanisms. Certain variants of a specific contextual factor may require more complex control strategies than others" (Van der Merwe, 1997, p6). In the late bilingual speaker, speech production in L2 will probably differ from L1 because it is not as familiar and has not become as automatised and the speaker will experience it as motorically more complex. While communicating in L2, the speaker also has to process more consciously on both the language and motor levels and this impacts even further on the processing demands. Maner, Smith and Grayson (2000) cite many studies that indicated interaction between processing levels in their own study on the effect of sentence complexity on movement stability. Their results indicated that "the motor commands to the muscles have less stable patterns of activity when processing demands are higher" (Maner et al., 2000, p569). Klein, Zatorre, Milner, Meyer and Evans (1995, p31), in their study on neural substrates of bilingual language processing using evidence from positron emission tomography, found left putamen (part of the basal ganglia) activation during L2 repetition tasks and not during L1 repetition tasks. They postulated that "activation of the left putamen is a function of the increased articulatory demands imposed by speaking a language learned later in life". This was the only study that could be found that reported on speech production in a second language. They described it as an unexpected finding as they were studying language processing. However, this is a valuable contribution as it indicates differential processing patterns in the brain during production of L1 and L2.

Motor learning is a concept which relates closely to the process of speech acquisition in a first and second language and to the issue of relearning of speech motor planning after brain damage. The child comes to know the sounds used during speech production by others and then has to learn to translate these acoustically based goals into appropriate motor actions guided by sensory feedback. Motor learning refers to the process of acquiring skilled actions through practice and experience (McNeil, Robin & Schmidt, 1997). Lubker and Gay (1982), in their study on labial protrusion for rounded vowels in Swedish versus American English, found that speakers of Swedish begin their liprounding movement earlier, have more extensive lip movement and achieve more precise goal positions of the lips than do speakers of American English. Their conclusion was that articulatory goals are language specific and that the neurophysiological coding and transformation processes underlying these goals must be learned. An invariant core motor plan with spatial and temporal specifications must be learned for each phoneme (Van der Merwe, 1997). Phonemes that occur in both L1 and L2 can share such a core motor plan, but in the case of non-shared phonemes a new motor plan must be learned while the second language is acquired. Afrikaans and English share many consonants and vowels, but there are also language specific phonemes. The need to adapt core motor plans to the phonetic context of an utterance (Van der Merwe, 1997, Borden & Harris, 1984) adds to the complexity of sensorimotor control, and speech production in L2 will require new strategies for adaptation to the sound environment, that must be learned.

Intervention of AOS needs to take principles of motor learning into account (McNeil et al.,1997). McNeil et al., (1997, p329) define AOS as a "phonetic-motor disorder of speech production caused by inefficiencies in the translation of a well-formed and filled phonologic frame to previously learned kinematic parameters assembled for carrying out the intended movement, resulting in intra- and interarticulator temporal and spatial segmental and prosodic distortions". This definition clearly indicates a motor problem in AOS. The core of a disorder needs to be addressed in intervention. The SML Program (Van der Merwe, 1985) is based on principles of motor learning and targets the range of processes involved in the motor planning of speech as depicted in the four-level framework (Van der Merwe, 1997). A core motor plan for each phoneme of the language is learned (in the case of developmental apraxia of speech) or relearned in the case of acquired apraxia of speech. This acquisition is hierarchically organised based on the clients' sense of ease of production of the different phonemes, starting with those which are easiest. Adaptation in movement specifications to the phonetic environment for each phoneme, is systematically controlled in five so-called variation levels (Van der Merwe, 1985). In this way the principle of variable practice is addressed (Schmidt, 1988), thus promoting generalisation and carry-over (McNeil et al., 1997). The syllable structure of utterances is also controlled starting with consonant, vowel, consonant, vowel (CVCV) utterances and gradually progressing to CVC and longer syllable structures. Nonsense syllables are used as treatment material and only a few meaningful core words are actually practiced during treatment. The programme is based on many more principles of motor learning such as repetition through drill work, but it is beyond the scope of this article to go into more detail (see Van der Merwe, 1985 for detail on principles, long term stages, steps and variation levels) . In the present study, the SML program was applied to a bilingual apraxic speaker, but only L1 phonemes and core words were targeted in treatment. The speech characteristics of this speaker in his first and second language and the generalisation of improvement to his first and second language were explored in this study.

METHODOLOGY

AIMS

This study aimed to explore the perceptual speech characteristics of apraxia of speech in a bilingual speaker and the effect of non-language specific treatment on speech production, in L1 (Afrikaans) in comparison to L2 (English). The sub-aims were four-fold:

- Firstly, to determine if the apraxic speaker presented with the same type of perceptual characteristics in his first and second language and to determine if the severity of the disorder was equal in the two languages as displayed in the number of perceptual errors and words correctly produced without any perceptual errors on the different complexity levels (1 to 11) of the test material during the early and post-treatment periods.
- Secondly, to determine if the frequency of occurrence of the different perceptual error categories were similar in the two languages during the early treatment period and the post-treatment period.
- Thirdly, to determine if the number of perceptual errors in both languages increased and the number of words correctly produced decreased as the complexity of the levels increased.
- Fourthly, to determine if improvement occurred, as reflected in the number of perceptual errors and the number of words correctly produced without any perceptual errors in the two languages during the early treatment and post-treatment period.

RESEARCH DESIGN

This study was part of a comprehensive research project in which the efficacy of the Speech Motor Learning Program (Van der Merwe, 1985) was experimentally tested using a successive level analysis design (Kearns, 1986; Van der Merwe, 1998). Eleven consecutive levels of complexity were established based on the subject's sense of ease of production of the different consonants, vowels and consonant clusters and according to the hierarchy of syllable structures of nonsense units and words determined by the SML Program. The rating of ease of production was based on five evaluations on three different days. Treatment material and test material for each level were developed. The test material included 10 L1 words and 10 L2 words for each of the 11 levels (see Appendix A).

Testing of the L1 words occurred continuously as in the case of a multiple probe design, but testing of the L2 words only took place on two occasions namely during the early period of treatment (just after the baseline tests were completed) and during the post-treatment period which was one year after treatment ceased. The present study comprised a comparison of data collected during the early treatment period (three years post-onset) and the post-treatment period (six years post-onset) for both languages.Treatment continued for two years, twice a week and was done by the first author. Level 6 was reached when treatment was unexpectedly terminated due to changed personal circumstances of the client. He was seen again one year later and at the time baseline maintenance tests of L1 and also the L2 test was done. Post-treatment data reflect maintenance of skills acquired during treatment. Maintenance is the ultimate goal of intervention and such results are powerful evidence of the results of a treatment programme and for this reason data from the post-treatment period were analysed.

The aim of the present study was not to test the efficacy of the SML program, as this was done in another study (Van der Merwe, 1998), but rather to compare the effect of treatment on L1 versus L2. Changes in behaviour that did occur during the study could be assigned to the effect of treatment as it is generally accepted that the rate of recovery after acute insult to the nervous system decreases steadily after a six months period of spontaneous recovery until a plateau is reached (Culton, 1969). On the other hand, recent studies on neuroplasticity indicate that treatment can induce change many years post-onset (Thompson, 2000).

SUBJECT

The subject was a 54 year old university-educated male who suffered a cerebro vascular incident (CVI) three years prior to the time treatment commenced and the first test was done. He was a first-language Afrikaans speaker who was exposed to English from about five years of age both in school and socially. The Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983) (an informally translated Afrikaans version) done three years after the CVI, showed no problems other than in fluency. He had normal hearing, no hemiplegia and no dysarthria symptoms such as asymmetry in the oral structures, involuntary movements or muscle tone disorders. He had small lesions near Broca's area and the left parietal-occipital and right occipital areas. He displayed speech symptoms typical of apraxia of speech (Kent and Rosenbek, 1983; McNeil et al., 1997) such as the presence of effortful trial-and-error groping articulation, dysprosody, such as slow speech rate and syllabic speech, inconsistent phoneme distortions, substitutions and distorted substitutions. During the early treatment period this subject displayed severely unintelligible speech and communicated with the greatest effort in his first language. He did not even attempt to produce a single word in his second language. At the time of the post-treatment test he was an independent person who communicated intelligibly in his first language although he still displayed symptoms of apraxia of speech. He still refused to use his second language but was more willing to attempt production of short utterances.

MATERIAL

The 11 levels of the treatment material and the test material comprised different phonemes combined in various syllable structures as prescribed by the SML program. Level 1 for example, contained the consonants / p, m, s, x / and seven vowels in CVCV structures. Levels 1 to 4 contained the CVCV structure, levels 5 and 6 the CVC structure with sounds from the first four levels, levels 7 and 8 contained the CVCVC and CVCVCVC structures with sounds from the first four levels, levels 9 and 10 contained consonant clusters in CCVCV structures and level 11 contained the consonants he found most difficult to produce in CVCV structures (see Appendix A for test material).

The test material consisted of 10 words in both Afrikaans and English on each level containing the sounds of the particular level and previous levels and combined in the syllable structure of the particular level. The number of times each sound occurred in different word positions could not be controlled completely due to the different requirements of the material, but such rules were adhered to as far as possible. In the English words the same consonants were used and as far as possible the same vowels or the nearest equivalent SA English vowel. The same 110 words for each language were used for the two tests done during the two different points in time.

The treatment material consisted of between 40 and 60 series, each containing five to seven nonsense units on each level and also 10 to 20 Afrikaans words on each level. None of these treated words were included in the test material. Generalisation was therefore tested. The steps and procedures described in the programme were applied during treatment.

PROCEDURE

Testing was done in a soundproof environment and the VU meter of the Nakamichi 550 versatile cassette system recorder was continuously monitored by an assistant. The English words were first produced by imitation combined with reading from flash cards in order to familiarise the subject with the words. The cards each contained just one word. The English words were then produced by self-initiation through reading and this material was analysed in this study. The Afrikaans words were more familiar to him due to previous testing and these were produced by reading from flash cards.

PERCEPTUAL ANALYSIS OF THE DATA

The authors, who are experienced listeners, did perceptual analysis by consensus. Comparison with analyses of material from four levels previously done for the purpose of the original study, reached a reliability score of 89%.

The perceptual error categories were consonant substitutions, voicing errors, consonant distortions, vowel errors, omissions and additions and transpositioning of phonemes and start-restart behaviour. Errors were scored as substitutions when another sound than the target sound was accurately produced. Voicing errors included all voiced-voiceless distortions. Distortions were considered as such when the sound produced was not an accurate production of the target sound due to either temporal distortion or spatial misplacement. Distorted substitutions were scored as two errors. Vowel errors included all distortions and substitutions of vowels as it was almost impossible to determine perceptually if a vowel was distorted or substituted. Substitutions with vowels from the other language were regarded as vowel errors even if they were the nearest equivalent vowels that were produced. A good example in this instance is the vowels /a/ in Afrikaans and /ʌ/ in South African English. Omissions and additions of phonemes were scored as such. Transpositioning of phonemes did not occur. Start-restart behaviour included phenomena such as pauses filled with sound, audible tonic blocks and self-corrections. Each occurrence of such audible behaviour was counted as one error.

PROCESSING OF THE DATA

To address the first aim of the study the number of errors in each perceptual error category on each level during the two tests was counted for each language. The number of errors is displayed in Figures 1 and 2. The number of words correctly produced without any audible perceptual error was also counted and these are displayed in Figures 3 and 4. The total number of errors and the number of words correctly produced in the two tests in the two languages are all compared in Table 1.

To address the second aim of the study the number of errors in each perceptual error category was converted to a percentage of the total number of errors and these were ordered according to the frequency of occurrence in Table 2.

In order to compare the different levels in the two languages, the number of errors on each level were converted to a percentage of the total number of errors during a specific test. These are summarized in Table 3.

A comparison of the early treatment and post-treatment scores based on the number of errors and the number of words correctly produced on the different levels in each language is displayed in Figures 5 to 8.

In order to determine if significant differences existed in the various comparisons, the Wilcoxon Signed Rank Test was done on the data. In the case of this study, this test is more powerful than the sign test since both direction of change and the magnitude of change is taken into account (Pett, 1997). Since the observations are less than 25 the T-value (the smaller sum of like-signed ranks) (Siegel, 1956) was determined in each case. The null hypothesis was that no significant differences existed in the comparisons made.

RESULTS

COMPARISON OF NUMBER OF PERCEPTUAL ERRORS AND WORDS CORRECTLY PRODUCED BETWEEN THE TWO LANGUAGES DURING THE EARLY TREATMENT AND POST-TREATMENT TESTS

Perceptual errors

Statistical analysis indicated that significantly more perceptual errors occurred in L2 than in L1 both during the early treatment and post-treatment tests. The early treatment scores for L1 (median = 8) and L2 (median = 16) differed significantly (p = 0.007). The post-treatment scores for L1 (median = 5) and L2 (median =16) also differed significantly in the expected direction (p = 0.004). In Figures 1 and 2 the total number of perceptual errors on the different levels was compared between the two languages for the early treatment period and the post-treatment period separately. During the early treatment period (Figure 1) more perceptual errors occurred in L2 than in L1, except on Levels 9 and 10. The differences between the languages, however, were only three in the case of Level 9 and one in the case of Level 10. In both languages the highest number of errors occurred on Level 8 which contained the longest utterances (CVCVCVC) and the phonemes of Levels 1 to 4. This is particularly true for L2 in which he had 44 perceptual errors on the 10 words of Level 8. The nearest score to this one, is 24 errors in the case of Level 7.

During the post-treatment period (Figure 2) the apraxic speaker again displayed more errors in L2 than in L1 but the difference between the languages was not as great as during the early treatment period, although it was still statistically significant. On Levels 2 and 4 an equal number of errors occurred and on Levels 6 and 10 only one more error occurred in L2 than in L1 (Figure 2).

In Table 1 the total number of perceptual errors (and

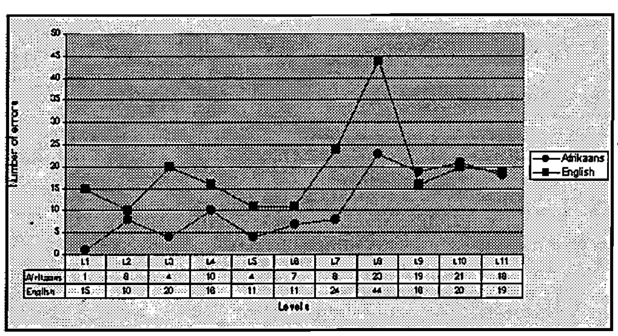

FIGURE 1: Total number of perceptual errors per level during the early treatment period in Afrikaans (L1) versus English (L2).

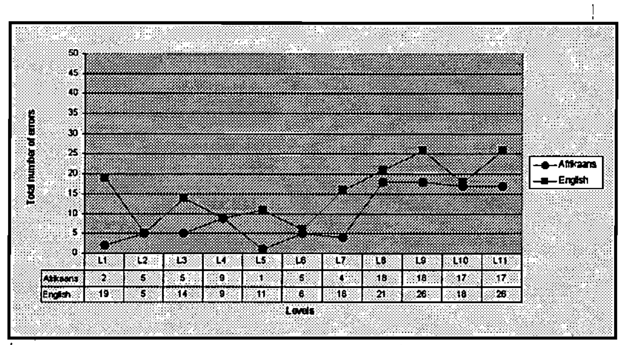

FIGURE 2: Total number of perceptual errors per level during the post- treatment period in Afrikaans (L1) versus English (L2).

the total number of words correctly produced) for all levels was compared between the two languages. During the early treatment period a total of 123 errors were made in L1 and 206 in L2. The difference between L1 and L2 therefore was 83. During the post-treatment period, 101 errors occurred in L1 and 171 errors in L2. The difference at that time was 70. This confirms the observation made earlier, namely that the difference between the languages with reference to number of perceptual errors, tended to decrease during the post-treatment test, but L2 still showed significantly more perceptual errors.

Words correctly produced

The Wilcoxon Signed Rank Test indicated significantly more words correctly produced in L1 than in L2 during both the early treatment and post-treatment tests. The number of words correct during the early treatment period for L1 (median = 3) differed significantly from L2 (median = 1) in the expected direction (p = 0.0165). During the post-treatment test, there was still a significant difference (p = 0.0055) between the number of correct words in L1 (median = 5) and L2 (median = 2). In Figures 3 and 4 the number of words correctly produced in the two languages is indicated for the early treatment period and post-treatment period separately. Both languages had fewer words correctly produced on the higher levels. During the early treatment period (Figure 3) the number of words correctly produced in L1 varied between nine and zero, while in L2 it varied between three and zero, clearly indicating better production in L1. During the post-treatment period (Figure 4) the scores for L1 again varied between nine and zero and for L2 between six and zero, which indicated a bigger improvement in L2 but the difference between the languages was still significant.

In Table 1 the total number of words correctly produced for all levels is compared between the languages. During the early treatment period the difference between L1 and L2 was 23, while during the post-treatment period the difference was 29. The difference between the languages in the case of words correctly produced, increased, which is contrary to the trend observed for perceptual errors. This indicates that L2 improved more than L1 with regard to number of perceptual errors, but that greater improvement occurred in L1 than in L2 with regard to amount of error-free speech.

COMPARISON OF THE FREQUENCY OF OCCURRENCE OF THE DIFFERENT PERCEPTUAL ERROR CATEGORIES IN THE TWO LANGUAGES DURING THE EARLY TREATMENT AND POST-TREATMENT TESTS

In Table 2 the frequency of occurrence of errors in the different perceptual error categories as percentages of the total number of errors during a particular test, is ordered from the lowest to the highest frequency from left to right for each language separately. During the early treatment test an almost identical pattern of distribution occurred in the two languages. In both languages, voicing errors followed by consonant substitutions had the lowest frequency of occurrence while consonant distortions followed by vowel errors had the highest frequency of occurrence.

During the post treatment period both languages still displayed voicing errors followed by substitutions as those categories with the lowest frequency of occurrence. During this period vowel errors followed by distortions had the highest frequency in L1 while in L2 start-restarts followed by vowel errors had the highest frequency of occurrence. In

TABLE 1: Total number of perceptual errors and total number of words correctly produced in Afrikaans (L1) versus English (L2) during the early treatment and the post-treatment period.

Period	Number of perceptual errors			Number of correct words		
	Afrikaans	English	Difference	Afrikaans	English	Difference
Early treatment	123	206	83	37	14	23
Post-treatment	101	171	70	53	24	29
Difference	22	35		16	10	

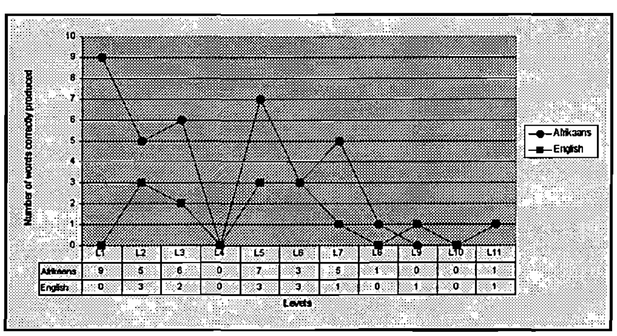

FIGURE 3: Number of words correctly produced per level during the early treatment period in Afrikaans (L1) versus English (L2).

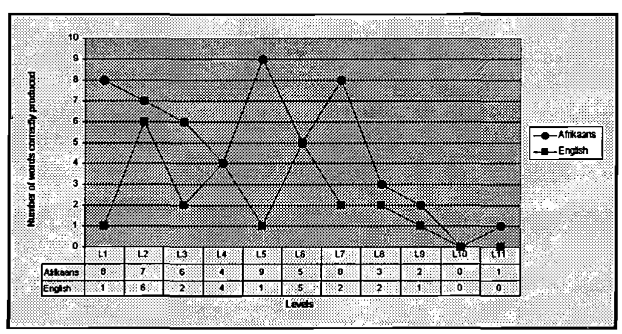

FIGURE 4: Number of words correctly produced per level during the post-treatment period in Afrikaans (L1) versus English (L2).

L1 there was a gradual increase in the frequency of the different error categories, while in L2 the percentage of occurrence of vowel errors is much higher than any of the other error categories. The percentage of consonant distortions is relatively low in comparison to additions, omissions and restarts. This is contrary to the early treatment test results and the L1 post-treatment results.

THE PERCEPTUAL ERRORS AND THE WORDS CORRECTLY PRODUCED ON THE ELEVEN LEVELS OF COMPLEXITY DURING THE EARLY TREATMENT AND POST-TREATMENT TESTS

Table 3 indicates the perceptual errors on the 11 different complexity levels as percentages of the total number of errors during a particular test in a specific language. There was not a systematic increase in the percentage of errors on the different levels, in either language, but it is clear that levels 8, 9, 10 and 11 did induce more errors than the lower levels in both languages. This trend is true for both the early and post-treatment tests and for both languages. It must be kept in mind that during the post-treatment test, Levels 1 to 6 had been treated. The post-treatment percentages of the first six levels tended to be lower than during the early treatment test, although not consistently on all levels, which indicates improvement on the first six levels.

COMPARISON OF EARLY TREATMENT AND POST-TREATMENT SCORES IN THE TWO LANGUAGES WITH REFERENCE TO THE NUMBER OF PERCEPTUAL ERRORS AND THE NUMBER OF WORDS CORRECTLY PRODUCED

Perceptual errors

According to the Wilcoxon Signed Ranks Test, the number of perceptual errors in L1 during the early treatment test (median = 8) and post-treatment test (median 5) differed significantly in the expected direction ($p = 0.0075$). The early treatment test for L2 (median = 16) did not differ significantly ($p = 0.1535$) from the post-treatment test (median = 16). Figures 5 and 6 indicate the number of perceptual errors during the early treatment and post-treatment period compared for L1 and L2 respectively. The total number of errors decreased in both languages, but in L2 more so than in L1. A decrease in number of errors was not observed on all levels. The total number of perceptual errors as displayed in Table 1, confirms the improvement that occurred in both languages. In L1 the difference between the early treatment period and the post-treatment period was 22, and in L2 the difference between these two tests was 35. L2, therefore, improved more than L1 did with regard to the total number of perceptual errors. However, the great improvement on Level 8 actually swayed this result. Statistical analysis indicated that a significant improvement did not occur as the method used took all scores as spread over all levels into account.

Words correctly produced

With regard to words correctly produced, the Wilcoxon Signed Ranks Test indicated that the early treatment score for L1 (median = 3) and the post-treatment score (median = 5) differed significantly ($p = 0.0075$) indicating a significant improvement in L1. The early treatment scores for L2 (median = 1) and the post-treatment scores (median = 2) did not differ significantly ($p = 0.06$). The total number of words correctly produced without any perceptual error on the different levels in L1 and L2 respectively, is displayed in Figures 7 and 8. A greater number of words were produced error free (perceptually) on most levels in L1 during the post-treatment test. Only in the case of Level 1 this trend is reversed (nine correct words during early treatment versus eight during the post-treatment test) and in the case of Level 3 an equal number of correct words

TABLE 2: Ordering of the frequency of occurrence of errors in the different perceptual error categories as percentages of the total number of errors from a low to a high frequency in Afrikaans (L1) versus English (L2) during the early treatment period and the post-treatment period.

Language	Ordering of categories from lowest to highest frequency of occurrence: Afrikaans versus English during the early treatment period					
Afrikaans	Voicing Errors 9%	Consonant substitutions 10%	Start-restarts 11%	Additions, Omissions 14%	Consonant distortions 24%	Vowel errors 32%
English	Voicing errors 5%	Consonant Substitutions 7%	Additions, Omissions 13%	Start-restarts 18%	Consonant distortions 20%	Vowel errors 37%
Language	**Ordering of categories from lowest to highest frequency of occurrence: Afrikaans versus English during the post-treatment period**					
Afrikaans	Voicing errors 4%	Consonant substitutions 13%	Additions, Omissions 15%	Start-restarts 21%	Vowel errors 23%	Consonant Distortions 24%
English	Voicing errors 5%	Consonant substitutions 10%	Consonant Distortions 13%	Additions, Omissions 15%	Start-restarts 18%	Vowel errors 39%

(six) occurred. The implication of this result is that the errors that did occur tended to be on particular words, while there were a greater number of words that were produced error-free. An increase in the number of words correctly produced in L2 also occurred although the number of correct words was not as high as in L1. A reverse in this trend occurred on Levels 5 and 6 in L2, but the difference was only two words on both levels. On three levels the same number of correct words occurred. Improved performance therefore did occur on six of the 11 levels although no

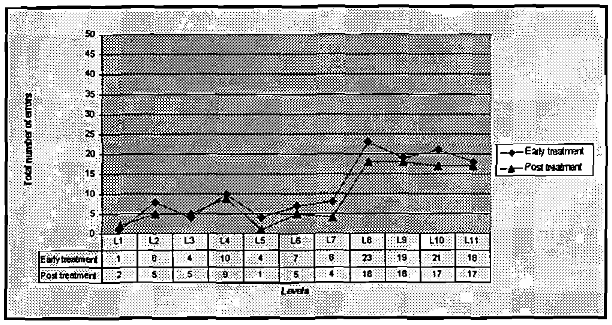

FIGURE 5: Total number of perceptual errors in Afrikaans (L1) per level during the early treatment period versus the post-treatment period.

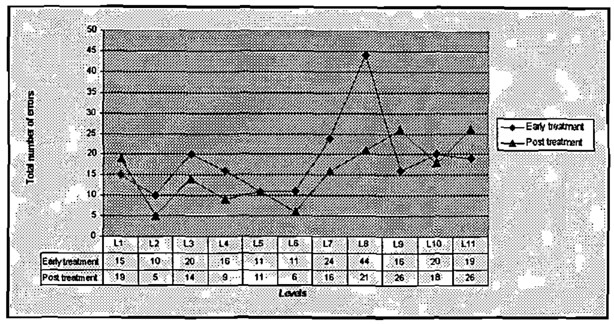

FIGURE 6: Total number of perceptual errors in English (L2) per level during the early treatment period versus the post-treatment period.

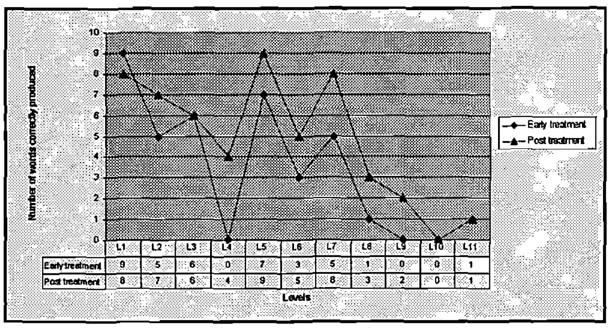

FIGURE 7: Number of words correctly produced in Afrikaans (L1) per level during the early treatment period versus the post-treatment period.

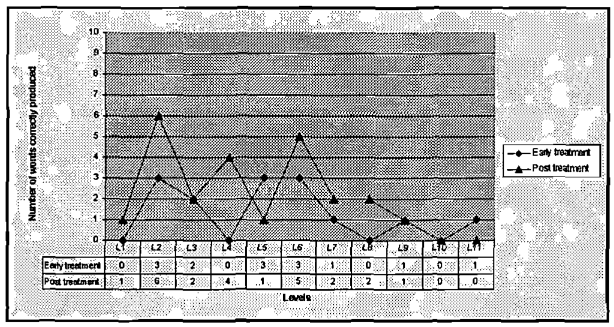

FIGURE 8: Total number of words correctly produced in English (L2) per level during the early treatment period versus the post-treatment period.

TABLE 3: Perceptual errors on the different levels as percentages of the total number of errors in Afrikaans (L1) versus English (L2)during the early treatment period and the post-treatment period.

Level	Afrikaans		English	
	Early treatment N= 123 (100%)	Post-treatment N=101 (100%)	Early treatment N=206 (100%)	Post-treatment N=171 (100%)
1	0.81%	1.98%	7.28%	11.11%
2	6.50%	4.95%	4.85%	2.92%
3	3.25%	4.95%	9.70%	8.18%
4	8.13%	8.91%	7.76%	5.26%
5	3.25%	0.99%	5.33%	6.43%
6	5.69%	4.95%	5.33%	3.50%
7	6.50%	3.96%	11.65%	9.35%
8	18.69%	17.82%	21.35%	12.28%
9	15.44%	17.82%	7.76%	15.20%
10	17.07%	16.83%	9.70%	10.52%
11	14.63%	16.83%	9.22%	15.20%

treatment in L2 was offered. In the case of Level 4, performance improved from no words correctly produced, to four correct words.

The total number of words correctly produced for all levels as displayed in Table 1 confirms that improvement did occur in both languages. L1 improved by 16 words correctly produced and L2 by 10. In this instance the improvement was not greater in L2 than in L1.

DISCUSSION

The results indicated that the same perceptual characteristics occurred in L1 and L2 of the apraxic speaker in this study, but that the number of perceptual errors were significantly more in L2 and also that the number of words correctly produced was significantly more in L1, indicating a more severe disorder in speech production in L2. With regard to the second part of the main aim of this study, it was found that improvement occurred in both languages although it was not significant in L2. The data, however, indicated improvement with regard to number of perceptual errors and number of words correctly produced in L2. In other words generalisation occurred to both languages including L2 that was not at all targeted during intervention and which the speaker did not try to use during communication.

PERCEPTUAL CHARACTERISTICS OF BILINGUAL APRAXIA OF SPEECH

The perceptual characteristics of the disorder in L1 and L2 seem to be similar, although the severity of the problem in the less familiar language seems to be greater. In the speaker that was studied, more perceptual errors occurred in L2, indicating a more severe speech problem in L2. The perceptual errors that were observed in this speaker in both L1 and L2, are the characteristic features of AOS as described in the literature (McNeil et al., 1997; Odell, McNeil, Rosenbek & Hunter, 1990; Van der Merwe, Uys, Loots & Grimbeek, 1988; Kent and Rosenbek, 1983; Wertz, LaPointe & Rosenbek, 1984).

The frequency of occurrence of the perceptual error categories of the two languages was almost identical during the early treatment test (see Table 2). However, treatment seemed to have had an effect on the frequency of occurrence of some of the perceptual error categories, particularly in L2. During the post-treatment test, this client had far more vowel errors than any other type of error. The reason for this is probably the fact that the L2 vowels were not targeted in treatment. The same consonants occurred in the test material of both languages, but some of the vowels differed. It is also not known if he did use the correct pronunciation of the L2 vowels before the onset of his problem. As stated earlier, the use of an L1 vowel in an L2 word was considered an error, even if it was produced without any distortion. Judging vowel errors is for this reason problematic, especially in two languages with near equivalent vowels such as Afrikaans and English. Second language speakers often have an accent due to the fact that the vowels of the first language are used and some of these vowel errors perhaps were not true apraxic errors. The decision to score such vowel "substitutions" with vowels from the other language as errors, was made in order to keep analyses as uncontaminated as possible with no exceptions made and also because substitutions with English (L2) vowels during the production of Afrikaans (L1) words were observed, indicating the ability to produce the English vowels correctly.

The low occurrence of consonant distortions (in the third lowest place) in L2 after treatment (see Table 2) was surprising, as distortions are usually regarded as the most characteristic feature of AOS. As in L1 he had the second highest score in this category during early treatment. The reason for the lower occurrence during the post-treatment test is probably not the low occurrence of consonant distortions in L2, but rather the higher occurrence of other errors such as omissions (third highest occurrence) and start-restarts (second highest occurrence) that occurred more frequently because he was speaking his second language and was applying strategies that enabled him to produce speech in L2. The other reason is the high occurrence of vowel errors as discussed earlier.

MOTOR COMPLEXITY AND BILINGUAL APRAXIA OF SPEECH

The severity of the speech disorder in L2 seems to be greater than in L1 if the number of perceptual errors and the number of correct words are used as an index of severity. This seems to indicate that this speaker experienced speech production in his second language as motorically more complex and that the higher demands placed on his speech sensorimotor planning ability induced a greater number of errors and less error-free speech in L2. This inference is based on the assumption that an increase in motor complexity will cause more speech errors in AOS. The results of the present study strongly suggest that this is indeed the case.

The material used in the two languages in this study contained similar consonants and syllable structures but in some words L2 vowels occurred and in the case of Level 11, one L2 consonant. The question is why the L2 material induced significantly more errors. One reason is that the L2 vowels were less familiar and production less automatised. This speaker apparently tried to attain the correct L2 accent, and by doing this, he found the production of the L2 words to be more difficult. The other plausible reason is the issue of coarticulatory cohesion. During speech production, sounds overlap and lose their distinctiveness as is evident in their canonical form, and are co-produced or coarticulated (Kent & Minifie, 1977; MacNeilage, 1980). The motor goals of the consonants in the L2 words needed to be adapted to the L2 vowels, as adaptations in the core motor plan need to be made under the influence of the sound environment in which a phoneme is produced (Van der Merwe, 1997) and this factor probably further added to the motor complexity as experienced by the second language speaker. Therefore, it was not only the vowels in the L2 words he found more difficult to produce, but also the consonants.

A related question is whether the same kind of factors influenced the severity of the disorder in the two languages. The results indicated that in both L1 and L2 he made most of the perceptual errors on the longest utterances (Level 8) during the early treatment test. During the post-treatment test the length of the utterance did not seem to be the factor that influenced the number of errors most in L2. There is no obvious explanation for this result. It is well-known that apraxic speakers make more errors on longer words (Kent & Rosenbek, 1983; Strand & McNeil, 1996, McNeil, et al.,

1997) which require more complex motor planning. The variability of apraxic symptoms and the fact that only one production of each word was analyzed, could explain this result. The most viable explanation is the possibility that he acquired strategies such as syllable segregation during treatment that enabled him to produce longer words with more success than during the early treatment period. This acquired strategy was generalised to both languages but had the greatest impact on the language he found most difficult to produce. In both languages more errors occurred on the four highest levels of the test material which represented higher levels of motor complexity, based on this speaker's sense of ease of production. This indicates a similarity in the type of factors that will influence motor complexity in both L1 and L2.

GENERALISATION OF TREATMENT

Improvement occurred in both languages. The data as presented in this study, do not provide proof that the improvement was due to the intervention, except for the fact that progress seemed to be more pronounced on those levels that were treated. In the original study experimental control was demonstrated, indicating improvement due to intervention (Van der Merwe, 1998). It was not the aim of the present study to display experimental control, but rather to determine if generalisation of improvement occurred to L2. This indeed happened. In this regard it must also be kept in mind that the post-treatment test was done one year after treatment was terminated and that this client received no therapy during that year. The results as shown in this study, therefore, also reflect maintenance which seemed to have occurred in both languages. This fact is quite significant particularly with regard to the results of L2 and strengthens the conclusions reached in this study. The words included in the L2 test had only been encountered once, three years earlier during the early treatment test and then not again until the post-treatment test. It is most unlikely that he remembered any of these words and practiced them. At the time of the post-treatment test he still refused to speak English, although he understood and read it. The changes that did occur were therefore most probably due to the intervention that occurred. Had more attention been given to L2 during treatment, his ability to speak L2 might have been much better.

CONCLUSION

Bilingual apraxia of speech seems to be as much a reality as bilingual aphasia. To the disadvantage of clients with AOS, this issue has been ignored for much too long. Clinically, it is known that clients express their reluctance to communicate in a second language as they find it more difficult. However, South African society necessitates bilingualism (or multilingualism). Intelligible communication is the first priority, but we can improve more than one language by applying a treatment programme that facilitates speech production in general and includes core words from more than one language.

Only one case was used and only one repetition of each word was analysed in this study. The symptoms of AOS are known to be variable and several repetitions of one word will render more reliable results. However, some clear trends emerged in this study which can be regarded as quite significant and which indicate that the field warrants further research. The material used in this study did not differ that much between languages. If consonants that do not occur in L1 were included in the test material, the degree of the problem in L2 would probably have been even more severe. Different subjects with different levels of proficiency in a second language will also provide more insight into the problem of bilingual AOS. These issues need to be studied in future research.

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APPENDIX A

LEVEL 1:

Phonemes: ***Afrikaans:*** / p, m, s, x, a, i, u, ɔ, ə, oː, eː /
English: /ə, ɒ, ɔː, ʌ/

Structure: CVCV

Afrikaans:	*English:*
mamma	super
poppie	soppy
geesie	saucy
sagie	poppy
papie	summer
gape	see-saw
moesie	possey
gommie	soupy
sopie	supper
magie	puppy

LEVEL 2:

Phonemes: ***Afrikaans:*** / l, t, k, n / Level 1 vowels
English: /æ/

Structure: CVCV

Afrikaans:	*English:*
lappie	lucky
tasse	tackey
kopie	copy
liese	lama
toppie	cocky
kase	Tammy
tiekie	kitty
lippe	cooler
kieme	Lassy
losse	comma

LEVEL 3:

Phonemes: / d, b, f / Level 1 vowels (and /æ/ in English)

Structure: CVCV

Afrikaans:	*English:*
nasie	dummy
bokkie	booty
niese	knotty
voete	fussy
bate	deeper
dose	nutty
vinne	filly
note	bunny
bosse	nappy
dasse	dotty
uu	

LEVEL 4:

Phonemes: / ɛ, əu, əi/

Structure: CVCV

Afrikaans:	*English:*
sousie	pony
boute	Katy
myne	Lassy
sesse	soapy
meisie	patty
lyke	daddy
messe	needy
pyne	Betty
lessie	messy
kouse	Tony

LEVEL 5:

Phonemes: Level 1 phonemes (and /æ/ in English)

Structure: CVC

Afrikaans:	*English:*
mop	map
gas	seem
soom	pass
sies	miss
sog	sip
moes	palm
pop	mass
gis	piece
sap	soup
mag	mop

LEVEL 6:

Phonemes: Level 2 and 3 consonants and Level 1 to 4 vowels

Structure: CVC

Afrikaans:	*English:*
duif	deaf
net	knot
been	bean
lok	look
tien	tan
fout	coal
keel	fat
koud	tough
toon	call
nok	note

LEVEL 7:

Phonemes: Level 1 to 4 phonemes

Structure: CVCVC

Afrikaans:	*English:*
belet	panel
mossies	needed
semel	limit
koekies	carphone
laken	noodle
gemeet	possum
nadat	fatal
tekkies	saddle
datum	Lucas
futiel	panic

LEVEL 8:
Phonemes: Level 1 to 4 phonemes
Structure: CVCVCVC

Afrikaans:	***English:***
moedeloos	penniless
sakeman	telephone
besoekies	decoded
bemoedig	satanic
namiddag	coconut
fouteloos	bulimic
besoedel	buttercake
pennesak	melodic
koekepan	cellotape
babelas	metalic

LEVEL 9:
Phonemes: / sn, sp, sk, tw / and Level 1 to 4 phonemes
Structure: CCVCV

Afrikaans:	***English:***
spanne	snappy
skoene	spooky
skole	scaly
spuite	spotty
skapie	sneeky
twakke	skinny
spoke	spacy
snippe	snooker
skote	speaker
snoete	Scotty

LEVEL 10:
Phonemes: / st, pl, sl, xl / and Level 1 to 4 phonemes
Structure: CCVCV

Afrikaans:	***English:***
stappie	study
plasse	plateau
gloede	sloppy
slapie	stoney
stuipe	sleapy
glase	Stacy
slotte	plumber
plasie	steamy
gladde	pluto
stokkie	sticky

LEVEL 11:
Phonemes: / h, v, j, r / and Level 1 to 4 phonemes (and /ɹ/ in English)
Structure: CVCV

Afrikaans:	***English:***
here	happy
woede	very
jappie	hockey
roete	ruddy
rare	hurry
wydte	valley
jokkie	rocky
hase	hello
jare	veto
rape	holly