

CHAPTER SEVEN

CONCLUSIONS AND IMPLICATIONS

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CHAPTER SEVEN

CONCLUSIONS AND IMPLICATIONS

“If speech is so easy, should not the study of speech be easy? The higher we look into the nervous system, however, the less we know. We know a substantial amount about the sounds which emerge from the mouth of a speaker, and from acoustic analysis have derived information on production... We can infer from information on muscle activity something about the nerve impulses which fire the muscles. We know little, however, about the organization and coordination of these impulses in the brain and even less about how these impulse patterns are derived from stored linguistic knowledge and ultimately from thought.” (Borden & Harris, 1984:45)

7.1 INTRODUCTION

The main aim of this study was to obtain information regarding the effect of speech production in L1 versus L2 on specific temporal parameters of speech production in bilingual normal speakers and bilingual speakers with either AOS or PP. In order to achieve the main aim of the study, specific sub-aims were formulated. The findings of the study are preliminary in nature, since a study regarding the effect of speech production in L1 versus L2 on temporal parameters of speech production in persons with either AOS or PP has not yet been undertaken. Although the results of the study cannot be generalized, owing to the limited number of subjects who participated in the study, specific trends emerged which have the potential to inform on the nature of AOS and PP and speech production in these subjects under circumstances of increased processing demand imposed by increasing speaking rate and speech production in L2. The results of this study also serve to stimulate further research related to bilingual speech production in AOS and PP.

In the following section, the conclusions that can be drawn from the results of the study will be discussed with reference to the main and sub-aims of the study. The theoretical and clinical implications of the current study will then be presented and discussed, whereafter a critical review of the methodology will be provided and recommendations for further research will be made.

7.2 CONCLUSIONS BASED ON THE RESULTS OF THE STUDY

The current conclusions apply only to the subjects and test stimuli of the present study. Only further research with more subjects, different test stimuli and other methods of investigation of speech production in L1 versus L2 will reveal the extent to which these conclusions can be generalized. The fact that some of the results are in agreement with the findings of previous studies, indicates that the findings of the present study are characteristic of persons with either AOS or PP.

The conclusions that can be drawn from the results of the study will be divided into three sections in terms of their theoretical relevance.

7.2.1 Conclusions regarding the influence of speech production in L2 on temporal parameters of speech production

The nature of the influence of L2 on temporal parameters of speech production was deduced from the findings related to the accomplishment of durational adjustments in L1 compared to L2, the extent of durational adjustment in L1 compared to L2, the extent to which the experimental subjects differed from the normal group in L1 compared to L2 and the variability exhibited in L1 compared to L2. The results regarding the aforementioned aspects led to the formulation of the following conclusions:

7.2.1.1 The accomplishment of durational adjustments in L1 compared to L2

- Normal speakers are flexible in the accomplishment of durational adjustments in that they are mostly successful in shortening durations in the FR, which indicates that their speech motor systems are highly skilled and can adjust to circumstances of increased demands.
- Speech production in L2 causes difficulty with the *achievement of durational adjustments* in persons with either AOS or PP when increased demands have

already been imposed by an attempt to increase speaking rate. Consequently persons with AOS and PP experience more difficulty with durational adjustments (decreasing durations in the FR) in L2 compared to L1. This leads to the conclusion that, under circumstances of increased processing demand, speech production in L1 is presumably “easier” than in L2.

7.2.1.2 Extent of durational adjustment in L1 compared to L2

- In normal speakers as a group, the extent of durational adjustment (decrease of duration in the FR) was not greater in L1 compared to L2, regarding VD and VOT for all utterance groups and regarding UD for two of the three utterance groups. Durational adjustments were thus accomplished to a greater extent in L2 in the majority of instances for the normal group, which implied that achievement of durational adjustments was generally presumably not more difficult in the L2 context for the test stimuli used in the present study. However, individual normal speakers were affected differently by L2 regarding the extent of durational adjustment in L1 compared to L2. Two of the normal speakers generally exhibited a greater extent of durational adjustment in L1 compared to L2 regarding all measured parameters, while the other three did not exhibit this trend, except with regard to UOD. The latter finding leads to the conclusion that in some normal speakers, speech production in L2 might be less automatized than in other speakers, causing the extent of durational adjustments to be smaller in this language. Temporal control is thus presumably more difficult for these speakers in L2.
- The effect of speech production in L2 on temporal control is evident in the experimental subjects in that *durational adjustments* (decrease of duration in the FR) are generally greater in these persons when speaking in L1. The latter finding indicates that durational adjustment is presumably more easily accomplished in L1 than in L2.

7.2.1.3 The extent of difference between experimental subjects and the normal group

- In subjects AOS1, PP2 and PP3, the difference between their durations and those of the normal group was most pronounced in the L2FR context, which was hypothesized to impose the greatest processing demand. Subjects AOS2 and AOS3 also occasionally exhibited the greatest extent of difference from the normal group in L2FR, but did so less often than AOS1, PP2 and PP3. Only one subject, PP1, did not exhibit any tendency to differ most from the normal group in L2FR. These former findings indicate that although L2FR appeared to be the most difficult speaking context for some of the experimental subjects because of the deviation from the normal group being most pronounced in this context, it is not equally true for all subjects. This finding might be due to different strategies applied by subjects with either AOS or PP when speaking in more demanding contexts. Furthermore, this finding might point towards the fact that some speakers might have been more fluent in and more accustomed to speaking in L2 than others. Consequently the L2 context did not impose increased processing demands on the speech mechanisms of those subjects. In other words, those subjects did not perceive speech production in L2 as being more difficult compared to L1 contexts.

7.2.1.4 Variability in L1 compared to L2

- In the normal group, variability generally tended to be the greatest in either L2NR or L2FR regarding VD, UD and UOD, which indicated that the L2 context might have led to greater variability in these subjects. The greater variability in the L2 context could be the result of instability regarding motor control because of increased processing demands imposed by the L2 context. Another explanation for the increased variability in the L2 context could be that speech production in L2 was less automatized and consequently resulted in less consistency on repeated productions of a specific utterance. Increased variability thus appeared to be a normal reaction when the processing demands were increased. Variability of temporal parameters might thus be useful for

- determining which contextual factors impose increased processing demands and consequently lead to greater complexity of production.
- In the normal group, variability was more often greater in L2 *normal rate* than in L2 *fast rate*. When speaking at a faster than normal rate, normal speakers presumably can become more precise regarding repeated production of a word despite the increased demand of speaking in L2. This could be due to controlled processing being applied in the L2FR context, since it is expected to be a more difficult/demanding context. The boundaries of equivalence might also be smaller when speaking at a rate that is faster than the habitual rate, necessitating more precise movements and consequently controlled processing. The controlled processing thus caused these subjects to be more precise during repeated productions of a word when they spoke at a faster than normal rate. This controlled processing might not always be successful, however, due to the demands becoming too high with the combined demand imposed by L2 and a faster than normal speaking rate.
 - In the experimental subjects no consistent trend emerged regarding the tendency for variability to be the greatest in the L2NR or L2FR context, with the exception of AOS1, who generally exhibited greater variability in either of these contexts. This finding might indicate that these speakers applied more controlled processing whilst speaking in L2, or that they compensated by slowing down their speaking rate and consequently increased duration. The slower rate that was then employed by these subjects presumably led to more consistent production on repeated trials of a specific utterance.

7.2.1.5 Final conclusion regarding the influence of speech production in L2 on temporal parameters of speech production

Speech production in L2, compared to L1, appears to have posed greater processing demands on persons with either AOS or PP in the present study, which influenced the temporal parameters of speech production in those speakers. This influence was evident from the fact that difficulty with the accomplishment of durational adjustments was experienced more frequently in L2 compared to L1. Furthermore, in the experimental subjects, a greater extent of durational adjustment was generally

achieved in L1 and the greatest difference from the normal group generally occurred in L2. In the normal group, L2 led to greater variability, but other than this, this group was able to adjust successfully to the increased demands. Speech production in L2 can thus be regarded as a contextual factor which increases the complexity of production. The increased processing demands imposed by speech production in L2 are most probably related to the novel and less automatized nature of speech production in L2 compared to L1, which is presumably more familiar and more automatized.

The fact that language influences the motor parameters of speech production implies that higher level cognitive processes impact on the motor control of speech. All levels of processing involved in speech production thus presumably share processing resources, causing these to be more easily exceeded when difficulty with one or more levels of the speech production process is present owing to the impaired processes requiring more than normal resources. When the available resources are exceeded, persons experiencing difficulty with speech and language processing are more susceptible to erroneous production or deviation from normal speakers.

7.2.2 Conclusions regarding the nature of AOS and PP

7.2.2.1 Conclusions regarding the nature of AOS and PP derived from results relating to the duration of temporal parameters

- The majority of the experimental subjects with AOS generally exhibited longer durations than the normal group across all four contexts regarding VD, UD and UOD, indicating difficulty with temporal control in these speakers. The fact that longer than normal durations were present in all speaking contexts could indicate that slow speaking rate, or longer durations could be a core characteristic of AOS and not necessarily only a compensatory strategy that is employed when the demands of the speaking context become too high. Regarding UD, subject AOS3 did not constantly exhibit longer durations than the normal group across all four contexts. Subject AOS3 had the least severe

AOS, which might imply that the severity of the disorder influenced the extent of difficulty experienced with regard to temporal control.

- Since temporal control is exerted during all the motor stages of speech production (motor planning, motor programming and execution) as specified in the four-level framework of speech sensorimotor control (Van der Merwe, 1997), it is difficult to determine exactly to which level of the speech production process the difficulty of the subjects with AOS regarding temporal control can be attributed. Furthermore, difficulty at one level of the speech production process will influence operations involved in the lower levels. In relation to Schmidt's schema theory (Schmidt, 1975), the deficit in the subjects with AOS in the present study might be related to difficulty with parameterization of the GMP, in other words, with specification of the absolute values of the temporal (and spatial) parameters for movement execution and, in this case, speech production. The correct GMPs were presumably selected, since perceptually on-target speech was produced.
- Although the subjects with PP often had longer durations than the normal group across all four contexts, they generally exhibited less instances of this behavior than the subjects with AOS. Although a deficit regarding temporal control thus appears to be part of the pathogenesis in subjects with PP, it appears to be less consistent than in the subjects with AOS. In the present study, the subjects with PP were thus successful more often than subjects with AOS with regard to temporal control when processing demands were increased. The longer durations in the subjects with PP might therefore be due to a compensatory strategy (slowing rate), which is applied when the processing demands become too high, and are not necessarily a core feature of PP.
- The subjects with AOS generally had longer durations regarding the measured temporal parameters than the subjects with PP, indicating that the severity of the motor disorder in AOS is greater than it is in PP.

7.2.2.2 Conclusions regarding the nature of AOS and PP derived from results on token-to-token variability of temporal parameters

- Most of the experimental subjects exhibited greater token-to-token variability regarding durational measures, as measured using SDs, than the normal group across all four contexts. This seems to point towards the presence of a motor control deficit underpinning the disorder in both these groups of speakers. Greater token-to-token variability also presumably points towards less stable motor control systems in these subjects.
- Variability demonstrated by the subjects with AOS was generally greater than that demonstrated by the subjects with PP regarding VD and UOD for all utterance groups and regarding UD for the voiceless fricative utterance group. This finding indicates that the underlying causes of greater than normal variability in both AOS and PP might be different.

7.2.2.3 General conclusions regarding the nature of AOS and PP

- The fact that only on-target utterances were analyzed in the present study and still revealed differences from the normal group, implies that speakers with AOS or PP are somehow able to compensate for their impairments and still obtain perceptually accurate speech. As discussed in chapter six, trade-offs might occur regarding the achievement of various motor goals under circumstances of increased processing demand. A degree of flexibility in the speech production mechanisms of persons with AOS and those with PP thus seems to be preserved, despite difficulty regarding one or more of the stages of speech production. The extent to which subjects are able to compensate, in spite of their speech and/or language impairments, might be used as a prognostic indicator (Seddoh *et al.*, 1996a).

7.2.3 Conclusions regarding the influence of speaking rate on temporal parameters of speech production

- Normal speakers were generally successful with decreasing duration in the FR, whereas both subjects with AOS and those with PP had occasional difficulty accomplishing durational adjustments. This finding might point towards a motoric inflexibility in subjects with either AOS or PP (Kent & McNeil, 1987).
- Speaking at a faster than normal speaking rate appears to increase both the linguistic and motor demands, since the operations involved in both these processes have to take place at a faster than normal rate. The increased speaking rate, together with speech production in L2, thus causes subjects with speech and language deficits to be more susceptible to breakdown in respect of temporal control.

7.2.4 Conclusions regarding the effect of speech production in L2 on the control of different temporal parameters

- Normal speakers generally had a greater extent of durational adjustment in the FR in L1 compared to L2 regarding UOD, although this trend was not observed for the other measured parameters. The latter finding might indicate that this aspect of temporal control might be more sensitive to the influence of the language of production (L1 versus L2) than UD, VD and VOT. UOD in the normal speakers in the present study is equivalent to the stop gap duration, in other words, the period of silence preceding the release for a stop consonant. This period of constriction precedes the burst release for plosive production and the onset of voicing in order to produce either a voiced or a voiceless plosive. Consequently, it might be a more difficult parameter to control.
- *VOT* appears to be less sensitive to the influence of increased processing demands imposed by speaking at a faster than normal rate and by speech production in L2. This is substantiated by the following findings:

- a) Very few experimental and normal subjects exhibited a greater extent of durational adjustment in L1 compared to L2 regarding VOT, even though they exhibited this behavior regarding the other temporal parameters which were measured, namely VD, UD and UOD. The latter finding might be due to the fact that a change in VOT could lead to the production of a voiced consonant instead of a voiceless consonant and vice versa. The boundaries of equivalence might thus be narrower for VOT than for the other measured parameters, causing subjects to exert more conscious control regarding production of either a voiced or a voiceless plosive.
- b) Subjects AOS2 and AOS3 generally exhibited longer durations than the normal group across all four contexts regarding VD, UD and UOD. This behavior did not occur regarding VOT, which indicates that temporal control of this parameter might be preserved to a greater extent in these subjects compared to the other parameters. However, AOS1, the most severe apraxic, exhibited longer durations than the normal group across all four contexts regarding VOT as well as the other measured temporal parameters. The latter finding indicates that the extent to which temporal control is affected might be dependant on the severity of the impairment. Although the VOTs of the experimental subjects were longer than those of the normal group, they did not result in substitution of voiced plosives for voiceless plosives. The longer than normal VOT durations were thus still within the boundaries of equivalence. If the VOTs had exceeded the boundaries of equivalence, a voiced plosive might have been replaced by a voiceless plosive.
- c) The durations of PP2 and PP3 never differed most from the normal group in L2FR regarding VOT, even though their durations differed most from the normal group in L2FR regarding most utterance groups for VD, UD and UOD. This finding indicates that VOT was influenced differently by the increased demands, compared to the other temporal parameters in PP2 and PP3.
- d) Only one of the experimental subjects, PP1, exhibited greater than normal variability regarding VOT across all four contexts. This implies that not one of the other experimental subjects exhibited greater variability regarding VOT across all four contexts, even though greater than normal variability was generally exhibited by these subjects regarding the other measured parameters.

- e) In the normal group the greatest variability was never exhibited in either L2NR or L2FR regarding VOT, even though this group generally exhibited the greatest variability in either L2NR or L2FR regarding VD, UD and UOD.
- In the theoretical framework of speech sensorimotor control proposed by Van der Merwe (1997), it is posed that IAS, of which VOT is an example, is an independent operation in the motor planning of speech. Other operations include, for example, sequential organization of movements and planning of consecutive movements. It thus appears as if the different operations involved in the motor planning of speech can be affected selectively. The fact that VOT is not affected to the same extent as the other temporal parameters by the increased demands might also indicate that some aspects of motor control are less prone to disruption than others in the presence of a neurologic lesion.

7.3 IMPLICATIONS OF THE STUDY

7.3.1 Theoretical implications

The present study is the first acoustic study to investigate the effect of speech production in L1 versus L2 on temporal parameters of speech production in bilingual speakers with AOS. Up to now bilingual speech production in AOS has been greatly ignored. Ignorance regarding bilingual speech production in AOS is most probably due to the fact that speech and language processes are often regarded as operating independently. Previous studies have challenged the latter view and have shown that “higher level language processes” impact on “lower level motor processes” (Maner *et al.*, 2000; Strand & McNeil, 1996). From the results of the current study and a previous perceptual study by Van der Merwe and Tesner (2000), it can be concluded that bilingual AOS is as much a reality as bilingual aphasia (Van der Merwe, & Tesner, 2000). Considering that it is estimated that approximately half the world’s population is bilingual (Grosjean, 1982), it is imperative that bilingualism in AOS be acknowledged and dealt with in both the clinical and research settings.

The present study contributes to the growing database relating to the acoustic characteristics of persons with AOS or PP. Furthermore, information was obtained regarding speech production in these groups of speakers under circumstances of

increased processing demand, as imposed by an attempt to increase speaking rate and speech production in L2. This information highlights the fact that speech production in L2 poses increased demands to the speech production mechanisms of persons with either AOS or PP. Furthermore, it underscores the importance of recognizing the effect of language processing, specifically L1 versus L2 speech production, on speech motor control. The results of the present study also rendered information regarding the underlying nature of the impairment in AOS and PP. In this regard the nature of the impairment in AOS and PP appears to be similar in L1 and L2, but more pronounced during speech production in L2. Speech production in L2 is presumably motorically more difficult due to the novel and less automatized nature of L2 compared to L1, and this intensifies the motor deficit in bilingual speakers with AOS. The study of bilingual AOS provides the opportunity to learn more about the nature of this disorder, as well as about the interaction of speech and language processing in the brain.

The results of the present investigation indicate the need to incorporate both motor and language aspects when compiling models of speech production for the explanation and the study of aspects of normal and pathological speech motor control. The importance of this is underscored by the fact that the different stages involved in speech production appear to interact and influence one another. Speech is a fine motor skill, but cannot be completely understood without the incorporation of the language processes that precede production (Kent, 1990). Motor and language processes appear to interact in a direct and complex way, with the result that the complexity of speech and language processing cannot be fully understood and studied when either of these perspectives is neglected. The framework of speech sensorimotor control proposed by Van der Merwe (1997) incorporates both these elements and can account for the deficits observed in persons with either AOS or PP in the present study. The results of the study underscore the need for a comprehensive framework of speech motor control within which to explain and interpret findings.

7.3.2 Clinical implications

Although every research project renders only a minute contribution towards the vast potential knowledge base relating to a particular subject, the thoughts and subsequent research stimulated by each new study reaches far beyond the reported results. In order to truly benefit the field of study, however, the results of the empirical study need to lend themselves to clinical application. Research should thus aim to enhance the performance of the clinician in the clinical setting by, for example, providing a clearer description of disorders, assisting in differential diagnosis, improving understanding of the nature of various disorders and ultimately by providing a backdrop for the development of more effective assessment and treatment methods. In this regard, the results of the present study also have important clinical implications. The clinical implications of the present study will be discussed below.

- The fact that L2 increases the processing demands to the speech production mechanism implies that L2, as a contextual factor, needs to be taken into account when compiling assessment and treatment procedures for persons with either AOS or PP. When a speaker has to perform speech production tasks in L2, performance might deteriorate depending on the nature of the other demands imposed by the speaking context. It is consequently important to take the language in which evaluation and treatment is conducted into account. Furthermore, if it is not possible to provide therapy in a person's L1, other contextual factors which have the potential to increase the processing demands need to be limited during the initial stages of therapy, for example, increasing speaking rate and linguistic complexity of an utterance. As the person's motor skills improve, more demanding contexts can be employed. In her therapy program for speech motor learning for persons with AOS, Van der Merwe (1985) emphasizes the importance of grading task complexity when conducting therapy with persons with AOS. In the present study, the accomplishment of changes in speaking rate appears to be a difficult task for persons with both motor and linguistic-symbolic planning deficits. Furthermore, a reduction in speech rate appears to be employed by some speakers as a compensatory strategy when the

demands of the speaking context are increased. In such instances, slowed speaking rate is presumably the result of the application of more conscious and controlled processing. Slowing speech rate might consequently be useful as a technique for obtaining on-target speech during the initial stages of therapy. During on-target speech production subjects are given the opportunity to build up a sensorimotor memory of correct production for the utterances that are targeted.

- The fact that different contextual factors influence persons with various speech and language disorders differently emphasizes the need for experimenting with different contexts of speech production in different speakers. Since some contextual factors might not lead to breakdown in certain speakers, these contexts can be used in therapy whilst other more demanding contexts, leading to breakdown or greater deviation from normal speakers, should be avoided in the initial stages of therapy. For example, if accomplishment of on-target speech production is more difficult in L2 in a bilingual speaker with AOS, L1 sounds and utterances should be targeted first in therapy. Once the phonemic repertoire of L1 has been mastered, L2 speech sounds and utterances can be targeted.
- From the results of the study it is evident that subjects with either AOS or PP might share common features. Unlike the traditional belief, subjects with PP might thus also exhibit difficulty regarding certain aspects of speech motor control. It is important to recognize the presence of common characteristics when attempting differential diagnosis in persons with AOS or PP. Characteristics identified in the present study as relating to AOS include slower than normal speaking rate, longer than normal durations regarding VD, UD and UOD, and greater than normal variability regarding the aforementioned durational measures. The characteristics that were reported for the subjects with AOS also apply to the subjects with PP in the present study, but were more severe and occurred more consistently in the subjects with AOS.
- The results of the present study indicate the underlying impairment in AOS to be motoric in nature. Therapy programs, such as the Speech Motor Learning (SML) Program (Van der Merwe, 1985) would thus be effective for treatment of AOS, since this program incorporates principles of motor learning and aims to facilitate speech motor planning and control. The fact that persons with PP also appear to exhibit a motor component underlying the nature of their impairment implies that these speakers might also benefit from the SML Program (Van der Merwe, 1985).

However, this will need experimental confirmation. A preliminary study by Van der Merwe and Tesner (2000) has shown that the SML Program (Van der Merwe, 1985) might be useful in facilitating generalization from L1 to L2 regarding improved speech production. Consequently this program might be useful for improving speech production in bilingual speakers with AOS, and possibly also for those with PP.

7.4 EVALUATION OF THE RESEARCH METHODOLOGY

Although an attempt was made to structure the experimental design according to the guidelines for scientific research (Smit, 1983), certain aspects may be subject to criticism. The first of these pertain to the *limited number of subjects* who participated in the study. Pure AOS is seldom encountered and consequently subjects who meet the inclusion criteria are few. In this regard McNeil *et al.* (2000:229) state that “it is our experience that “pure” AOS is so rare that practicing clinicians will be unlikely to observe it more than once or twice in the course of their careers. This is likely to be the case even if they are sensitized to its importance and are exposed to a full and continuing caseload of neurogenic communication disorders”. The time-consuming nature of the analysis method used in the present study further makes inclusion of large subject numbers impractical for a single researcher. In the present study, an attempt was made to include subjects with the purest possible form of either AOS or PP. It was thus decided to obtain a reliable sample from a small number of “pure” subjects, rather than obtain unreliable data from a larger number of subjects who did not meet the inclusion criteria. The advantage of using smaller groups and even single cases is documented in the relevant literature (Kamhi, 1985; Siegel & Spradlin, 1985). Most recent acoustic studies in AOS and PP included groups of four to five subjects (Clark & Robin, 1998; Seddoh *et al.*, 1996a, b; Strand & McNeil, 1996).

Another possible criticism pertains to the fact that some experimental subjects were *not completely homogeneous regarding the severity* of their disorders. Subject AOS1, for example, exhibited more severe AOS than subjects AOS2 and AOS3. Subject AOS3, although exhibiting apraxic speech characteristics, was a much more fluent communicator than AOS1, whose speech was hesitant and laborious. For this reason it was decided not to group the subjects, but to describe the results of each subject

individually. The latter aspect is disadvantageous since statistically significant results cannot be obtained through using descriptive statistics in this manner. On the other hand, the use of descriptive statistics for each individual subject can be regarded as an advantage, since this has potential to reveal individual differences between subjects that have the same speech and/or language disorder, but different levels of severity. The latter might lead to the identification of subtypes of AOS, as suggested by the results of certain studies, for example, a study by Square-Storer and Apeldoorn (1991). Descriptive results of individual subjects thus have the potential to more accurately describe the behavior of a specific subject with a specific speech and/or language disorder. Furthermore, if the severity of the problems experienced by the subjects differs and a particular subject's level of severity or behavior differs significantly from that of the other subjects in the group, the group results might reflect the performance of this particular subject and might not be representative of the general behavior of persons in the specific group.

Because of the *amount of descriptive data* in the present study and the *large number of variables* that had to be incorporated (the four contexts of speech production, four temporal parameters and fourteen utterances), many aspects of the data could not be discussed and specific aspects had to be singled out in an attempt to answer the research question. Consequently only the main trends pertaining to the main and sub-aims could be highlighted. Furthermore, since the *number of utterances* that were analyzed was quite large, it was difficult to view the results of specific utterances in detail. The use of fewer utterances might allow for more detailed analysis regarding the influence of the articulatory characteristics of an utterance, whereas a larger number of utterances might be more representative of the influence of L2 across utterances.

The *speech stimuli* used for analysis in the present study were *virtually identical* in L1 and L2, with the exception of the carrier phrase which preceded the test utterance. Use of these test utterances might thus not be representative of the processing demands imposed by spontaneous speech production in L1 and L2 respectively. The *similar nature of the L1 and L2 utterances in the present study* might thus have limited the potential to reveal differences regarding speech production in L1 versus L2. In other words, if speech production in L2 was more demanding to the speech

production mechanism, the nature of the test stimuli might not have been able to reveal this adequately. To limit the influence of other variables, for example, the motor complexity of the utterance itself, it was necessary to use utterances in L1 and L2 that were phonemically and phonetically similar. If the utterances had differed phonemically, differences that were obtained regarding speech production in L1 and L2 might have reflected the motoric demands of the utterances in each language and not necessarily the effect of the language variable (L1 versus L2) as such. However, despite the very similar nature of the utterances in L1 and L2, trends regarding the influence of speech production in L2 still emerged.

Another aspect of the empirical study that requires consideration concerns the *parameters* that were examined. It might be necessary to study other aspects of the acoustic signal in addition to the temporal parameters of the present study, to determine the influence of speech production in L2. Studying other temporal factors, such as, second formant transition duration and between-word segment durations might reveal differences regarding speech production in L1 and L2 more clearly. A study of other aspects of the acoustic signal, for example formant trajectories using linear predictive coding, could reveal aspects about the accuracy of spatial parameters during production. Furthermore, if spatial parameters were studied in conjunction with temporal parameters, more information might come to light about the different operations involved in the motor control of speech.

Pertaining to the *data collection procedure*, an aspect which might have influenced the results is the fact that speaking at a faster than normal rate was not controlled in the present study. In other words, subjects were merely requested to speak as fast as they could whilst still maintaining accuracy of production. Some subjects might thus have spoken at a faster rate than others and often the experimental subjects were not able to speak faster than their control rate. Although an external cue for the required rate could have been employed, for example by using a metronome, subjects might still not have been able to achieve speech production successfully at the required rate. Valuable information was obtained by observing the subject's ability to achieve durational adjustments without cueing.

7.5 RECOMMENDATIONS FOR FUTURE RESEARCH

From the results of the study it is evident that bilingual AOS is as much a reality as bilingual aphasia (Van der Merwe & Tesner, 2000). However, speech production in bilingual speakers with AOS has seldom been systematically investigated. Since speech production in L2 appears to pose higher processing demands to the speech production mechanisms of some persons, it is important to study the influence of speech production in L1 versus L2 in greater depth and in different ways to determine how it impacts on the various aspects of speech production in normal speakers and speakers with communication impairments. From the results of the present study, the need for further research regarding bilingual AOS becomes evident. In this regard the following recommendations for further research are made:

- Since it became evident that not all temporal parameters were affected equally by the increased processing demands (speaking in L2 and at a faster than normal rate), it is recommended that a comparison be made between temporal control of different temporal parameters. By comparing different temporal parameters, or determining whether a relationship exists between them, it would become possible to establish whether temporal control of some temporal parameters is more difficult than that of others, especially when processing demands are increased by speech production in L2. More could thus be learned about temporal control of different parameters in normal and disordered speakers under circumstances of increased processing demand.
- Since not all normal and experimental subjects appear to be affected in the same way by speech production in L2, it becomes evident that it is important to study the speech of individual subjects over a wide range of behaviors in order to determine specific trends amongst various subjects in different subject groups. By studying individual subject performance, more can be learned about the different strategies employed by subjects under circumstances of increased processing demand.
- An analysis of spatial parameters, together with temporal parameters of speech production, might be useful in highlighting the extent and nature of deficits in AOS and PP, as well as the occurrence of trade-offs during speech production in

L1 and L2 respectively. Some persons might exhibit spatial deficits whilst others might exhibit deficits regarding temporal control only. A third group might exhibit both temporal and spatial deficits. By studying various aspects of motor control, subtypes of AOS might be identified.

- Related to the identification of subtypes of AOS, is the study of non-speech oral-motor behavior though determination of visuomotor tracking ability in AOS as suggested by Clark and Robin (1998). Since language processing is not involved in the study of non-speech oral-motor control, the study of this aspect might be useful in identifying motor control disturbances related to AOS without biasing data through the use of either L1 or L2. This would be particularly useful when subjects cannot be evaluated in their first language due to the examiner not being fluent in that particular language.
- A study of the effect of speech production in L1 versus L2 on the frequency and type of errors produced using perceptual analysis could potentially provide information on the difficulty of speech production in L1 versus L2 and the perceptual consequences. The study by Van der Merwe and Tesner (2000) was the only study which could be found in this regard.
- An investigation of the effect of various treatment programs on parameters of speech production in L1 and L2, in order to determine if carryover of speech motor learning took place from the language in which therapy was conducted to the production of the second language, would be useful in determining which therapy programs are relevant for use with bilingual speakers. Specifically, the study of subphonemic aspects of speech production which have been used to identify the core features of AOS, for example, segmental and intersegmental durations and variability of durations (McNeil *et al.*, 2000) in L1 and L2 should thus be assessed before and after treatment to determine the influence of treatment on these parameters in both languages. In this regard, Van der Merwe and Tesner (2000) found that carryover from L1 to L2 took place when the Speech Motor Learning Program of Van der Merwe (1985) was used with the bilingual speaker with AOS who participated in their study. The study by Van der Merwe and Tesner (2000) used perceptual analysis of speech errors.
- A study of different aspects of motor control during speech production in L1 and L2 should aid in determining whether similar aspects of speech production are affected in both languages, for example, coarticulation, IAS and speaking rate. By

determining whether similar aspects of speech motor control are affected in L1 and L2, more will be revealed about bilingual speech and language processing. Differential processing patterns might become evident for speech production in L1 versus L2.

- The operating range during repeated production of an utterance can be determined by deducting the smallest duration of a specific parameter from the largest duration in L1 and L2 respectively. This might provide insight regarding the operating range within which one has to stay to remain within the boundaries of equivalence for the production of speech sounds. It should be interesting to see if this operating range differs between L1 and L2. The latter has the potential to reveal more about the boundaries of equivalence and speech motor control in L1 and L2 respectively.
- Different levels of analysis, for example, electromyographic, kinematic, acoustic and perceptual methods, could be used to determine whether breakdown at different levels of the speech production process occurs in each language. It should be interesting to see if different methods of analysis reveal similar patterns of deficit in L1 and L2. Furthermore, one would also be able to see whether different parameters of speech production are affected similarly, for example acoustic and kinematic parameters.
- The study of parameters of speech production in persons with different levels of bilingualism and even multilingualism has the potential to reveal more about the linguistic and motor control of more than one language. From the aforementioned it could be determined if persons who are more fluent in a specific language are more skilled regarding motor and/or linguistic control in this language compared to persons who learned a second language later on in life and are less fluent. The investigation of the aforementioned will be particularly informative in the presence of a neurologic lesion.
- The influence of various contextual factors, for example, linguistic complexity and sound structure on the parameters of speech production (temporal and spatial) could be studied in an attempt to determine how these factors should be implemented to facilitate speech production, or how they should be limited during therapy until a greater level of skill has been achieved. The effect of contextual factors will therefore influence the compilation of both assessment and treatment procedures.

- The study of speech production in L1 versus L2 can be conducted in persons with other types of speech production difficulties, for example, persons who stutter or those with dysarthria, to determine if L2 is more difficult to produce in these populations. This could in turn reveal more about the nature of speech motor control in L1 and L2 in persons with deficits at different levels of the speech production process.

7.6 CONCLUDING REMARKS

The accurate description and characterization of the salient characteristics of neurogenic speech disorders and the influence of various contextual factors on these is essential for differential diagnosis, the compilation of effective assessment and treatment procedures and the development of models of speech production for explanation of normal and disordered speech motor control.

The results of the present study pertain to several theoretical issues and make an important contribution towards the available knowledge regarding the nature of the impairment in persons with either AOS or PP and the influence of contextual factors on speech production of these persons. The main aim of this study was realized in determining that L2 imposes additional processing demands to the speech production mechanism. It was determined that the result of the increased processing demands is manifested in specific aspects of temporal control in persons with either AOS or PP, as well as in greater token-to-token variability regarding durational measures in normal speakers. The results of the study led to the identification of differences in the nature of the underlying deficits in persons with AOS or PP. Furthermore, conclusions could be drawn regarding normal and disordered speech motor control under circumstances of increased processing demand.

In summary, the results of the study have shown that both speakers with AOS and those with PP exhibit deficits regarding temporal control, which is intensified by an increase in the processing demands induced by speaking at a faster than normal rate and speech production in L2. The deficits exhibited by these groups of speakers are presumably due to a deficit regarding speech motor control, since greater variability than normal was exhibited in both these groups of speakers. Longer than normal

durations were more consistently present in speakers with AOS than in those with PP, which could imply that slow speaking rate is a core characteristic of AOS. In subjects with PP, longer than normal durations were not as consistently present, which could imply that slow rate might be a compensatory strategy that is applied when the processing demands increase. Furthermore, the durations in the subjects with AOS were generally longer than those in the subjects with PP regarding VD, UOD and VOT. The variability in the subjects with AOS was also generally greater than in the subjects with PP regarding VD and UD. The motor deficit in AOS thus appears to be more severe than in PP, with the implication that the underlying deficit in PP might be only partly attributable to a deficit regarding speech motor control.

The results of the study suggest that more studies investigating the influence of contextual factors, specifically speech production in L1 versus L2, on the speech of normal speakers and speakers with neurogenic speech and language disorders are needed, using other parameters of speech production as well as different methods of analysis and speech material. Further research of this type is imperative for a better understanding of speech and language disorders, and ultimately for optimization of assessment and treatment protocols for bilingual or multilingual speakers.

7.7 SUMMARY OF CHAPTER SEVEN

In this chapter the conclusions that were drawn from the results of the study were presented and the theoretical and clinical implications were discussed with reference to the results of the empirical research. This was followed by a critical review of the research methodology. Finally, recommendations for further research were made, whereafter it was concluded that the main and sub-aims of the study had been realized as it was concluded that L1 and L2 can be regarded as contextual factors that influence the complexity of production. The languages of the bilingual or multilingual speaker thus need to be taken into account in the clinical and research setting when dealing with subjects with either AOS or PP.