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A phonological investigation in speech and aphasic speech in Mandarin

This book aims to demonstrate general and specific comparisons between normal speakers and left-brain damaged patients in Mandarin by looking at their phonological performances, and shows how the two error corpora can help resolve certain apparent conflicts among different approaches. The book starts out with a general exploration of speech errors categorized into phonological patterns and an overview of paraphasic studies in cross-linguistic perspectives, focusing on longstanding problems and the aspects of speech production models to which these problems are pertinent. The methodology for how to collect speech-error and paraphasic data in Mandarin is then rendered. It explicates every detailed procedure and the backgrounds of subjects participating in the two studies. The discussion of the two error corpora and results of statistic analyses are provided when those studies presented figures on the specific issues under investigation. This book consolidates and reconciles a number of competing theoretical models for speech production planning and execution in Mandarin, in light of evidence from naturally-occurring speech-error data and from production deficits in left-brain damaged aphasic patients. Such findings can be incorporated in terms of current psycholinguistic models of speech production planning. A substantial amount of the speech-error and paraphasic data is provided to help validate the results as well as facilitate further study by other researchers.

I-Ping Wan received her Ph.D. in Linguistics from the Department of Linguistics and a Ph.D. certificate from the Center for Cognitive Science, at the University at Buffalo, State University of New York (SUNY-Buffalo), in 1999. She then taught at National Dong Hua University for a year and has been teaching at the Graduate Institute of Linguistics, National Chengchi University, since fall 2000. She is currently a Visiting Scholar in the Department of Linguistics at Harvard University in 2006-2007. Her research areas include phonology, phonetics, psycholinguistics and cognitive science.

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Publisher: Crane Publishing Co., Ltd.
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Tel: +886-2-23934497 Fax: +886-2-23946822
email: service2@crane.com.tw

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CHAPTER I
INTRODUCTION

The study of speech errors has long served as a window through which investigators have attempted to detect the processes and structures underlying linguistic performance. Researchers in the past decade have used the patterns and constraints observed in extensive collections of errors to argue both for the validity of phonological units as processing units, and for particular phonological theories or cognitive processing models (e.g., Fromkin, 1973a; Shattuck-Hufnagel, 1979; Stemberger, 1983; Dell, 1984; Levelt, 1989; Bock & Levelt, 1994). There has also been much work which has attempted to determine the psychological validity of various linguistic claims ranging from the existence of certain units to the existence of particular rules. Recent interest in speech errors has focused largely on the evidence such errors provide about levels of linguistic analysis and psycholinguistic models of speech production processes (e.g., Fromkin, 1973a, 1980; Cutler, 1982; Stemberger, 1983; Berg, 1987; Jaeger, 2004; among others).

Recently there has been an increasing interest in the study of speech production processes. A number of researchers have started to look at evidence from aphasic speech. Aphasic speakers produce a wide range of errors, which are of interest to linguistic or psycholinguistic theories, since they provide a source of evidence as to the content of information processing and serve as certain constraints in relation to the normal production system. The aphasic errors are not simply a misarticulation, a lack of knowledge or memory error, or a false start. Therefore, it is generally accepted that aphasic speech constitutes an important source of data for testing the processes and structures underlying linguistic performances, and it allows us to better understand the planning units and structures involved in mechanisms of language production better (e.g., Blumstein, 1973; Schwartz, Saffran, Bloch, & Dell 1994; Schwartz, Gagnon, Martin, Dell, & Saffran, 1996).

From the beginning of modern work on aphasic deficits, researchers have been aware that similar-looking phenomena occur at a much lower frequency in the speech of normals (e.g., Meringer and Mayer, 1895), and the similarities between normal and aphasic errors are increasingly receiving attention. Most research work on aphasics seeks to increase our knowledge of the primary characteristics of the speech production. However, there are fewer researchers collecting and analyzing large numbers of errors from normal Mandarin speakers. There has not been a large amount of overlap in the issues examined. Many well-studied phenomena in aphasia have never been examined in normal speech, and vice versa. This study is a beginning effort to rectify the situation, representing research on normals' speech errors that was directly inspired by work on aphasia. I will present data showing similarities and differences in normal and aphasic speech.

Naturally-occurring speech-error data and aphasic errors can be viewed as behavioral data. According to Shattuck-Hufnagel (1986), behavioral data are not always absolute. If a given factor influences the error corpus more often than chance would predict, then one can suggest that such a factor plays a role in processing. However, a number of counterexamples may be found in the data collection, one might still base on the majority of examples to make some claims. This is different from what is typically done in theoretical linguistics where one or a very few unaccountable counterexamples are enough to refute a claim.

The relevant studies by Fromkin (1973b), Garrett (1988) and many others suggest that the process of speech planning can be viewed as a series of stages, each devoted to a specific level of linguistic planning. In these models, the planning of a sentence involves various processing components which perform increments of the planning task and of production at specific levels of representation in sequences. A semantic/conceptual representation is assumed to be constructed first, which is then in turn followed by two linguistic representations, one involving syntactic and the other involving phonological information. Finally, the last level of planning is the phonetic representation of the utterance. This *serial* approach predicts that a speech error only occurs at a distinct level of speech production planning, with other levels unaffected. However, other researchers propose *parallel* models of production, where multiple levels of processing take place simultaneously (e.g., Dell 1988). Dell's spreading activation model of speech production is a connection model, which is a model of lexical organization and retrieval. This model contains four levels of nodes including semantic, syntactic, morphological, and phonological levels; words are organized into networks, each node of which connects units based on semantic and phonological relatedness. The activation of a concept activates lexical items sharing semantic features with the thought to be conveyed, including aspects of their grammatical usage and phonological forms, which constitutes the nucleus and the final codas together. As a node at one level is activated, it may activate other nodes at the same level or at other levels. The representations work in parallel, and thus there is a close interaction between semantic and phonological levels. This parallel approach thus predicts that a speech error occurring at one level may activate the processing at a different level. The empirical coverage has been carried out on both serial models and parallels models. Serial models of normal sentence production has repeatedly served as a framework for locating particular aphasic error types at certain stages and thereby interpreting different aphasic syndromes as disruptions at different levels. In the representation system where aphasic patients are largely intact, the disparity between normal and aphasic speech is due to the difficulties for aphasic patients to process efficiency. Dell et al. (1997) showed that the manipulation of two parameters, a decrease in activation transmission between neighboring processing units and an increase in decay rate, can successfully account for patterns of naming errors in normal and aphasic speakers, suggesting that there are some underlying similarities between the two populations.

In this book, I will show that many kinds of aphasic errors demonstrate precisely what slips in normals do. Consequently, it is not unreasonable to consider that the study of aphasia can indeed shed light on normal language processes as well as aphasic processes and can be handled in a framework designed to account for speech errors in normal speakers. To contrast aphasic errors with speech errors, I will generally compare the aphasic data to analyses of speech-error data, using a Chi-square test to determine differences between aphasic patients and normal speakers in Mandarin. The current study is based on data from two error corpora in Mandarin. The first corpus is based on 5499 speech errors from a corpus collected by the author's research team from native speakers of Mandarin between 1995 and the present. The speech error data are derived from brief excerpts of taped-recorded natural speech. These excerpts are taken from free conversation, conference discussions, broadcasts, lectures, and interviews with students, with over a hundred different speakers whose ages range from 20 to 50 years old. It should be noted that not all the speakers produced errors in the excerpts held in the data collections. The second corpus is based on excerpts of aphasic errors collected from a group of fluent aphasics in Mandarin, Wernicke and conduction, the patients of which produced paraphasias pooled for the purposes of statistic analysis. The corpus contains 3000 aphasic speech errors collected by two assistants and the author from aphasic speakers of Mandarin between 2002 and the present. The aphasic error data are drawn from interview questions with aphasic patients. The questions were produced during the course of open-ended conversations regarding the patients' illness, work, weather, hobbies, family, friends, etc. The interviewers sometimes prepared pictures and the patients were requested to name the pictures or to tell a story. Each patient was individually tested in a moderately quiet room, and the spontaneous speech interviews lasted for about 30 minutes for each patient. The raw data used in this study was selected from the tape-recorded interviews. For each potential error, a guess was made at the intended target independently by the two assistants and the author. Notes were compared, and inconsistencies resolved by negotiation. If the potential error in the patient's utterance was identified as an error whose target words could clearly be determined by the surrounding context, the error was considered to have been identified. Otherwise, no target was assumed. The error utterances were transcribed using the International Phonetic Alphabet for more precise identification. Detailed descriptions of how the two error corpora are collected and the number of subjects who has contributed to the studies are presented in Chapter III.

It is interesting to see the implication of the assumed similarity of the speech of normals and aphasics. If these two populations exhibit a comparable behavior, the study of the processing failures in normal speakers may hold the key to coming to grips with language breakdown in aphasia. One might wonder why the aphasic work in this study does not include patients suffering from Broca's aphasia. Given the slow production rate in non-fluent aphasia, it might not be considered appropriate to compare the normal speakers to Broca's patients. To avoid lumping together potentially disparate types of paraphasic performance, the aphasic study is limited to include Wernicke's and conduction aphasias. Ten criteria will be examined in the two error corpora throughout the whole research work. The ten criteria are evaluated based on general units of errors, form types, and directionality.

Currently there is less research being conducted using naturally-occurring speech errors as a fine method in relation to theoretical framework, although some researchers continue to be active in this paradigm by using error data to test or refine some framework in models of speech production planning (e.g., Dell, 1984, 1988). One main reason for the ebb in speech-error research is that most of the relevant studies have been based on English. The other major corpora of speech errors have been collected are on Dutch and German (Meringer & Mayer, 1895; Berg, 1987; 1988; Levelt, 1989). It is not surprising to find that the studies of Dutch and German have not shown major differences from the results of studies on English. Jaeger (2004) mentioned that tens of thousands of speech errors made by speakers of English, Dutch, and German have been collected and analyzed so some researchers have felt that there is simply not much left to be learned from this data source, and thus this research methodology has to some extent fallen by the wayside in recent years. In order not to undervalue the study as a good research methodology, looking at data from speakers of other languages is certainly the simplest extension, and there is fortunately an upsurge of this sort of research currently taking place. Some long-standing problems in the phonology other than English can be addressed in a fresh way; see, for example, Wan & Jaeger's (1998) speech-error-based analysis of the representation and processing of tone in Mandarin.

The obvious way to revive the study would be to expand the data base to aphasic patients other than normal speakers in terms of models of fluent vs. non-fluent speech production planning; several studies have looked at the similarities and differences between errors made by normal and aphasic speakers (e.g., Schwartz et al., 1994). On the other hand, the methodological issue raised above has undoubtedly contributed to the paucity of error data on aphasic patients. It is clear that error data on aphasic patients could provide hitherto unavailable insights into the patient's knowledge of language structures, given the fundamental hypothesis that the error is made on a structure after language breakdowns. By looking at data from abnormal languages and from non-Germanic languages, researchers may be able to refine their models or framework of speech production planning so they are applicable to a broader range of language structures and representation.

The organization of this study is as follows. The following chapter will present an overview of speech errors and aphasic speech in linguistic research by looking at the ten criteria (errors involving phonological units, contextuality, the distance between source and error units, error types, segments vs. features, similarities and phonological representations, the parallel syllable structure constraint, the initialness effect, the directionality effect, and the size of target-source units), focusing on longstanding problems and the aspects of linguistic theory to which these problems are pertinent in Mandarin. In Chapter III, I will present the methodology of the speech-error and aphasic error data collections and the subjects in these two studies. The classification system, used to categorize errors will be presented and justified, is followed by a discussion of principles involved in making decisions on ambiguous cases. In Chapter IV, I will first discuss the general distribution of error types involving phonological units. Further, I will examine the general phonological characteristics of speech errors that have been discussed widely in cross-linguistic speech-error literature. After discussing general statistical properties of these errors, I will then examine the degree to which errors are well-formed linguistically. I will then discuss the role of similarity in conditioning errors and the directionality of ordering errors. In Chapter V, the general findings and analyses followed the same patterns as in the speech-error study will be presented. Chapter VI will present a general comparison to the results from a corpus of aphasic error speech. A number of important issues regarding the psychology of speech production and the nature of phonological representations as well as the mechanisms underlying phonological encoding in aphasic speech will be examined. In addition, the phonological analyses from speech errors and aphasic speech will be supported by looking at data from cross-linguistic relevant literature in detail, relating it to some basic assumptions underlying current models of speech production.

CHAPTER II
LITERATURE REVIEW

2.1 Introduction

The study of speech errors has long been discussed intensively for at least a century. It has provided a rich source of data for the processes and structures underlying linguistic performance and models of language representation as well as speech production planning (e.g., Fromkin, 1973a, 1980; Cutler, 1982; Stemberger, 1983; Berg, 1987; Jaeger, 2004; among others). Speech error studies have a long tradition of use for testing or examining the patterns and constraints observed in extensive collections of errors to argue both for the validity of phonological units as processing units, and for particular phonological theories or cognitive processing models (Fromkin, 1973b; Shattuck-Hufnagel, 1979; Stemberger, 1983; Dell, 1984; Levelt, 1989; Bock & Levelt, 1994). Similarly, aphasic speech also constitutes an important source of data for testing linguistic representation and thus the phenomena of aphasia provides tests of the validity of certain aspects of linguistic theory (e.g., Blumstein, 1973; Schwartz et al., 1994).

Few aphasic data have been compared with those of normals. A few scholars such as Blumstein (1973), Dressler (1978, 1980), and Keller (1981) have found qualitative and quantitative differences so more and more researchers believe that the difference between normal speakers and aphasic patients is one of degree, not of kind (e.g., Marshall, 1977; Stemberger, 1984, 1985a; Miller & Ellis, 1987; Buckingham, 1992). A number of compelling arguments show that one and the same model may be able to deal with patterns observed in both normal speakers and aphasic patients (Martin, Dell, Saffran, & Schwartz, 1994). Butterworth (1992) posited that the representational system of aphasic patients is largely intact, the disparity between normal and aphasic speech is best understood as a difference in processing efficiency, suggesting that there is an underlying similarity between normal and aphasic speakers.

The theme of this study is to provide a detailed investigation of the phonological components in aphasic speech in Mandarin with data from naturally-occurring speech errors in Mandarin as a comparison, and so to further see how the data in the two error corpora relate one to another and to find out whether the results can provide adequate evidence regarding the cognitive status of phonological processes which occur during speech production planning and execution. If these two populations exhibit a comparable behavior, the study of the processing failures in normal speakers may hold the key to coming to grips with language breakdown in aphasia.

The comparison of speech errors and aphasic speech is greatly facilitated by the fact that they fall into the same error categories. Ten criteria will be examined throughout the two error corpora. The size of the phonological units involved in errors will be the basic issue to look at. A very fundamental distinction is contextual and non-contextual influences. Contextual errors can be furthered to be measured in terms of how many syllable spans there are between target and source elements. Turning to types of errors, the most basic categories at the descriptive level are substitutions, additions, and omissions. The independent existence of the basic phonological units (segments and features) is examined in terms of the role in the most fundamental phonological units in processing. An overall hierarchy of feature involvement in target-source pairs reflects phonetic similarities in consonants. Parallel syllable structure constraint and initialness effect are two general criteria in the two error collections. Contextual errors are subdivided according to the directionality of influence: when the source occurs after the error, the case is classified as anticipatory whereas when the source occurs before the error, the case is assigned to the class of perseveration. The phonological environment in target-source pairs is the final criterion to be examined in the two error corpora.

The current study is based on the empirical data from two error corpora in Mandarin (speech errors: N=5499; aphasic errors: N= 3000) to examine the ten criteria discussed above. The following section is a sketch of general patterns and different comparisons found in cross-linguistic studies. The examples in English are drawn only from speech-error data from a number of researchers as there is a lack of comprehensive aphasic error data within the following sub-categories in the relevant English studies.

2.2 Errors Involving Phonological Units

Based on a sizable error corpus, Fromkin (1973b), Nooteboom (1973), Shattuck-Hufnagel (1983), and Stemberger (1983) suggest that an analysis of speech errors shows the discreteness of the phonological units, and such evidence supports the existence of features, phonemes (both segment-size units and allophone variation), productive phonological and morphological processes, i.e., vowel harmony, and syllables. Examples in English drawn from Fromkin's (1973a) corpus are provided in (1-7).

(1) I: a **<u>C</u>**anadian from **<u>T</u>**oronto → a **<u>T</u>**anadian from **<u>T</u>**oronto

In this example, the consonant [t^h] is anticipated and substituted for another consonant [k^h].

(2) I: gr**<u>ou</u>**p thr**<u>ee</u>** → gr**<u>ee</u>**p thr**<u>ee</u>**

In this example, the vowel [i] is anticipated and substituted for another vowel [u].

(3) I: **<u>f</u>**inger **<u>sp</u>**ell → E: **<u>sp</u>**inger **<u>f</u>**ell

In this example, the onset consonant cluster [sp] and the single consonant [f] exchange their positions.

(4) I: f**<u>i</u>**ght very h**<u>ar</u>**d → E: f**<u>ar</u>**t very h**<u>i</u>**de

In this example, the rhyme [aj] and another rhyme [ar] change their positions.

(5) I: late aft**<u>ernoon</u>** classes →E: lat**<u>ernoon</u>** classes [lejtərnuwn]

In this telescoping error, the two words get collapsed and concatenated into one. The new form takes [lejt] from the first syllable and the syllables [ərnuwn] from the second one.

(6) I: s**<u>p</u>**ell **<u>m</u>**other → E: s**<u>m</u>**ell **<u>b</u>**other

In this example, the feature [nasality]/[voicing] has been reversed, causing the segments [p]-[m] to be realized as [m]-[b].

(7) I: próphesy → E: [prəfásij]

The error in (7) shows a case where the lexical stress was shifted from the initial to the following syllable.

Nooteboom (1973), Fromkin (1973b), and Shattuck-Hufnagel (1983) all found that in their data collections, phonological errors overwhelmingly involve single segments, and in single segment errors, consonant and vowels rarely interact with each other. Larger units such as consonant clusters or rhymes are sometimes involved in errors, and the chance is much rarer. Blumstein (1973) also found that the overwhelming predominance of segmental paraphasias in her aphasic speech data in English (Broca: single C=77.7% vs. consonant cluster=22.3%; Conduction: single C=77.1% vs. consonant cluster= 22.9%; Wernicke: single C=76.7% vs. consonant cluster=23.3%). There is wide agreement that the most frequent case in speech errors is single-segment interaction. However, larger units sometimes constitute a small proportion in the corpus. The combinations of larger units are fairly incohesive, with consonant clusters being more cohesive than VC sequences which in turn are more cohesive than CV sequences (e.g., Stemberger, 1983; Shattuck-Hufnagel, 1983; Berg 1989). However, strong evidence from Dressler et al. (1986) in a comparative study of speech errors and aphasic speech reported that 65% of slips involve single segment interaction and 35% involve larger phonological units, whereas 95% of the paraphasias are segmental and only 5% are not. Monoi et al. (1983) presented a similar picture from data collected in Japanese aphasics. In terms of ratio of CV to VC errors, these studies found that CV and VC patterns will be more nearly equal. Aphasics tend to produce relatively more single-segment errors than normals do. In general, data from the two error studies show that there is a tendency towards more segment errors in nature. In summary, both predictions receive some support from aphasic studies. The ratio of VC to CV errors appears to be more balanced in aphasic studies than in speech errors.

2.3 Contextuality

Studies from cross-linguistic speech errors have shown that target and source units usually occur within the context of utterance when source units influence target units in a fairly narrow window, mostly restricted to a clause (e.g., Nooteboom, 1973; Garnham et al., 1982). When there is an identical source unit in the vicinity of the error, the error is classified as contextual. Therefore, the contextual window usually refers to target-source elements interacting within a clause. In contextuality, it is understandable to see what is already known about the constraints that are imposed on target-source pairs, and about sound movement errors which influence their encoding. Examples in English are provided in (8-9) (Berg, 2006).

(8) I: big red **b**eefy **t**omatoes → E: big red **t**effy **t**omatoes

In this example, it is likely that the consonant [t] in tomatoes is anticipated and substituted for another consonant [b]. Since there is an identical source in the utterance context, the malfunction is contextually motivated.

(9) I: Tell me you really liked my salad → E: Tell me you really liked my s**h**al

In this example, there is no identical source consonant [ʃ] in the utterance context so [ʃ] happens for no apparent reason. Since there is no such a source unit in the vicinity of the error, this error is classified as non-contextual.

Berg found that contextual errors far outnumber non-contextual ones in normal speech in his corpus in English. Shattuck-Hufnagel (1975) also found that contextual errors make up a large proportion of the total number of speech errors in her corpus. However, evidence from Blumstine (1973) has found that the preponderance of phonological errors in aphasic speech is non-contextual in her aphasic corpus in English. Wilshire (2002) found a proportion of 17.3% contextual errors in Wernicke's and Conduction aphasics in English. This general pattern was replicated by Monoi, Fukusako, Itoh, and Sasanuma (1983) for a very high rate of non-contextual consonant errors (65.8%) in Broca's aphasics and for a somewhat lower rate of non-contextual vowel errors (38%). Allerbeck (2000) found that there are a higher rate of non-contextual errors (63.8%) observed in German-speaking Wernicke's aphasics. The Swedish data represented a most extreme case since non-contextual errors reach 81% (Soderpalm, 1979). This finding from the cross-linguistic studies seems to hold for all the language studied and all types of aphasia except for the aphasic study in Schwartz et al. (1994). Schwartz et al. (1994) looked at a comparison between errors in a naturally-occurring speech-error corpus and in an aphasic speech corpus, and they suggested that there is no empirical or theoretical basis for applying a fairly narrow restriction when coding aphasic patients' errors. Therefore, in their term of contextual errors, that could be the case in which target-source influences operate within or without clauses. They re-analyzed contextual influences over a larger window, spanning the clause before and after the error, and every occurrence of the substituted phonetic elements in that context window was counted as a potential source for the error. That explains why they found a lower rate of non-contextuals in their aphasic study. If they would have analyzed contextual influences based on the standard procedure, and narrowed the window in a fairly restricted sense that is currently adopted in most of speech-error studies, there might be a higher rate of non-contextuals. Regardless of contextual windows, this cross-linguistic finding seems to hold for all the language studied and all types of aphasia, suggesting that contextuality plays less of a role in aphasic speech although it does play an important role in normal speech production.

2.4 The Distance between Source and Target/Error Unit

Studies from normal speech errors have shown that source segments influencing target segments usually occur within the context of utterance (e.g., Nooteboom, 1973; Garnham et al., 1982). Evidence from the preceding work indicates that speech is planned in clausal units. An examination of speech errors in which words are exchanged reveals that the largest percentage of such errors involves words in the same clause (Garrett 1975, 1976). Garrett found that 85% of word-exchange errors involved elements within a single clause. Fromkin (1973b) from her phonological error corpus found that 79% of source-target pairs are within the same clause. Cooper and Paccia-Cooper (1980) found that certain sequences of sounds often undergo rule-governed changes, i.e., syllable contraction in fast speech, and such phonological processes apply less often across clause boundaries, indicating that the rules operate primarily within clausal units. All of the sources lead to an implication; that is, speech is planned in clausal units.

The source segment that influences the production of the target usually occurs within the context of the utterance. In the past, most speech-error studies have been done in Germanic languages and the majorities of convenient and linguistically-pertinent strategy is the binary division of contextual errors into within-word and between-word error sub-categories. The distance between the source and the target in Germanic languages is measured in within-word and between-word categories. If target/error and source unit occur in the same word, the case will be categorized as in a within-word error, as exemplified in (10), but when error and source unit belong to different words, the case will be classified as in a between-word error, as exemplified in (11). These examples are drawn from Stemberger (1983).

(10) I: **c**or**p**us → E: **c**or**c**us

In this example, an aspirated [k] is perseverated to an ambisyllabic position, and becomes unaspirated [k]. The target consonant [p] and the source consonant [k] are part of the same word so this error is classified as falling within the within-word category.

(11) I: b**r**ake f**l**uid → E: b**l**ake f**r**uid

By contrast, it is obvious that a word boundary is crossed in this example where the consonant [r] and another consonant [l] exchange their positions, and they occur in different words. This error is then classified as falling within the between-word category.

In addition, Berg (1988, 2006) found that in speech errors, the interacting units in exchanges tend to be closer together (i.e., within-word category) than those in anticipations and perseverations. Berg (2006) further found that the majority of errors in his data collections are between-word errors, suggesting that the domain of speech errors extends to the phrase and even the sentence. The span over the target-source elements is found to be larger in speech errors, and the distance between them generally does not exceed seven syllables

(Nooteboom 1973). Given a frequency distribution of the sound errors in spontaneous speech as a function of the distance between the target-source units involved in speech errors, Nooteboom suggested that speech errors with a span of one to seven syllables may be related to capacity in processing units. The short memory span may contain about seven units so it is possible to interpret this finding as an argument for the syllable to be a unit in the phonemic programming system.

However, the aphasiological literature does not regularly draw a clear dividing line between within-word and between-word paraphasias. Berg (2006) commented that in many aphasic data collections, the error type is an artifact of the method used. For example, a single-word production task such as object naming involves a strong bias toward producing within-word errors. Therefore, within-word errors are in the absolute majority in aphasic speech.

The statistical properties of within-word and between-word phonological errors are notably different in English and other Germanic languages, and they are analyzed separately. However, due to the fact that there is a strong phonotactic constraint in Mandarin syllables, there are too few within-word phonological errors in the two error corpora in Mandarin to make an analysis of interest; the phonological analyses in this study are completely based on between-word errors.

As mentioned above, in Mandarin, there are restricted phonotactic constraints in Mandarin syllables. The maximal syllable is (C)(G)V(X), with C a [+consonantal] segment, G a glide, V the nucleus vowel, and X either a nasal or a glide. The within-word errors would be possible in a case in which an initial consonant involving a nasal or a glide interacts with a coda nasal or coda glide. However, cases like this are very rare. Therefore, the majority of errors that are drawn from the corpus are related to between-word errors. I will follow Nooteboom's methodology and measure the distance between the source and target units in syllables.

2.5 Error Type

Speech error types such as substitution, addition, and omission show the replacement of the target unit. In substitution errors, one element is completely substituted for another. Addition errors occur in the case where an element is inserted into an incorrect location. Omission errors occur in the case where an element is omitted in the context to make the error and source become either more structurally similar or less structurally similar. Most of the errors, in which the target is simply replaced by another segment, or in which the target is omitted or another unit is added in a new location, are within the utterance. Examples drawn from Fromkin's (1973a) corpus are given in English, as exemplified in (12-14).

(12) I: **t**onal **p**honology → E: **f**onal **p**honology

In this example, the consonant [f] is anticipated and substituted for another consonant [t].

(13) I: steel feet → E: steel f**l**eet

In this example, the consonant [l] is added to the following syllable, after the consonant [f].

(14) I: **st**retch your legs → E: retch your legs

In this example, the consonant clusters [st] are omitted from the origin syllable.

Wells-Jensen (1999) in her cross-linguistic corpus found that phonological substitution errors far outnumber addition and omission errors in English, Hindi, Japanese, Spanish, and Turkish. This analysis can also be confirmed in Nooteboom's (1973) error corpus in Dutch and Berg's (1987) error collection in German. For example, Nooteboom (1973) found that among 787 Dutch slips, substitution errors (N=555, 74.6%) far outnumber addition errors (N=173, 23.3%), which significantly outnumber omission errors (N=16, 2.2%). The general hierarchy of error types shows that substitution errors occur more frequently than addition errors which in turn occur more frequently than omission errors (e.g., Nooteboom, 1973; Berg, 1987; Wells-Jensen 1999). Consequently, the hierarchy of error types is listed as follows: substitution > addition > deletion.

However, studies from aphasic speech show some discrepancies. Blumstein (1973) found that substitution errors are more common than omission errors, which in turn outnumber addition errors. Hotpof (1980) and Berg (2006) both found that omission errors constitute the absolute majority in English-speaking aphasics. Data from other languages for which data are available confirm this pattern (e.g., Ardila et al., 1989 for Spanish; Beland et al., 1990 for French; Moen, 1993 for Norwegian; Romani & Calabrese, 1998 for Italian; Allerbeck, 2000 for German). Berg (2006) further found an interesting relationship between contextuality and the rate of omissions vs. non-omissions (i.e., substitutions and additions). He found that there are proportionately more omissions in the non-contextual category than in the contextual category; non-contextuality seems to increase the probability of omissions.

2.6 Segments vs. Features

Segment errors and errors which involve phonetic features rather than segments are both found in English (e.g., Fromkin, 1973b; Shattuck-Hufnagel and Klatt, 1979; Cutler, 1980; Stemberger, 1983). Those phonological errors that provide convincing evidence for the existence of features are those in which a feature value is involved in a syntagmatic error. These errors do not involve the interaction of whole segments, and there is no clear or identical whole-segment source that can be found for the error in the context of utterance.

It is generally accepted that feature errors provide convincing evidence for the existence of features, suggesting that a feature value is involved in syntagmatic error. The value of one feature is anticipated or perseverated, and substituted for a different value of the same feature in another segment. However, these errors are not classified as non-contextual errors since there is a source segment which has a feature value that changes to match the target segment. The value of one feature can be anticipated or perseverated, and substituted for a different value of the same feature in another segment. Evidence from Fromkin (1973b, 1975), Shattuck-Hufnagel and Klatt (1979), Cutler (1980), and Stemberger (1983) shows that features are involved in this type of error in English. Nooteboom (1973), Fromkin (1973b), and Shattuck-Hufnagel (1982) all found that in their data collections, phonological errors overwhelmingly involve single segments. However, Stemberger (1983) presented a different analysis in which feature errors are more common than single segment errors and are of a simpler nature. Examples listed below show how different the researchers classified their errors.

(15) I: su**__ch__** o**__b__**servation → E: su**__b__**…su**__ch__** o**__b__**servation

This example is classified as a segment error in that the error involves the substitution of the consonant [b] for another consonant [tʃ]

(16) I: That was **__t__**errific → E: That was **__k__**errific.

This example is assigned to the class of feature errors in Stemberger's classification system since it involves the misordering of feature value. Although Stemberger's classification system is different from those of other researchers, it is generally believed that the predominance of single-segment errors is more extreme in speech-error data.

Although segmental-feature errors have been found in previous studies to be much less common than errors involving whole segments, they do occur in enough cases to warrant the conclusion that features exist as part of the internal structure of segments. Evidence from Fromkin (1973a, 1975), Shattuck-Hufnagel and Klatt (1979), Cutler (1980), and Stemberger (1983) shows that features are involved in this type of error in English. Feature values themselves can be involved in errors, giving evidence of the existence of features as phonological units. However, feature errors are not nearly as common as segment errors; they occur with enough frequency to support their cognitive status in processing. The different frequencies between the segmental and featural errors support Shattuck-Hufnagel & Klatt's model (1979), in which segments from underlying phonological representations are selected and inserted into syntagmatic slots by a 'scan-copier' mechanism; if segments are phonetically similar and occur in similar syllable-structure slots they are eligible for misselection and misinsertion, but features themselves are not available for this mechanism. Fromkin (1973b) came to a similar conclusion, arguing that features are not "independently controlled" in speech production, and therefore are not as susceptible to error as whole segments. Therefore, their data support the findings, providing more evidence for the existence of features in phonological units, but also suggesting that features are not readily eligible for misselection and misinsertion; thus features are independent units, but they are not as independent as segments in speech production. Therefore the analysis of errors convincingly shows that consonant features have cognitive status during speech production planning, and segmental units are the primary planning units in speech production.

Few aphasic studies have worked on segment errors versus feature errors. A number of aphasic studies have found that aphasic patients are more likely to produce errors in which the target-source pairs are violated in voice-onset-time feature (Blumstein et al., 1977, 1980; Itoh et al., 1982; Gandour & Dardarananda, 1982, 1984; Shewan et al., 1984; Baum et al., 1990). The majority of aphasic studies in phonology are on the segment paraphasias to lexical paraphasias, and so far no reports have compared the incidence of feature and segment errors in aphasic speech.

2.7 Similarity and Phonological Representations

In substitution errors, the target and source are usually very similar, and each shares most of the phonological features. Sixty to eighty percent of substitution errors share all but one feature (Fromkin, 1973b; MacKay, 1973; Nooteboom, 1973; Van den Broecke & Goldstein, 1980; Levitt & Healy, 1985; Stemberger, 1989; Frisch, 1997; Jaeger, 1992, 2004). This property has been shown to occur in speech errors in every language for which data are available. In addition, the feature involving place of articulation is the feature most often violated in speech errors. This is very similar to English and German, suggesting that the hierarchy of feature distribution may have some cross-linguistic validity; this may be related in a simple way to the number of possible feature violations in phonological inventories.

Defining whether one segment is phonetically similar to the other is done by looking at how many phonetic features they share. Most researchers have found that errors involving whole segments are more common than featural errors in English (Fromkin, 1973a/b; Stemberger, 1983; Shattuck-Hufnagel, 1986). The fact that individual feature values can also occasionally be the error units suggests that features exist as part of a segment structure but are less available to the speech production planning mechanism. The cross-linguistic spontaneously occurring error corpora that Van den Broecke and Goldstein (1980) examined are drawn from consonant errors consisting of 1369 speech errors in English (Fromkin, 1980), 1057 speech errors in English (Shattuck-Hufnagel, 1975), 542 speech errors in German (Meringer and Mayer 1895; Meringer 1908), and 235 speech errors in Dutch (Nooteboom, 1973).

Van den Broecke and Goldstein (1980) compared a number of feature systems and proposed a new one which incorporates evidence from speech errors in English and German. Jaeger (1992, 2004) also adopted a similar feature system. The feature specifications for disambiguating the consonants involve the following: voice, stop, place ([bi]labial, dental, alveolar, palatal, velar, glottal), and nasal. The feature fricative plus approximant are further added for classificatory purposes. The speech error feature system proposed by Van den Broecke and Goldstein (1980) for adult English is listed in Table 2-1.

Table 2-1: Speech error feature specifications for English consonants

	p	t	k	b	d	g	m	n	f	v	θ
Voice	-	-	-	+	+	+	+	+	-	+	-
Stop	+	+	+	+	+	+	+	+	-	-	-
Place	B	A	V	B	A	V	B	A	B	B	D
Nasal	-	-	-	-	-	-	+	+	-	-	-
Fric/ appr.	-	-	-	-	-	-	-	-	+	+	+

Table 2-1: Speech error feature specifications for English consonants (Cont'd)

ð	s	z	ʃ	l	r	w	j	h	tʃ	dʒ
+	-	+	-	+	+	+	+	-	-	+
-	-	-	-	-	-	-	-	-	+	+
D	A	A	P	A	A	V	P	G	P	P
-	-	-	-	-	-	-	-	-	-	-
+	+	+	+	-	+	+	+	+	+	+

They looked at all the contextual single-consonant substitution and exchange errors to see whether they display phonetic similarity between target and source segments, and to test whether the hierarchy and rank order exist in consonantal features in English. Van den Broecke and Goldstein (1980), who analyzed feature relationships of English slips using a multi-dimensional scaling technique, suggested that the rank order of feature involvement for English is the following: PLACE > VOICE > MANNER (STOP > FRICATIVE + APPROXIMANTS > NASAL).

In general, the consonant error is more likely to substitute for another if the two consonants differ by only one feature across all data sets. Dell (1980) and Berg (1985), from results based on their corpus, indicated that the hierarchy of feature distribution for English is the following: PLACE > MANNER > VOICE. Notwithstanding, they do not explain exactly what the features involved in manner are, and their hierarchies do not include nasality.

In summary, evidence from cross-linguistic speech-error data shows a general pattern where errors are distributed hierarchically among the phonological features. The feature of place of articulation is the feature most often violated in speech errors in English, German, and Dutch. Manner features are violated less often, and the [voice] feature is violated least often.

In aphasic studies, Blumstein (1973) found that distinctive features errors are more likely to occur between phonemes related by a single feature than phonemes separated by several features. This finding confirms the property found in normal speech errors. She further found the hierarchy of feature dissolution is in the following order: Continuant > Compact > Voice > Grave > Nasal > Strident (for Broca's patients); Continuant > Compact > Grave > Voice > Strident > Nasal (for Conduction's patients); Compact > Continuant > Voice > Grave > Strident > Nasal. Although the distribution of errors is not the same in each group, she suggested that there is a general pattern underlying the hierarchies in aphasic speech.

It is important to mention that the issue of consonant similarities is the focus so will be discussed in this study, and the issue of vowel similarities will not be addressed. Since there are few vowel errors in my aphasic speech corpus (N=81), of 81 errors, only a few of them are relevant to the study presented here; some of the vowel errors are non-contextual and even if they are contextual errors, a number of them involve the errors of addition or the error of deletion, which would not help discuss the similarity between target and source units. In order not to draw a conclusion too early, the analysis of vowel similarities in terms of the number of shared features in the two error corpora will not be the focus of discussion in this study[1].

2.8 The Parallel Syllable Structure Constraint

One of the most powerful principles that govern phonological speech errors is the parallel syllable structure constraint. It holds that an onset consonant tends to interact with another onset consonant, a nuclear vowel tends to interact with another nuclear vowel, and a coda consonant tends to interact with another coda consonant. Examples (17) and (18) honor the constraint whereas example (19) violates it. Examples (17-18) are drawn from Fromkin's corpus and example (19) is taken from Stemberger's (1983) corpus.

(17) I: **<u>P</u>**aris is the most **<u>b</u>**eautiful city → E: **<u>B</u>**aris is the most **<u>b</u>**eautiful city

In this example, the initial onset consonant [b] is anticipated and substituted for another initial onset consonant [p]. The target and source consonants are both in syllable-initial positions.

(18) I: wi**<u>th</u>** a bru**<u>sh</u>** → E: wi**<u>sh</u>** a bru**<u>sh</u>**

In this example, the final coda consonant [ʃ] is anticipated and substituted for another final coda consonant [θ]. The target and source consonants both occur in syllable-final positions.

(19) I: Tha**<u>t</u>**'s stu**<u>p</u>**id → E: Tha**<u>p</u>**'s stu**<u>p</u>**id.

In this example, the ambisyllabic consonant [p] is anticipated and substituted for the syllable-final coda consonant [t]. The target and source consonants are not from the same syllable positions.

Stemberger (1989) agreed with Fromkin's (1973b) finding in which target and source segments usually occupy similar positions in their

[1] I would like to express my great gratitude to the reviewer for pointing out this inconsistency to me.

respective syllables, and found that there is a tendency for consonants in parallel parts of the syllable to interact. The English speakers show very low rate of cross-position errors. Similarly, evidence from aphasic studies leads Blumstein (1973) to suggest that aphasic patients follow the parallel syllable structure constraint as well. However, there are a few studies reporting sensitivity to parallel syllable structure constraint in aphasics. Kohn (1989) found 16% violations in English aphasics, and Goldmann et al. (2001) found 44% violations in English aphasia. Dressler et al. (1986) also found that 32% in their Italian aphasic corpus disregarded the parallel syllable structure constraint. Allerbeck (2000) and Knels (2001) both found 35% violation rate in German.

2.9 Initialness Effect

There is a strong tendency for syllable-initial consonants to slip. Dell and Juliano (1996) found that about 80% of consonant misordering errors occur with initial onsets. Shattuck-Hufnagel (1986) also found the similar property in her corpus. She found that 40% to 50% of movement errors show an initialness bias. Although the percentage is smaller than that of Dell and Juliano, it is nevertheless substantially greater than what would be expected if all sounds were equally likely to slip in English. In most languages that have been investigated so far, naturally-occurring speech errors occur more often in a word-initially position than in any other position. This bias exists in the domain of the syllable, with syllable-initial errors being more common than syllable-final errors (Vousden, Brown, & Harley, 2000). For instance, example (17) is an example of syllable-initial position and example (18) is a case of target-source pairs occurring in the syllable-final position. Evidence from English speech-error studies has found the vulnerability of word-onset processing. That means, speech errors occur more often in a word-initial than in any other position.

However, it has been found that word-onset vulnerability which is so prevalent in speech errors cannot be replicated for aphasic speech. A few studies found that the coda is more strongly impaired than the other syllabic constituents in German (Stark & Stark, 1990). More direct evidence is available from an examination of English-speaking aphasics. Trost & Canter (1974) found that word-initial consonants were slightly less accurately produced than word-final ones. By contrast, Blumstein (1973) found in her aphasic study that most of the substitutions show a bias toward errors in syllable-initial position.

2.10 Directionality Effect

When contextual errors are examined, the results are influenced by how symmetrical applied it is in the forward direction (anticipatory), the error units preceding the source element, as shown in (20), and the backward (perseveratory) direction, the error unit following the source element, as shown in (21).

(20) I: some **f**unny **k**ind → some **k**unny **k**ind

In this example, the source consonant [k^h] is anticipated and replaces the target consonant [f]. Since the source occurs after the target, it is an anticipatory error.

(21) I: **g**ave the **b**oy → E: **g**ave the **g**oy

In this example, the source consonant [g] is perseverated and replaces the target consonant [b]. Since the source occurs before the target, it is a perseveratory error.

It has long been reported in the speech-error literature that speakers make more anticipation than perseveration in phonological errors, and exchanges are less common than either (e.g., Nooteboom, 1973; Berg, 1987; Stemberger, 1989; Wells-Jensen 1999). The studies which have made this claim have all been done with the error data from three Germanic languages: English, Dutch, and German. For example, Nooteboom (1973) in his Dutch slips corpus found that anticipations (N=592, 75.2%) far outnumber perseverations (N=152, 19.3%) which again outnumber exchanges (N=43, 5.5%). However, Gandour (1977) found the opposite direction occurred in Thai tone errors with more perseverations than anticipations by a ratio of about 2 to 1. Wan's (1999, in press) study of Mandarin tone errors found results similar to that of Gandour's findings in relation to Thai tone errors, suggesting that tone languages may have different direction properties in terms of the error distribution. However, evidence from aphasiological data and language acquisition data shows a tendency towards more perseverations than anticipations. Evidence from

Buckingham and Kertesz (1976) and Buckingham (1985) showed that perseveratory influences (either word or sound) in jargon aphasic speech may cross one or more clauses. Schwartz et al. (1994) looked at a comparison between a naturally-occurring speech-error corpus and aphasic speech corpus, and they suggested that there is no empirical or theoretical basis for applying a fairly narrow restriction when coding aphasic patients' errors. Therefore, in their term of contextual errors, that could be the case in which perseveratory and anticipatory influences operate within or without clauses.

Schwartz et al. re-analyzed contextual influences over a larger window, spanning clause before and after the error, and each and every occurrence of the substituted phonetic elements in that context window was counted as a potential source for the error. There is less anticipatory rate in English aphasic studies than in naturally-occurring speech-error data (e.g., Allison & Hurwitz, 1967; Hudson, 1968; Blumstein, 1973; Soderpalm, 1979; Buckingham, 1985; Kohn, 1989; Schwartz et al., 1994). Although most of the numbers are too low to warrant a statistical comparison, the proportion of anticipatory errors in aphasiological data is less than that in speech-error data. The data from German and French aphasics also confirmed the same pattern (Allerbeck, 2000 for German; Knel, 2001 for German; Lecours & Lhermitte, 1969 for French).

2.11 Syllable Size of Target-Source Units

The final criterion to be investigated is the size of source-error units involved in speech errors and aphasic speech. There is wide agreement in which an element is more likely to substitute for another elment if they share a similar phonological environment. There is a question regarding whether syllable size of target-source pairs provides such an explanation. In this section, I will analyze whether there is a syllable structure consistency between target and source elements in the substitution errors in the two error corpora. Since syllable structure is a very imporant issue in Mandarin phonology, and none of any studies in the speech-error and aphasiological literature has ever looked into the domain of syllable structure consistency. Therefore, I will use this criterion to see if target-source pairs share the same type of syllable.

In the foregoing, the methodology of the data collections will be looked at first. Ten different criteria will then be used to investigate the speech-error data and aphasic speech in Mandarin. I will present a number of general findings of my study, focusing on the long-standing issues related to the ten criteria, and provide a substantial amount of examples. Comparisons in the two error corpora will be explicated in Chapter VI.

CHAPTER III
METHODOLOGY

3.1 Introduction

The use of speech errors to look at issues in linguistic theory and also at speech production planning models has a long history (Fromkin, 1973b, 1980; Dell, 1980; Cutler, 1982; Stemberger, 1983; Garrett, 1988; Levelt, 1989; Baars, 1992; among many others). Speech errors are defined as one-time errors made during speech production planning, such that the speaker produces an utterance which is at odds with his or her intended utterance, differing from the intended utterance in terms of lexical choice, syntactic structure, or phonological structure. While most of this research has focused on errors from English, Dutch or German, a few recent studies have looked into cross-linguistic data (Berg, 1987; Wells-Jensen, 1999), and I have recently begun publishing on speech errors in Mandarin (Wan, 1997, 1999, 2002a, b, to appear, in press; Wan & Jaeger, 1998, 2003; see also Shen, 1993; Chen, 1993, 1999; Yang, 1997).

Speech errors have been shown to be invaluable evidence for the cognitive status of specific linguistic units and processes in specific languages. Increasingly, aphasic speech errors have been serving as the data upon which theories of speech production have been built (e.g., Ellis, Miller & Sin, 1983; Ellis, 1985; Schwartz, 1987; Kohn & Smith, 1990; Buckingham, 1992; Butterworth, 1992; Gagnon et al., 1997). Aphasia is a disorder of language produced by injury to the brain structures most essential for language functioning so aphasic speech also constitutes an important source of data for testing linguistic representation and can be accommodated in the theoretical models that have been proposed for normal language production. Therefore, the phenomena of aphasia can provide tests of the validity of certain aspects of linguistic theory and speech production models. Since aphasic language is often examined on the basis of the errors that are made, a meaningful comparison necessitates that the same method be employed in the study of errors produced by normals.

Few neurolinguistic studies have examined the impact of disturbances to the production in aphasic patients and compared the production deficits to the characteristics of normal speech. The following illustrates the methodology and subjects in coding the errors during normal and aphasic running or spontaneous speech. The study will expect to find that the observed differences between the error patterns of aphasic, and normal speech will have had profound influence on the development of normal speech production models. In most speech production models, which have already started to guide much aphasic research, planning frames direct the phonological encoding of a sentence. The frames provide the phonological specification and representations. Phonological representations are inserted into these frames while undergoing a process of segmental interpretation, whereby a complete segmental representation is derived from the more abstracted stored form (Garrett, 1980).

3.2 Methodology and Subjects in Speech Errors

The speech-error data that are discussed in the study are taken from a corpus of spontaneous speech errors (N=5499) spoken by normal speakers of Mandarin spoken in Taiwan in naturalistic settings and the error corpus has been collected in the Graduate Institute of Linguistics at National Chengchi University over the past 9 years. Standard collection procedures were followed, and all errors were analyzed and classified using the system discussed in Wan (2002b) (for a more detailed discussion of procedures and some potential problems that might be rendered, see MacKay, 1980). The subjects in this study are all native speakers of Mandarin spoken in Taiwan. Most of the dialects have undergone some general sound changes which are currently taking place in Taiwan, whereby the retroflex affricates [tʂ, tʂ^h, ʂ] are being lost and replaced by dental affricates [ts, ts^h, s], and whereby the velar nasal following the high front vowel such as [iŋ] is being dropped and replaced by the dental nasal after the high front vowel such as [in]. However, certain speakers in the subject groups continue to distinguish dental from retroflex affricates, and a velar nasal from a dental nasal, respectively.

These errors were collected under four different conditions in naturalistic settings; there were approximately over 100 subjects who contributed data. The data were collected in four different circumstances. First, between 1995 and 1997, subjects were recorded while having free-conversations in naturalistic settings, during which the subjects did not know they were being recorded. After each conversation, the subjects were informed that the conversation had been recorded, and permission was obtained to use their data. Second, in 1998 I recorded 40-hours of free conversation involving 24 speakers whose age ranged from 20 to 50 years old (Not all speakers produced errors) and these speakers were informed that the conversation had been recorded. Third, other errors were gathered following the 'pen and paper' method. That is, when slips occurred in situations where speakers were not being recorded (e.g. in normal conversations, during lectures, etc.), the errors were immediately written in a notebook. During the entire data collection period, whenever I overheard speech errors in situations where speakers were not being recorded, I immediately wrote the error into a notebook. Once identified, an error was written down immediately, with as much of the context utterance as possible; pertinent facts about the physical and social context as well as the state of mind of the speaker and use of mind-altering substances were also recorded. Four, the speech-error data were derived from thousands of tape-recorded brief excerpts of natural speech and were collected by the author and her research team between 2000 and the present. These excerpts were taken from free conversation, conference discussions, broadcasts, lectures, and from interviews with students. For each error I recorded the complete utterance including self-corrections, and relevant contextual information; portions were written in phonetic transcription, when appropriate. The errors were collected by monitoring speech in everyday situations, and noting when the speaker has departed from the intended form of an utterance; the target was usually obvious from context, and in most cases was confirmed by the speaker, either by self-correction, a question from listeners, or by subsequent discourse. Therefore, evidence showed that an error has occurred including self-correction, pause or gesture, comment by the speaker or by listeners, direct questioning of the speaker or in some cases, the unaided intuition of the listener.

In summary, the errors were collected from over 100 different speakers whose ages ranged from 20 to 50 years old; note that not all speakers produced errors under the data collections. For each error in the corpus, the author recorded the complete utterance including self-corrections, and relevant contextual information; portions were written in IPA phonetic transcription as appropriate. Thus the errors will be reported below in terms of the actual pronunciations the subjects produced during the error utterance. In the study, subjects ranged from monolingual to trilingual, with Mandarin as their first language and Taiwanese as their other language(s) if any. However, all the errors were collected when the speakers were conversing in Mandarin; any errors which showed a bilingual influence were not included in the data set to be examined in the study. Therefore, I take the majority of these errors to accurately reflect the processing involved in speaking Mandarin.

3.3 Methodology and Subjects in Aphasic Speech

The error data in aphasic speech are drawn from the corpus of aphasic errors spoken by native speakers of Mandarin spoken in Taiwan in natural speech settings. Standard collection procedures were employed and were categorized according to the speech-error classification system in the study. Aphasic speech is sometimes marred by the production of paraphasias. Speech was constantly monitored for errors. Whenever one was noted, it was immediately written down, along with as much context as possible, the speaker's name, the date, and what the speaker had intended to say. This target was usually obvious from context, and in most cases was confirmed by the speaker, either by self-correction, a question from another listener, or by subsequent discourse. To mitigate the problems of attention bias and the saliency of different types of errors, errors were collected only in situations where a large amount of attention could be devoted to error collection.

Eight aphasic subjects have contributed the aphasic error data to this study. These individuals were all diagnosed as having a fluent-type (Wernicke's aphasia and conduction aphasia) of paraphasias, and were distinguished by clinical characteristics and accompanying pathology. It is generally accepted that Broca patients exhibit typical speech patterns characterized by slow and halting speech, and they are often unable to initiate fluent production of words. The Wernicke patients, on the other hand, show prototypical speech patterns in which comprehension of words and sentences are severely impaired, that is, their speech output is fluent, but they make very little sense. Conduction aphasia involves a syndrome in which one is not able to repeat spoken languages. The diagnosis and classification of the aphasic groups was based on the evaluation of the Chinese version of the Boston Diagnostic Aphasia Examination (BDAE). Each diagnosis had been substantiated by a CT scan for all eight aphasics as part of their standard clinical care, and arrangements with regard to the grouping were made by the therapists of the Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital. It can be suggested that the subcategories of such groups are necessary to check the performance of all eight aphasic patients individually since any production deficits among left brain-damaged patients could be attributed to a certain type of aphasic syndrome. However, few single-case or patient-group studies have been reported with regard to the specific findings. Individuals that were diagnosed with a non-fluent form of aphasia or a motor speech impairment (e.g., dysarthria or apraxia) are excluded in this study to avoid attributing phonetic or articulatory distortions to a phonological origin.

The data contains 3000 aphasic errors collected by the author's research team from aphasic speakers of Mandarin between 2002 and the present. The aphasic error data are drawn from a confrontation picture naming task as well as interview questions with aphasic patients. Most of the contexts involved the questions which were produced during the course of open-ended conversations regarding the patients' illness, work, weather, hobbies, family, friends, etc. These patients made occasional segmental and suprasegmental errors during their conversation speech with the therapists.

Each patient was individually given the interview in a moderately quiet room, the spontaneous speech of which lasted about 30 minutes for each patient. The raw data used in this study was selected from the tape-recorded interviews. For each potential error, a guess was made at the intended target independently by two assistants and the author. We then compared our notes, and inconsistencies were resolved by negotiation. If the potential error in the patient's utterance was identified as an error whose target words could clearly be determined by the surrounding context, the error was considered to have been identified. Otherwise, no target was assumed. The error utterances were transcribed using the International Phonetic Alphabet for more precise identification.

All of these aphasic patients suffer from unilateral damage on left hemisphere caused by cerebral vascular disease, brain trauma, brain tumor, or stroke. Table 3-1 shows a summary of the significant features of each patient's case.

Table 3-1: Patient summary

	Clinical type	Sex	Age	Education	Work
#1	Wernicke	M	56	College	Business
#2	Wernicke	M	64	College	Business
#3	Conduction	M	47	University	Business
#4	Wernicke	F	42	Senior High	Business
#5	Conduction	M	63	Senior High	Business
#6	Wernicke	M	45	M.A.	Government Official
#7	Wernicke	M	50	College	Engineer
#8	Wernicke	M	59	Senior High	Business

Table 3-1: Patient summary (cont'd)

	Etiology	Post Onset (y;m)	Lesion site
#1	Stroke	5; 04	Left temporal lobe
#2	Stroke	6; 10	Left temporal lobe
#3	CVA*	3; 10	Left parietal lobe
#4	CVA*	5; 12	Left temporal lobe
#5	Stroke	5; 09	Left posteriorsuperior temporal lobes
#6	CVA*	6; 08	Left temporal lobe
#7	Trauma	5; 02	Left temporal lobe
#8	Tumor	5; 02	Left temporal lobe

*CVA: Cerebral Vascular Accident

There was special emphasis on phonological errors in the recordings of the utterances. In the study, some problems arose in making decisions as to which errors were contextual and non-contextual. This indecision may have contributed to have the low rate of contextual errors observed in this study. Since the conversations between the aphasic patients and therapists always lasted for 30 minutes, each a transcription is less than ten pages. If an error is made, it is not difficult for the assistants to check the whole transcription to see whether or not the source unit(s) occurs before or after the error unit within an utterance or across the utterance. Therefore, such an error was classified as 'non-contextual' when no source identical to the error unit(s) occurred in the utterance. One might argue that such a strict restriction should not be applied to aphasic speech when coding patients' errors since there may not be any reason to predict an anticipatory or perseverative effect within utterance in their speech. However, since evidence from speech errors in normal production clearly limits the contextual influences within clauses in a strictly restricted narrow window, nearly within seven-syllable spans, it is more symmetrical to make an evaluation based on the same criteria and see how large a size of window aphasic patients can reach, spanning the source-error pairing before and after clauses. If the source and error unit(s) occurs across clauses, there might be a possibility to classify it as a potential contextual error. The spontaneous speech collected from the eight aphasic patients was transcribed using IPA fonts. The frequencies tabulated were based on the actual pronunciations produced by the patients and not on the target tones.

At the time of these analyses, there were 5499 and 3000 errors of all types in the speech-error and aphasic speech corpora, respectively. However, not all these errors are relevant to the ten research questions in the study. Various relevant subsets of the data will be discussed where appropriate. The total sample size for any given type of error will vary. Since the data are observational in nature, chance error rates are not immediately apparent, causing some difficulties in comparing the rates of two different types of errors.

While many of the sentences containing these errors may appear ambiguous or even well-formed when presented out of context as in this study, few are ambiguous in context; the target was known with certainty in all the errors analyzed here. To mitigate the problems of attention bias and saliency of different types of errors, errors were collected only in situations where a large amount of attention could be devoted to error collection. I used data gathered from transcriptions of tape recordings, and I will touch on a number of important issues, including the nature of phonological representations and the basic mechanisms underlying phonological encoding system. After discussing general statistical properties of errors, I will examine the degree to which errors are nonetheless well formed linguistically, the role of similarity in conditioning errors, and the directionality of ordering errors. This last topic will allow us to address some basic assumptions underlying current models of language production.

3.4 Classification System

In an earlier study by Wan (1999), it was found that speech errors in normal production in Mandarin can occur at any stage of the speech production planning process (see Fromkin 1973a, 1980, Cutler 1982 for classic studies of speech errors in English, and Dell 1980, Garrett 1988 for speech production planning models). Under this study, I will focus on errors in the two error corpora which occur during the phonological planning stage, where underlying phonological representations are being assigned a surface phonetic form. Since the main focus of this study is phonological errors, I will discuss the phonological properties of non-phonological errors which are relevant to the speech-error and aphasic studies in Mandarin.

Errors were classified as ‘phonological’ if some non-meaningful phonological units were involved: phonetic features, single consonants or vowels, clusters of segments (including consonant clusters, rhymes, etc.), whole syllables, and tones. In each case I identified as closely as possible the ‘target’ units involved in the error (i.e., those which the speaker intended to produce), the ‘source’ of the error (i.e., those units which were the interfering factor in the error), and the ‘error’ itself (i.e., the units in the utterance production which violated the speaker’s intentions).

The errors were classified according to the following four criteria:

a) The phonological unit involved, as described above
b) The directionality of the error (i.e., the linear relationship between the error and source)
c) The type of error (substitution, addition, etc.)
d) The position in the syllable in which the error occurred

The terms used in these classifications with examples of each category in the two error corpora are provided in Appendices One and

Two. In each example, the first line will be the intended utterance (in surface phonetic transcription); the second line will provide a morpheme-by-morpheme gloss. The third line will be the error utterance, again in phonetic transcription, and the fourth a translation into English of the intended utterance. In the intended utterance and the units which were the error and source of interference, the target, error, and source elements are underlined and boldfaced. The element to the left of the arrow is the target, and the element to the right of the arrow is the error. A single-headed arrow indicates 'is replaced by', and a double-headed error indicates 'exchange'. The term 'meaningless' following the gloss of the intended utterance means either that the error utterance violates the syntactic rules of Mandarin, or that the error utterance contains a semantic anomaly that renders it meaningless.

3.5 Making Decisions in Ambiguous Cases

In the past, most of the researchers collecting speech-error data relied on the native-speaker linguist's intuitions as to what categories in the native language were heard by the native listener (Fromkin, 1973a). Fromkin (1973b, 1980) suggested that speech errors collected in a naturalistic setting have a cognitive validity in terms of the representation of speakers' minds during processing. However, one might argue that obtaining the speech-error data under naturalistic conditions does not have the overriding advantage of giving insight into the psychological structures and processes actually used by native speakers in the generation of speech. Even if evidence may be derived from psychological constructs, it is not always clear at which level of analysis the speakers operate on. Cutler (1982) suggested that such a methodology is subject to some listener bias. In order to eliminate the context-effect applying in naturalistic speech performance, Dell and Reich (1980) and Stemberger (1985) conducted a number of experiments, trying to reduce all anticipated potential distortions that might render evidential value of the errors ambiguous. Furthermore, Mowrey and MacKay (1990) then suggested that in speech errors induced in the laboratory by having speakers repeat 'tongue twisters' several times in succession, some phonetic differences between erroneously produced and intentionally produced consonants could be detected using electromyography. However, the majority of speech-error studies are drawn from spontaneously occurring errors, and the difference between controlled experiments and naturally occurring errors seems not to be significant. Therefore, in order to prove that the perception by a native speaker that a segment was spoken with a particular sound is a more valid psycholinguistic measure than the actual phonetic properties of the utterance, Wan (1999, 2002b) and Wan and Jaeger (2003) subjected several instances of erroneously produced sounds and the same sounds produced intentionally in the same environments in order to formant value analysis. It was found that there are no significant differences in analysis between the erroneously produced sounds and the same sounds produced intentionally in the same environment. Therefore, the speech errors collected in a naturalistic setting for this study will be taken as evidence reflecting psychological constructs in the language structure, and the data to be discussed below are thus sufficiently reliable to provide matter for analyses.

Wan (1999) in an earlier study found that Mandarin speech errors can occur at any stage of the speech production planning model, as in speech errors occurring in Germanic languages. It is often noted that in naturally-occurring or experimentally-elicited speech error data, there is evidence that the likelihood of sound substitutions creating real words is greater than would be expected by chance alone (Baars, Motley, & MacKay, 1975; Dell & Reich, 1981), and true semantic errors nearly always preserve lexical category; the error word is usually semantically related to the intended word. Therefore, in the two error corpora, if the error substitution accidentally creates a real word which violates lexical category and has no semantic relationship to the target word, causing an ungrammatical and meaningless utterance, such substitutions will be classified as phonological errors. The errors that are discussed here are classified as ‘phonological’ because non-meaningful phonological units are involved, that is, phonetic features, single consonants or vowels, clusters of segments (including consonant clusters, rhymes, etc.), whole syllables, and tones. Since most Mandarin morphemes are monosyllabic and Mandarin words are bi-syllabic, a change in one or more segments causing phonotactically permissible sequences nearly always produces actual morphemes and thus results in another actual word in Mandarin. However, phonological errors can be distinguished from true lexical errors in that lexical errors nearly always preserve lexical category, and are usually semantically related to the intended word; a phonological relationship is less common. Phonological errors, on the other hand, frequently violate lexical category and have no semantic relationship to the target word; thus they typically produce an ungrammatical or meaningless utterance. The following example illustrates the procedure followed in the classification of errors when unclear cases occur.

(1) I: **x**wɔ21-**tʂ^h**ɤ55 → 火車
fire-vehicle
E: **x**wɔ51-**x**ɤ55 (tʂ^h→x)
'train?' → meaningless

This spontaneous speech error is best analyzed as a phonological error where the consonant of the syllable [x] is perseverated and substituted for another consonant of the following [tʂ^h], leaving the vowel and tone of [ɤ55] in place. However, one might classify this case as a lexical error in which the lexical item [xɤ55] 'to drink' replaces another lexical item [tʂ^{h}ɤ55] 'car'. This interpretation is not quite correct since in this case, the error [xɤ55] is a verb 'to drink' whereas the target [tʂ^{h}ɤ55] is a noun 'car', and the error word is not of the same lexical category as the target, has no semantic relationship to the target, and is not phonetically similar other than having the same tone; the resultant utterance is therefore meaningless.

(2) I: t^{h}a55 pu35 jɑw51 k^{h}aj55 xwɔ**51**-tʂ^{h}ɤ55→
he not want drive goods-vehicle
E: t^{h}a55 pu35 jɑw51 k^{h}aj55 xwɔ**21**-tʂ^{h}ɤ55 (51→21)
fire-vehicle
'He doesn't want to ride a truck (for a living).' →
'He doesn't want to drive a train (for a living).'
他不要開貨車→他不要開火車

In this example, the smallest unit involved in the error is the tone; the tone unit [21] replaces another tone unit [51], leaving the other segments in place. One might consider it a tone error based on the minimal principle; however, this utterance does not render a source tone unit [21] so a phonological explanation is not possible in such a case. This case can be best described as a lexical error since [xwɔ51-tʂ^{h}ɤ55] 'truck' and [xwɔ21-tʂ^{h}ɤ55] 'train' preserve the same lexical category, and they have identical segments except that the tones in the first syllable are different. It is often found in English speech errors that two lexical items are semantically related when they are substituted for each other, and in many cases, they are also phonologically related. In English there is a class of substitutions known as malapropisms where there is only a phonological relationship; however, these are rare in Mandarin, where nearly every lexical substitution error shows a semantic relationship.

In making a decision about the classification of an error, the methodology is based on a 'minimal principle' proposed by Laubstein (1987), where the smallest segmental error unit is always chosen as being in accord with the simplest or most conservative analysis. First, the majority of unambiguous phonological errors involve single consonants or vowels in all languages (i.e., Wells-Jensen, 1999). Therefore, if a single segment analysis is possible, it is more likely to be correct. Second, if this principle is not adopted, the researcher could be free to choose whichever analysis he or she preferred, which could bias the analysis in favor of the researcher's preferred hypothesis. However, if there is an ambiguous error which can either be classified as a phonological or lexical error, the involvement of the smallest unit may not be the only solution. Consider the following example:

(3) I: **k**ɑŋ55-ts^{h}aj35-tɤ **t**ɑw55 → 剛才的刀
just-just-LINK knife
E: **k**ɑŋ55-ts^{h}aj35-tɤ **k**ɑw55 (t → k)
'the knife that was just here' → meaningless

In this example, one could argue that the onset, nucleus and tone of [kɑŋ55] were perseverated and substituted for the onset, nucleus and tone of [tɑw55]. However, the simplest analysis is that only the onset consonants [k] and [t] were involved in the error, and that the phonological similarity of the remainder of the two words facilitated the error. This facilitative 'repeated phoneme' effect is well-documented for English (Dell 1984). Dell (1984) elicited speech errors and found that repeated phonemes in the same word are contributory causes of phoneme exchanges, anticipations, or perseverations. He also found that repeated phonemes induce the misordering of sounds that are not adjacent to the repeated sounds, as well as those that are adjacent to the repeated ones.

Third, there were a number of errors which appeared at first glance to be quite complex; however, if the errors are analyzed in terms of the types of allophonic variation posited by various researchers, they became simple errors of the well-documented types. For example:

(4) I: xaj21-t^{h}a**n**55 ʂɑ**ŋ**51 → 海灘上
ocean-beach up
E: xaj21-t^{h}a**n**55 ʂa**n**51 (ŋ → n)
'at the beach' → meaningless

One might argue that this example is a rhyme substitution error ([ɑŋ]-[an]); however, the simplest way to account for it is to hypothesize that the nasal [n] is perseverated and substituted for the nasal [ŋ], and that the vowel [ɑ] then changes to its correct allophonic form, [a]. Since the vowels [a] and [ɑ] belong to the same phonetic variant [a], and again, as since according to Laubstein's (1987) minimal principle, the simplest or most conservative analysis is to choose the smallest segmental error unit in the target-source pairs and throughout the whole study, this principle will be adopted entirely without any inconsistency[1].

Fourth, an error was classified as 'non-contextual' only when no source identical to the error unit(s) occurred in the utterance.

(5) I: wɔ21 pu35 joŋ51-**k**oŋ55 → 我不用功
I not use-achievements
E: wɔ21 pu35 joŋ51-**t**oŋ55 (k → t)
'I am not diligent' → meaningless

In this example, the consonant [t] replaces the target consonant [k], and there are no other dentals [t] in the utterance.

Finally, a segmental error was classified as a feature error only when there was no segment in the utterance identical to the error segment, but a nearby segment contained the erroneously produced feature value. For example:

(6) I: **t^h**ɑŋ51-tɤ **k**ɑŋ55-xɑw21 → 燙的剛好
hot-LINK just-good
E: **k^h**ɑŋ51-tɤ **k**ɑŋ55-xɑw21 (t^h → k^h)
'hot enough' → meaningless

[1] I would like to express my gratitude to the reviewer for pointing this out to me. For more discussions on vowel alternations in Mandarin, please see Wan and Jaeger's (2003) interpretations.

This example is considered an error involving the feature, place of articulation. In this error there is no [k^h] in the utterance which could have been the whole-segment source of the error segment [k^h] in [k^hɑŋ]. However, there is a velar consonant [k] in the onset of the syllable two syllables to the right of the target word [t^hɑŋ], and therefore I analyze this as a case where the velar place of articulation from [k] has been anticipated across two syllables and substituted for the alveolar place of articulation of the target onset consonant [t^h], thus producing [k^h]. This analysis is reinforced by the fact that the rhymes following the onset consonants in both target and source syllables are identical, and that, as discussed above, the similarity of neighboring segments is a strong factor in predisposing segments to interact in errors (Dell 1984). Therefore, this is an unambiguous feature error within this classification system.

In summary, in the first part of this chapter, the methodology of data collection for this project was presented. I then presented a definition of speech errors as well as aphasic speech data. I also discussed how the errors in normal and aphasic speech can provide evidence for our understanding of language construct and structure. The methodology and subjects used in this study were discussed at length. I finally presented and justified the classification system used for the analyses of the two error corpora and gave examples of the classification in unclear cases; I also presented certain general principles for making classifications in ambiguous cases, and which principles are adopted consistently throughout the whole study.

In the next chapter, I will present a general overview of the findings of my study, focusing on the naturally-occurring speech errors produced by normal speakers in Mandarin and looking at the type of errors and units involved in error patterns by these speakers.

CHAPTER IV
RESULTS FROM SPEECH ERRORS

4.1 Introduction

Speech-error studies over the past several decades have used the patterns and constraints observed in extensive collections of errors to argue both for the validity of phonological units as processing units, and for particular phonological theories or cognitive processing models (Fromkin, 1973a/b; Shattuck-Hufnagel, 1979; Stemberger, 1983; Dell, 1984, Levelt, 1989; Bock & Levelt, 1994). There has been much work which has attempted to determine the psychological validity of various linguistic claims ranging from the existence of certain units to the existence of particular rules. In this chapter, a corpus of 5499 naturally-occurring speech errors made by native Mandarin speakers spoken in Taiwan will be examined. I will look at a number of important issues regarding the psychology of speech production and the nature of phonological representations as well as the mechanisms underlying phonological encoding in speech production. I will first discuss the general distribution of error types involving phonological units. Further, I will examine general phonological characteristics of speech errors that have been discussed widely in cross-linguistic speech-error literature. After discussing general statistical properties of these errors, I will examine the degree to which errors are well-formed linguistically. I will then discuss the role of similarity in conditioning errors and the directionality of ordering errors. A general comparison to the results from a corpus of aphasic speech will be explicated in Chapter VI. In Chapter VI, the phonological analyses from speech errors and aphasic speech will be supported by looking at data from cross-linguistic relevant literature in detail, relating it to some basic assumptions underlying current models of speech production.

In the present study, a corpus of 5499 aphasic errors drawn from native speakers of Mandarin spoken in Taiwan is provided to examine the following questions.

(1) Is there any equal proportion of phonological errors and lexical errors or do Mandarin speakers have a preference to produce errors of one kind more commonly than the other? Furthermore, in speech-error data involving phonological units, which phonological elements have a wider error distribution? The rationale for this question is that phonological errors are more common than lexical errors in normal speech errors (e.g., Nooteboom, 1973; Stemberger, 1989; Wells-Jensen, 1999).

(2) Do the speech errors in the present study involve more contextual errors or non-contextual errors? The rationale for this question is that studies on cross-linguistic speech errors have shown that source segments influencing target segments usually occur within the context of utterance (e.g., Nooteboom, 1973; Garnham et al., 1982). When there is an identical source unit in the vicinity of the error, the slip is classified as contextual. The contextual window usually refers to target-source elements interacting within a clause.

(3) What is the distance in a syllable between a source and error unit? The rationale for this question is that we can measure contextual errors between the source and error segments in terms of how many syllables there are. The answer to this question would help one to define how many syllable spans there are between the source and error units which may be potentially classified as contextual errors.

(4) Does the largest proportion of errors involve substitutions in speech errors in Mandarin? What is the frequency of omission and addition errors? Is there an equal proportion of omission and addition errors or not? The rationale for this question is that studies from naturally-occurring speech errors show a general hierarchy of error type in which substitution errors occur more frequently than addition errors, which in turn outnumber deletion errors (Nooteboom, 1973; Berg, 1987; Wells-Jensen, 1999).

(5) How will speech-error data provide evidence that bears on the question as to whether segments or features are the most fundamental phonological units in language processing? The rationale for this question is that most researchers have found that errors involving whole segments are more common than feature

errors in English (Fromkin, 1973a/b; Stemberger, 1983; Shattuck-Hufnagel, 1986).

(6) In whole segments involving contextual single-consonant substitution and exchange errors in Mandarin, do these segmental errors (i.e., target and source segments) display any phonetic similarity? Especially, how many feature differences are there between target and source segments? Is there any hierarchy and rank order of feature distribution in Mandarin? That is, which type of feature is violated the most often in Mandarin speech errors? The rationale for this question is that it is well-known that consonants are more likely to mutually interact with each other in errors if they are phonetically similar in speech errors in English (e.g., Fromkin, 1973b; MacKay, 1973; Nooteboom, 1973; Van den Broecke & Goldstein, 1980; Levitt & Healy, 1985; Stemberger, 1989; Jaeger, 1992, 2004; Frisch, 1997). Also, a number of researchers have found an overall hierarchy of feature involvement in speech errors and the feature that is violated the most often is place of articulation and the feature nasality is the feature violated least often (Van den Broecke & Goldstein, 1980; Jaeger, 1992, 2004).

(7) Does the error distribution in speech-error data honor syllable structure? That is, do the target and source segments share the same syllable structure position? The rationale for this question is that MacKay (1970) and Shattuck-Hafnagel and Klatt (1979) found almost no exceptions in their analysis of naturally-occurring speech errors in which an initial consonant interacts with another intial consonant, a nuclear vowel interacts with another nuclear vowel, and a coda consonant interacts with another coda consonant. Data from Stemberger (1985) and Berg (1997) confirm this property.

(8) Do the majority of speech errors involving target and source units tend to occur in syllable-initial positions or in syllable-final positions? The rationale for this question is that there is a strong tendency (close to 80%) in which initial consonants are more likely to err than noninitial ones (MacKay, 1972; Shattuck-Hufnagel, 1986).

(9) What is the directionality of the errors occurring in speech errors in Mandarin? Some researchers further subdivide contextual errors into anticipation (where the error unit precedes the source element) and perseveration (where the error unit follows the source element). The rationale for this question is that it is reported that there is a tendency to produce more phonological anticipations than

perseverations and exchanges in English and other Germanic speech errors (e.g., Nooteboom, 1973; Stemberger, 1989; Dell, Burger, & Svec, 1997; Wells-Jensen, 1999). However, Gandour (1977) and Wan (in press) found the opposite occurring in Thai and Mandarin tone errors, respectively, with more perseverations than anticipations and exchanges.

(10) What is the size of source-target units in speech errors in Mandarin? In syntagmatic single substitution errors, do the target and source segments share the same type of syllables? What is the most frequent syllable type? In syntagmatic errors involving larger units within syllables, is there any tendency to a particular structure type? The rationale for this question is that although there are strong phonotactic constraints in Mandarin syllables and most errors involve single segments, there are occasional errors in which larger units may be affected, in particular consonant clusters such as CG, or rhyme structures such as VG or VN, being uttered in whole units (Wan, to appear).

The rationale in addressing these questions is to gather evidence regarding the cognitive knowledge of Mandarin speakers in terms of representation and processes of their phonology, and also to provide evidence in favor of or against the previous cross-linguistic findings.

4.2 Errors Involving Phonological Units

Regarding the major classification of error distribution in the data collection in Mandarin, the error data show some patterns, as shown in Table 4-1 and Table 4-2. The phonological characteristic of speech errors include errors involving single consonant, single vowel, larger units involving consonant clusters, rhymes, and consonant-vowel units, syllables, features, and tones. Examples are given in (1-10).

Table 4-1: Speech errors

Speech errors	N
Phonological	5499
Lexical	2900

(1) I: kwa**n**55-t^{h}o**w**35 → 關頭
close-end
E: kwa**n**55-t^{h}o**n**35 (w→n)
'a critical moment' → meaningless

Example (1) is classified as a phonological error since the phonological unit, a consonant [n], is perseverated and replaces another phonological unit, consonant [w].

(2) I: **ts^{h}aj35-yn51**→ 財運
wealth-luck
E: **ʂɨ51-jɛ51** 事業
business-profession
'wealth and luck' → 'a career'

Example (2) is categorized as a lexical access error in that the lexical item [ts^{h}aj35-yn51] 'luck in making money' is replaced with another lexical item [ʂɨ51-jɛ51] 'a career'.

Table 4-2: Phonological units occurring in speech errors

Phonological units	N	%
Consonants	2806	51.03
Vowels	929	16.89
Consonant clusters	255	4.64
Rhymes	263	4.78
Consonant-vowel sequences	4	0.08
Syllables	186	3.38
Features	197	3.58
Tones	859	15.62
Total	5499	100

(3) I: ɥɛ51 **l**aj35 ɥɛ51 **n**an35 → 越來越難
more come more difficult
E: ɥɛ51 **l**aj35 ɥɛ51 **l**an35 (n →l)
'(this becomes) more and more difficult' → meaningless

Example (3) is of a phonological error involving a consonant substitution in which the initial consonant [l] is perseverated and replaces another initial consonant [n].

(4) I: t^{h}a55 tɕ^h**i**35 tɕ^h**y**51 waj51-mjɛn51 lɤ → 她騎去外面了
she ride go outs-side PERF
E: t^{h}a55 tɕ^h**i**35 tɕ^h**i**51 waj51-mjɛn51 lɤ (y→i)
'she went for a ride outside' → meaningless

Example (4) is of a phonological error involving a vowel substitution in which the vowel [i] is perseverated and replaces another vowel [y].

(5) I: **f**an21-tʂəŋ51 **xw**an51 ts^{h}wɑŋ35 → 反正換床
opposite-upright change bed
E: **f**an21-tʂəŋ51 **f**an51 ts^{h}wɑŋ35 (xw → f)
'anyway, (we) can change the bed' → meaningless

Example (5) is of a phonological error involving a consonant-cluster substitution in which the single consonant [f] is perseverated and replaces the consonant cluster [xw].

(6) I: j**ow**21 ʂɤ35-mɔ tʂ^{h}u55 ʐ**u**51 → 有什麼出入
have what-particle out in
E: j**ow**21 ʂɤ35-mɔ tʂ^{h}u55 ʐ**ow**51 (u→ow)
'What is the difference?' → meaningless

Example (6) is of a phonological error involving a rhyme substitution in which the rhyme [ow] is perseverated and replaces a single vowel [u].

(7) I: tɕja55 sɨ51 **p^{h}i**ŋ35 twɔ55 i35-kɤ fɑŋ-tɕjɛn55 →
more 4 36 square feet more one-CL room-space
E: tɕja55 sɨ51 **fə**ŋ35 twɔ55 i35-kɤ fɑŋ-tɕjɛn55 (p^{h}i→fə)
'If your (house) is added 144 square feet more, then you will make another room.' → meaningless 加四坪多一個房間

Example (7) is of a phonological non-contextual error involving a consonant-vowel substitution in which the consonant-vowel sequence [fə] replaces another consonant-vowel sequence [p^{h}i].

(8) I: ta51-**kaj**51-tɤ ljɑw35-**tɕjɛ**21 → 大概的瞭解
big-general-LINK understand-understand
E: ta51-**kaj**51 tɤ ljɑw35-**kaj**21 (tɕjɛ→kaj)
'loosely understand' → meaningless

Example (8) is of a phonological error involving a syllable substitution in which the syllable [kaj] replaces another syllable [tɕjɛ] without affecting the tone.

(9) I: tow55 ʂɨ51 **tʰ**ɑ55 **tʂ**ɑŋ21 **tɕʰ**ɥɛn35 → 都是他掌權
all is he hold power
E: tow55 ʂɨ51 **tʰ**ɑ55 **tʂʰ**ɑŋ21 **tɕʰ**ɥɛn35 (tʂ→tʂʰ)
'It's he who controls everything.' → meaningless

In (9), the onset [**tʂ**] becomes [tʂʰ] in either anticipation of the aspiration of the consonant [tʰ] or perseveration of the aspiration of the consonant [tɕʰ], and there is no [tʂʰ] source in the utterance.

(10) I: tʰwej55-tɕjɛn**51** xan**35** → 推薦函
push-recommend letter
E: tʰwej55-tɕjɛn**51** xan**51** (35→51)
'letter of recommendation' → meaningless

Example (10) is of a phonological error involving a tone substitution in which the tone [51] is perseverated and replaces another tone [35].

A Chi-square test was done to compare the number of errors in the sub-groups falling into each category in Mandarin. The results show that the error distributions in Mandarin occurred with a greatly significant difference ($\chi^2(7)=8586.722$, $p<.01$). It is apparent from Table 4-2 that there are a larger proportion of consonant errors in speech-error data (N=2806, 51.03%), followed by, in order, vowels (N=929, 16.89%), tones (N=859, 15.62%), rhymes (N=263, 4.78%), consonant clusters (N=255, 4.64%), features (N=197, 3.58%), syllables (N=186, 3.38%), and consonant-vowel sequences (N=4, 0.08%). The least common type of speech error is the combination of consonant and vowel movement error. It is very clear to see that consonant errors (N=2806) are approximately three times more common than vowel errors (N=929). This finding corresponds to some extent with the cross-linguistic findings. For example, in Jaeger's (2004) slips corpus in children, consonant errors in English are four or five times more common than vowel errors. Wells-Jensen (1999) also found in her corpus that in English and Hindi, consonant slips are approximately five times more common than vowel slips, and in Japanese and Spanish consonant slips are two times as common as vowel slips. Although most errors involve single segments, it is also possible to find a number of errors involving combinations of consonants and vowels in the corpus. In combinations of consonants and vowels, vowel-consonant-sequence (rhyme or VC) errors (N=263, 4.78%) and consonant-cluster errors (N=255, 4.64%) both far outnumber consonant-vowel-sequence (CV) errors (N=4, 0.08%). The results show that the error distributions in the combinations of consonants and vowels occurred with a greatly significant difference ($\chi^2(2)=249.322$, $p<.01$). Estimates of the percentage of phonological errors that involve single segments run from 70% to 90% (Nooteboom, 1973; Shattuck-Hufnagel & Klatt, 1979). Well-motivated phonological units such as the syllable and feature tend not to slip. In summary, estimates of the percentage of phonological errors that involve single elements run to 67.92% in Mandarin.

4.3 Contextuality

In the speech error data, phonological errors can be further subdivided according to whether or not there is a potential source for the error in the utterance context. More specifically, contextual errors are defined by the presence of a source element which is identical to the error unit. Non-contextual errors are defined by the lack of a source and the presence of an error cannot be motivated by the surrounding context. Table 4-3 presents the incidence of contextual and non-contextual errors in the speech-error corpus. Examples are given in (11-12).

Table 4-3: Contextual influences（N=5495）

Speech errors	N	%
Contextual	4343	79.04
Non-contextual	1152	20.96

(11) I: y21-jɛn35 **ɕ**ɥɛ35-**tɕ**jɛ51 → 語言學界
language-language study-field
E: y21-jɛn35 **ɕ**ɥɛ35-**ɕ**jɛ51 (tɕ→ɕ)
'in the field of linguistics' → meaningless

Example (11) is of a contextual error involving consonant substitution in which the source consonant [ɕ] is perseverated and replaces the target consonant [tɕ].

(12) I: u21 ljow51 **p**aj21 k^hwaj51 → 五六百塊
five six hundred dollar
E: u21 ljow51 **f**aj21 k^hwaj51 (p→f)
'five or six hundred dollars' → meaningless

Example (12) is of a non-contextual error involving consonant substitution in which the consonant [f] replaces the target consonant [p]. Note that there is no identical source consonant [f] in the context and therefore it is analyzed as a non-contextual error.

It is immediately apparent from Table 4-3 that contextual errors (N=4323, 79.04%) far outnumber non-contextual ones (N=1152, 20.96%), and this difference is hugely significant ($\chi^2(1)=1853.045$, $p < .01$). There is general consensus that contextual errors make up a large proportion of the total number of errors cross-linguistically. Especially, in the Mandarin speech-error corpus, it is found that the contextual errors involve the interaction of elements within a clause and in close proximity. This property has been found in many languages for which data are available (e.g., Nooteboom, 1973; Garnham et al., 1982; Wells-Jensen, 1999; Jaeger 2004). In summary, the similar pattern is replicated by data found in Mandarin speech errors as well, and the consensus thus suggests that contextuality plays a very important role in normal speech production since Mandarin speakers tend to produce speech errors in close proximity within a clause.

4.4 The Distance between Source and Error Units

Regarding the question of the distance between the source and target, contextual errors can be measured in a syllable between the error and the source element. In most relevant studies, researchers classify contextual errors as in within-word and between-word categories. If the error and source units occur in the same word, the case will be categorized as a within-word error, but when the error and source units belong to different words, the case will be classified as a between-word error. This distinction was illustrated in Chapter II. However, it is important to point out that error and source units are unlikely to occur within the same word in Mandarin due to the fact that there is a restricted phonotactic constraint in Mandarin syllables. The maximum syllable is (C)(G)V(X), with C a [+consonantal] segment, G a glide, V the nucleus vowel, X either a nasal or a glide, and C, G, and X optional. It is likely for an initial consonant interacting with another initial consonant, a prenuclear glide interacting with another prenuclear glide, a single vowel interacting with another single vowel, a coda nasal interacting with another coda nasal, a postnuclear glide interacting with another postnuclear glide, or a coda nasal interacting with another coda glide and vice versa. The only possible within-word errors could be the case in which an initial nasal interacts with a coda nasal or an initial glide interacts with a coda glide. However, such a possibility is relatively rare comparing with all the other above pattern chances. Table 4-4 shows the incidence of contextual errors according to the distance measured in a syllable between the interacting elements. For errors with more than one potential source, only the nearest source is included in these analyses. Examples of items falling into each window size are provided in (13-18).

Table 4-4: Frequency of error distribution as a function of syllable span between source and target[1] (N=4142)

Classification	1	2	3	4	5	6	7
1.Consonants (N=2141)	1403	412	169	94	35	24	4
2. Vowels (N=696)	385	177	63	24	43	0	4
3. Rhymes (N=232)	145	59	20	8	0	0	0
4. Consonant clusters (N=181)	98	52	13	12	6	0	0
5. Syllable (N=134)	51	39	32	9	0	0	3
6. Tones (N=758)	460	181	75	35	5	2	0
Total	2542	920	372	182	89	26	11

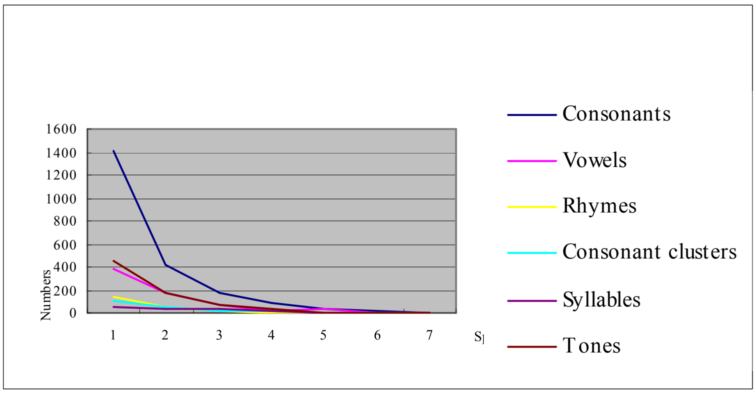

Figure 4-1: Frequency of error distribution as a function of syllable span between source and target

[1] The CV and feature errors are not related to this research question since the CV type of error is found to be non-contextual so there is no identical source in the utterance, and the feature errors are only counted as featural when there is a feature value adjacent to the target syllable, i.e., in a one-syllable span.

(13) I: zə̡n35-tɕja55 **p**u35 ʂɨ51 ʂwɔ55 jɑŋ35-y51-**p^h**jɛn51 →
people-home no is say foreign-potato-chip
E: zə̡n35-tɕja55 **p**u35 ʂɨ51 ʂwɔ55 jɑŋ35-y51-**p**jɛn51 (p^h→p)
'(that) person didn't say potato chips' → meaningless
人家不是說洋芋片

Example (13) shows a case in which the source consonant [p] is perseverated and replaces the target consonant [p^h] and the distance between the source and target units is measured in five syllables.

(14) I: t^h**a**55 l**i**35-k^{h}aj55 xɑw35 tɕjow21 lɤ → 他離開好久了
he leave-open very long PERF
E: t^h**i**55 l**i**35-k^{h}aj55 xɑw35 tɕjow21 lɤ (a→i)
'He has already left for a long time.' → meaningless

Example (14) shows a case in which the source vowel [i] is anticipated and replaces the target vowel [a] and the distance between the source and target units is measured in one syllable.

(15) I: p**u**35 jɑw51 kw**an**21 t^{h}a55 → 不要管她
NEG need care she
E: p**an**35 jɑw51 kw**an**21 t^{h}a55 (u→an)
'doesn't need to care about her' → meaningless

Example (15) shows a case in which the source rhyme [an] is anticipated and replaces the target vowel [u]. The distance between the source and target units is measured in two syllables.

(16) I: zə̡n35-**tɕj**a55 **t**ow55 k^{h}ɤ35-i21 → 人家都可以
people-home all can-as
E: zə̡n35-**tɕj**a55 **tɕj**ow55 k^{h}ɤ35-i21 (t→tɕj)
'other people can all…'→ meaningless

Example (16) shows a case in which the source consonant cluster [tɕj] is perseverated and replaces the target consonant [t]. The distance between the source and target units is measured in one syllable.

(17) I: **xwan**51-kɤ ti51-**fɑŋ**55 → 換個地方
change-CL ground-square
E: **xwan**51-kɤ ti51-**xwan**55 (fɑŋ → xwan)
'change to another place' → meaningless

Example (17) shows a case in which the source syllable [xwan] is perseverated and replaces the target syllable [fɑŋ]. The distance between the source and target units is measured in three syllables.

(18) I: ʂwaj**55**-tɑw**21** → 摔倒
fall down
E: ʂwaj**55**-tɑw**55** (21→ 55)
'fall down' → meaningless

Example (18) shows a case in which the source tone [55] is perseverated and replaces the target tone [21]. The distance between the source and target units is measured in one syllable.

In Table 4-4 and Figure 4-1, it is shown that significantly more errors occur in one-syllable spans than in other syllable spans ($\chi^2(6) = 8513.415$, $p < .01$). There is generally a monotonic decrease as the number of syllable spans increases. In addition, the planning span in rhyme error seems to be shorter than in the case for the other sub-group unit errors (i.e., four-syllable spans). In summary, the one-syllable-span errors are the majority in speech-error data in Mandarin.

4.5 Error Type

Regarding the error types, it is not surprising to find that phonological substitution errors far outnumber any other type of error, i.e., additions or omissions in English, Hindi, Japanese, Spanish, and Turkish (Wells-Jensen, 1999), an analysis that can also be confirmed in Nooteboom's (1973) Dutch slips corpus, Berg's (1987) German's slips selection, and Jaeger's (2004) English slips collection. The same pattern is found to some extent in the Mandarin speech-error corpus, as shown in Table 4-5; examples are given in (19-21).

Table 4-5: Types of Errors (N=5495)

Error type	N	%
Substitution	4563	83.04
Addition	514	9.35
Omission	418	7.61

(19) I: tɕ**y**51 tsaj51 i51-tɕʰ**i**21 → 聚在一起
gather in one-up
E: tɕ**y**51 tsaj51 i51-tɕʰ**y**21 (i→ y)
'gather together' → meaningless

In this example, the vowel [y] is perseverated and substituted for another vowel [i].

(20) I: pɑ**w**51-tʂ**a**51 an51 → 爆炸案
explode-explode case
E: pɑ**w**51-tʂ**w**a51 an51 (ϕ→ w)
'an explosive case' → meaningless

In this example, the postnuclear glide [w] is perseverated and added before the vowel [a] in the syllable [tʂa].

(21) I: jow21 x**wa**51 x**ɑw**21 ʂɑŋ55-ljɑŋ35 → 有話好商量
have words good discuss-measure
E: jow21 x**a**51 x**ɑw**21 ʂɑŋ55-ljɑŋ35 (w→ ϕ)
'discuss the issue positively' → meaningless

In this example, the prenuclear glide [w] is anticipated and deleted from the syllable [xwa].

The Chi-square test shows a great significant difference in substitution, addition, and omission errors in speech errors in Mandarin ($\chi^2(2)=6111.855$, $p < .01$). It can be seen that substitution errors far outnumber addition errors, which in turn outnumber omission errors. It is important to note that there is a slightly significant difference between additions and omissions ($\chi^2(1)=9.888$, $p =.002$).

4.6 Segments vs. Features

Segmental errors and errors which involve phonetic features rather than segments are both found in English (e.g., Fromkin, 1973; Stemberger, 1983). Although segmental-feature errors have been found in previous studies to be much less common than errors involving whole segments, they do occur in enough cases to warrant the conclusion that features exist as part of the internal structure of segments. Those phonological errors that provide convincing evidence for the existence of features are those in which a feature value is involved in a syntagmatic error. These errors do not involve the interaction of whole segments, and there is no clear or identical whole-segment source that can be found for the error in the context of an utterance. However, these errors are not classified as non-contextual errors since there is a source segment which has a feature value that changes to match the target segment. The value of one feature can be anticipated or perseverated, and substituted for a different value of the same feature in another segment. Table 4-6 presents the incidence of feature and segment errors in the present corpus. Examples are given in (22-23).

Table 4-6: Feature errors in consonants

	N	%
Feature	197	5.01
Segment	3735	94.99
Total	3932	100

(22) I: kwaŋ55 **tɕ**jaw51 **tʰ**a55-mən → 光叫他們
only call he-PLUR
E: kwaŋ55 **tɕʰ** jaw51 **tʰ**a55-mən (tɕ→ tɕʰ)
'only calling them…'→ meaningless

In this example, the [+aspirated] value on the VOT feature is anticipated and substituted for a [-aspirated] value of the same feature in the consonant [tɕ]; since there is no [tɕʰ] source in the utterance, this is considered a feature error.

(23) I: tsaj51 su51-**ʂ**ɤ51 **t<u>ʂ</u>**u51 → 在宿舍住
in lodge-shed live
E: tsaj51 su51-**ʂ**ɤ51 **ʂ**u51 (tʂ→ ʂ)
'(he) lived in the dorm' → meaningless

In this example, the whole-segment unit [ʂ] is perseverated and substituted for another whole-segment unit [tʂ]. Since there is an identical source in the utterance, this is classified as a segment error.

There are proportionately more whole-segment errors than feature errors ($\chi^2(1)=3183.480$, $p < .01$), and such a general pattern is replicated by the speech-error study found in the present Mandarin corpus. It is clear to find that feature errors involve smaller units than segment errors, and thus include most elementary unit of speech production. One interesting finding with regard to these feature errors is that features of consonants never interact with the features in vowels and vice versa. In general, this finding also supports the more recent views in phonological theory that suggests that segments have a hierarchical structure, as opposed to earlier views that segments are bundles of unordered features (McCarthy, 1982; Clements, 1985; Archangeli, 1988).

4.7 Similarity and Phonological Representations

It is well-known that consonants are more likely to mutually interact with each other in errors if they are phonetically similar in speech errors in English (e.g., Fromkin, 1973b; MacKay, 1973; Nooteboom, 1973; Van den Broecke & Goldstein, 1980; Levitt & Healy, 1985; Stemberger, 1989; Jaeger, 1992, 2004; Frisch, 1997). Therefore, defining whether one segment is phonetically similar to the other is done by looking at how many phonetic features they share. Van den Broecke and Goldstein (1980) compared a number of feature systems and proposed a new one which incorporates evidence from speech errors in English and German. Jaeger (1992, 2004) also adopted a similar feature system. Based on these cross-linguistic studies, a similar feature system for Mandarin has been developed, as shown in Table 4-7. The speech errors in the study involve all the contextual single-consonant substitution and exchange errors. Questions to be explored involve whether or not the target-source pairs display any phonetic similarity, and whether or not these segments have a hierarchical structure by looking at the hierarchy and rank order existing in consonantal features in Mandarin. Working on the phonetic similarity between the source and the target domain has been identified as a major motivating factor. Looking at consonantal features in target-source pairs in terms of phonetic similarity is the main focus in the study. Errors on vowels distinctions will not be addressed. There are two reasons for weighting the consonant similarity over the vowel similarity in the study: First, there is a little data in relation to the vowel errors in aphasic studies and it will be very difficult and also unjustified to make a comparison of the content of a large-scale corpus of speech-error data and a small scale of aphasic speech data. Second, most speech-error studies in relation to phonetic similarity are on consonantal substitutions and it is possible to make a comparison in the cross-linguistic studies.

Table 4-7: Speech error specifications for Mandarin consonants

	p	p^h	t	t^h	K	k^h	ts	ts^h	tʂ	$tʂ^h$	tɕ	$tɕ^h$	f
P	L	L	D	D	V	V	D	D	R	R	P	P	L
N	-	-	-	-	-	-	-	-	-	-	-	-	-
V	O	A	O	A	O	A	O	A	O	A	O	A	O
C	-	-	-	-	-	-	-	-	-	-	-	-	+
F	-	-	-	-	-	-	+	+	+	+	+	+	+

Table 4-7: Speech error specifications for Mandarin consonants (cont'd)

	ɕ	x	s	ʂ	ʐ	m	n	ŋ	l	ɥ	j	w
P	P	V	D	R	R	L	D	V	D	L-P	P	L-V
N	-	-	-	-	-	+	+	+	-	-	-	-
V	O	O	O	O	V	V	V	V	V	V	V	V
C	+	+	+	+	+	+	+	+	+	+	+	+
F	+	+	+	+	+	-	-	-	-	-	-	-

In Table 4-7, there are five parameters for Mandarin in the feature system. They are *place of articulation, nasality, voice onset time, continuancy,* and *frication*.

1. *Place of articulation*: this non-binary feature is divided into seven places: labial (L), dental (D), retroflex (R), labio-palatal (L-P), palatal (P), labio-velar (L-V), and velar (V).
2. *Nasality*: the three nasals, labial, dental, and velar have a positive value in regard to this feature.
3. *Voice onset time*: the dimension is divided into voiceless aspirated (A), voiceless unaspirated (O), and voiced (V); in addition, there is a two-way contrast in Mandarin stops and affricates for aspiration, but voicing contrast for fricatives and sonorants is [+voice] non-contrastive.
4. *Continuancy*: all sonorants and fricatives are labeled [+continuant]. Affricates are distinguished from fricatives by being [-continuant]; stops are [-continuant].
5. *Frication*: all fricatives and affricates are labeled as [+frication], and all others are [-frication].

Most relevant studies have described the five parameters as being classified into three dimensions: [place], [manner], and [VOT], since consonants can be classified in terms of place-manner-voice articulation. Therefore, the parameters involving *nasality*, c*ontinuancy*, and *frication* will be sub-categorized into the [manner] dimension[2]. The following table presents the contextual single consonant substitution and exchange errors by the type of feature involved, and some examples are provided in (24-26).

[2] Due to insufficient contextual single-consonant substitution and exchange error data in aphasic speech in the study, place-manner-voice articulation is mainly addressed.

Table 4-8: Phonological errors by the type of feature involved

Number of features	Feature(s)	N	Totals	%
1	Place	1007	1463	72
1	Manner	318		
1	VOT	138		
2	Place & VOT	31	467	22.98
2	Place & Manner	310		
2	Manner & VOT	126		
3	Place, Manner & VOT	102	102	5.02
Total		2032	2032	100

(24) I: **k**ɑŋ55- ts^{h}aj35- tɤ **t**ɑw55→ 剛才的刀
just-just-LINK knife
E: **k**ɑŋ55- ts^{h}aj35- tɤ **k**ɑw55 (t→k)
'the knife that was just here' → meaningless

In this example, the source consonant [k] is perseverated and substituted for the target consonant [t] and these two consonants are different by a one-feature violation: place of articulation.

(25) I: jow21 ʂɤ35-mɔ **p**an51-**f**a21 → 有什麼辦法
have what-particle handle-way
E: jow21 ʂɤ35-mɔ **p**an51-**p**a21 (f→p)
'What can (I) do?' → meaningless

In this example, the source consonant [p] is perseverated and replaces the target consonant [f] and these two consonants are different by a one-feature violation: manner of articulation.

(26) I: wɔ35 ɕjɑŋ21 ɕjɑŋ51 ni35 **tɕ^h**iŋ21-**tɕ**jɑw51 → 我想向你請教
I want to you ask-teach
E: wɔ35 ɕjɑŋ21 ɕjɑŋ51 ni35 **tɕ**iŋ21-**tɕ**jɑw51 (tɕ^h→tɕ)
'I would like to ask you' → meaningless

In this example, the source consonant [tɕ] is anticipated and replaces the target consonant [tɕ^{h}] and these two consonants are different by a one-feature violation: VOT.

(27) I: na51 pej55 **tʂ^{h}**a35 **t^{h}**ɑŋ51 → 那杯茶燙
that CL tea hot
E: na51 pej55 **t^{h}**a35 **t^{h}**ɑŋ51 (tʂ^{h}→t^{h})
'that tea is hot' → meaningless

In this example, the source consonant [t^{h}] is substituted for the target consonant [tʂ^{h}] and these two consonants are different by a two-feature violation: place of articulation and manner of articulation.

(28) I: noŋ51-tɑw51 ly51-**k^{h}**a21-tɤ-**x**wa51 → 弄到綠卡的話
get-COMP green-card-LINK-word
E: noŋ51-tɑw51 ly51-**x**a21-tɤ-**x**wa51 (k^{h}→x)
'If (you) get the green card' → meaningless

In this example, the source consonant [x] is anticipated and replaces the target consonant [k^{h}] and these two consonants are different by a two-feature violation: manner of articulation and VOT.

(29) I: **p**u51 ɕi21-xwan55 **t^{h}**aj35-**p**ej21 → 不喜歡台北
NEG hapyy-like Tai-north
E: **p**u51 ɕi21-xwan55 **p**aj35-**p**ej21 (t^{h}→p)
'(I) don't like Taipei' → meaningless

In this example, the source consonant [p] is either anticipated or perseverated and replaces the target consonant [t^{h}] and these two consonants are different by a two-feature violation: place of articulation and VOT.

(30) I: **t^{h}**a55 kan51-ma35 **ʂ**əŋ55-tɕ^{h}i51 → 他幹嘛生氣
he do-particle grow-air
E: ʂa55 kan51-ma35 ʂəŋ55-tɕ^{h}i51 (t^{h}→ʂ)
'Why is he upset?' → meaningless

In this example, the source consonant [ʂ] is anticipated and replaces the target consonant [t^{h}] and these two consonants are different by a three-feature violation: place of articulation, manner of articulation, and VOT.

The result of the similarity analysis shows that in whole segments involving contextual single-consonant substitution and exchange errors, these segmental errors (i.e., target and source segments) display a strong phonetic similarity in Mandarin. It is quite evident from the table that the consonant substitutions and exchanges are subject to the similarity constraint. Especially, the target and source segments that mutually interact with each other in errors share a one-feature violation (N=1463, 72%) so single-feature changes make up the large majority while three-feature changes are exceedingly rare. The number of one-feature-difference errors far outnumbers that of two-feature-difference errors, which in turn greatly outnumbers the number of three-feature-difference errors. There is a statistically higher rate of one-feature error over the other two types ($\chi^2(2)=1465.336$, $p<.01$). In addition, it is found that the feature that is violated the most often is place of articulation, and the feature [VOT] is the feature violated least often in Mandarin: The feature [place] is the feature which differs in the largest number of pairs (N=1007, 68.83%), with the features [manner], continuancy, frication, and nasality, being violated less often (N=318, 21.74%); the feature [VOT] is violated the least often (N=138, 9.43%). This property confirms to all the languages for which data are available (Van den Broecke & Goldstein, 1980; Jaeger, 1992, 2004). In two-feature-difference errors, the combination of [place] and [manner] far outnumbers the rest of the two combination types. In conclusion, this very high percentage lends credence to the hypothesis that these phonological elements interacting with one another in speech errors in Mandarin tend to be phonetically quite similar, and that the target and source segments tend to differ by a single feature: place of articulation.

4.8 The Parallel Syllable Constraint

The following examines whether there is a tendency for consonants in parallel parts of the syllable to interact. It has long been noted in speech-error literature that segments interacting in speech errors with one another usually occupy similar positions in their respective syllables, that is, syllable-initial consonants interact with syllable-initial consonants, syllable-final consonants interact with syllable-final consonants, and syllabic segments with syllabic segments (e.g., Fromkin, 1973a; Shattuck-Hufnagel, 1979, 1982; Cutler, 1980; Stemberger, 1989). Table 4-9 presents consonant substitution errors in terms of syllable position, and examples are provided in (31-33).

Table 4-9: Phonological consonant substitution errors by syllable position, given as a percentage

Syllable position	N	%
Initial-Initial	1375	67.67
Final-Final	641	31.55
Initial-Final	16	0.78
Total	2032	100

(31) I: **k**ɑŋ55-xɑw21 **t**ɑŋ55 → 剛好當
just-good be
E: **k**ɑŋ55-xɑw21 **k**ɑŋ55 (t→k)
'(it) happened to be ' → meaningless

In this example, the syllable-onset consonant [k] is perseverated and substituted for another syllable-onset consonant [t].

(32) I: kwa**n**55 mən35 tɑ**ŋ**55-ɕin55 tjɛn21 → 關門當心點
close door appropriate-heart little
E: kwɑ**ŋ**55 mən35 tɑ**ŋ**55-ɕin55 tjɛn21 (n→ŋ)
'shut the door quietly' → meaningless

In this example, the syllable-final consonant [ŋ] is anticipated and substituted for another syllable-final consonant [n].

(33) I: tsaj51 k**w**ej51 ɕi51 tʂo**ŋ**21 → 在貴系中
in you dept. center
E: tsaj51 k**w**ej51 ɕi51 tʂo**w**55 (ŋ→w)
'in your department' → meaningless

In this example, the syllable-onset consonant [w] is perseverated and substituted for a syllable-final consonant [ŋ].

It is apparent from Table 4-9 that the majority of cases involve a condition where consonants tend to interact with other consonants from homologous syllable positions (same syllable position: N=2016 vs. different syllable position: N=16). Note that this parallel syllable structure constraint is a statistical tendency since violations do occur at a low frequency in initial-final position ($\chi^2(2)=1366.271$, $p<.01$). Most cases (99.22%) involve a condition where syllable-onset consonants interact with other syllable-onset consonants and coda consonants interact with the coda consonants, suggesting that the similarity involving position in the syllable is particularly important. In summary, the error corpus shows that the target and source segments tend to be sensitive to parallel positions in their respective syllables.

4.9 Initialness

Speech errors show the reality of syllable structure in two ways. First, syllable position appears to determine how likely it is that target and source segments will interact. This issue has just been discussed in 4.8. Second, syllable structure appears to determine how likely it is that target and source segments will be separated in speech errors. This issue will now be examined. Data from the Table 4-9 show that 1375 (67.67%) errors involve target and source consonants occurring in syllable-initial position whereas 641 (31.55%) errors involve target and source consonants occurring in syllable-final position. The differential sensitivity of syllable-initial errors and syllable-final errors is highly significant ($\chi^2(1)=267.240$, $p<.01$). This property confirms Stemberger's (1983) finding that 80% of initial consonants are more likely to slip than non-initial ones in English (given the fact that Mandarin has a higher rate of initialness constraint), suggesting that the initialness effect plays an important role in the model of phonological encoding in Mandarin.

4.10 Directionality

Contextual errors may be subdivided according to whether or not the error unit precedes or follows the source element. The former type is referred to as anticipation, and the latter as perseveration. It has long been reported in the speech-error literature in Germanic languages including English, Dutch, and German that speakers make more anticipation than perseveration phonological errors, and exchanges are less common than either (e.g., Fromkin, 1973; Nooteboom, 1973, 1980; Stemberger, 1989; Wells-Jensen, 1999). Table 4-10 shows the percentages of phonological errors of various directionalities. This table distinguishes anticipations where the error and source are both spoken before a correction, perseverations where the source comes before the error, anticipation/perseveration where there are potential sources both before and after the error, and exchanges which include both contiguous metatheses and non-contiguous reversals[3]. Figures include substitutions, additions, omissions and movement units including consonants, vowels, consonant clusters, rhymes, syllables, and tones. Other phonological units such as features, multiple errors, and telescopings are not included in this count. Examples are given in (34-37).

Table 4-10: Directionality of errors

Speech errors	N	%
Anticipation	1698	39.1
Perseveration	2197	50.58
Anticipation/ Perseveration	313	7.21
Exchange	135	3.11
Total	4343	100

(34) I: wɔ21 **w**aj51-**p^h**wɔ35 → 我外婆
I outer-old woman
E: wɔ21 **p^h**aj51-**p^h**wɔ35 (w→p^h)
'my grandma' → meaningless

In this example, the source consonant [p^h] is anticipated and replaces the target consonant [w].

[3] This study does not focus on incomplete errors. There is a debate as to whether incomplete errors should be treated as anticipations or exchanges. Some researchers have thus argued that incomplete errors should be considered a separate class since it is possible that they represent interrupted exchanges.

(35) I: xən21 pu51 **ɕ**jɑŋ21 **n**jɛn51-ʂu55 → 很不想唸書
very no want read-book
E: xən21 pu51 **ɕ**jɑŋ21 **ɕ**jɛn51-ʂu55 (n→ɕ)
'(I) really don't want to study' → meaningless

In this example, the source consonant [ɕ] is perseverated and replaces the target consonant [n].

(36) I: mu51-tɕ^{h}jɛ**n**35 tɕiŋ21-tɕjɛ51-tɤ fa**n**51-wej35→
eye-front warn-warn-LINK model-range
E: mu51-tɕ^{h}jɛ**n**35 tɕiŋ21-tɕjɛ**n**51-tɤ fa**n**51-wej35 (ϕ→n)
'the area which is being guarded at present' → meaningless
目前警戒的範圍

In this addition error, the error consonant [n] occurs between two potential sources. It can come from either the syllable [tɕ^{h}jɛn] or the syllable [fan].

(37) I: wɔ35 ɕi21-xwan55 t^{h}a55 lɑw**21**-ʂɨ**35** → 我喜歡他老實
I happy-like he old-honest
E: wɔ35 ɕi21-xwan55 t^{h}a55 lɑw**35**-ʂɨ**21** (21↔35)
'I like his honesty' → meaningless
In this example, the two tone units, [21] and [35] have exchanged their positions.

It can be gleaned from Table 4-10 that perseverations outnumber anticipations, which in turn far outnumber anticipations/perseverations, and exchanges are the least common. A Chi-square test shows a significant difference in the number of four sub-groups ($\chi^2(3) = 2865.111$, $p < .01$). There are 50.58% of errors involving perseverations and 39.1% of errors involving anticipations. The differential sensitivity of perseveratory errors and anticipatory errors is highly significant ($\chi^2(1)=63.928$, $p<.01$). Most of the cross-linguistic data in speech-error literature has found a proclivity for anticipations, especially in English and Germanic languages. However, some other findings propose the opposite result, in which perseverations and anticipations occur with approximately equal frequency (e.g., Abd-El-Jawad & Abu-Salim, 1987 for Arabic; Min, 1998 for Korean; Well-Jensen, 1999 for Spanish, Hindi, and Japanese; Muansuwan, 2000 for Thai). In this study, it is found that perseverations are in the majority in Mandarin speech errors. The discussions and comparisons to other cross-linguistic findings will be provided in Chapter VI.

4.11 Syllable Size of Target-Source Units

The final question that is addressed in this section is the size of source-target units, and the size is customarily measured in syllable types. There is wide agreement that the most frequent type of errors is single-segment errors in speech-error studies, and such a single-segment substitution can come from various syllable types. The target and source segments may share the same syllable type or may have different syllable types. In addition, errors involving larger-unit elements are also possible, and the interaction involving larger units may also share the same syllable type or may have different syllable lengths. Table 4-11 presents the syllable-type relationship between target and source in naturally-occurring speech-error data in Mandarin; the target and source units involve single-segment interaction and larger-unit interaction errors. Four examples are provided for illustration in (38-41).

Table 4-11: Syllable type of target-source units N=5491
(Same syllable type: 3590 vs. Different syllable type: 1901)

Source \ Target	V	CV	GV	VG	VN	CVG	CVN	CGV	GVG	GVN	CGVG	CGVN
V	65	28	7	9					3	5		
CV	19	1141				85	67	76			7	15
GV		13	32						2			
VG			5		3	27						
VN	6			4	29		11			4		
CVG		139				398	50	43	8		95	13
CVN		85			7	76	900	12		5	3	195
CGV		98	6			43		166			4	15
GVG			3			10			35		5	
GVN	6		4		18		11		15	147		11
CGVG		6				121		46	19	4	213	15
CGVN	4	22				8	201	41	4	19	15	464

(38) I: l**y**21-l**i**51 → 履歷
agreement-experience
E: l**i**21-l**y**51 (i <-> y)
'resume' → meaningless

In this example, the vowels [i] and [y] exchange their positions, and they come from the same type of syllable: CV.

(39) I: mɑ**ŋ**35-wa**n**35 → 忙完
busy-finish
E: ma**n**35-wa**n**35 (ŋ→n)
'(one) is done (something)' → meaningless

In this example, the nasal [n] is anticipated and replaces another nasal [ŋ]. Note that the two nasals come from the same type of syllable: CVN.

(40) I: pu35-ɥo**ŋ**51 kwa**n**55 → 不用關
no-need close
E: pu35-ɥo**ŋ**51 kwɑ**ŋ**55 (n→ŋ)
'no need to close' → meaningless

In this example, the nasal is perseverated and replaces another nasal [n], and the adjacent vowel [a] changes to its correct allophone [ɑ]. Note the target [n] comes from a CGVN-type of syllable and the source comes from a GVN-type of syllable.

(41) I: **k**an21-**k**^{h}waj51 → 趕快
hurry-quick
E: **k**^{h}an21-**k**^{h}waj51 (k→k^{h})
'hurry up' → meaningless

In this example, the consonant [k^{h}] is anticipated and substituted for another consonant [k]. Note that the target [k] comes from a CGVG-type of syllable and the source comes from a CVN-type of syllable.

Table 4-11 depicts target-source pairing in same syllable types with those in different ones. It shows that the proportion of the target and source involving same syllable types is significantly greater than the number of target and source involving different syllable types. Calculation of χ^2 yields a highly significant difference in the same- vs. different-syllable types ($\chi^2(1)$= 519.527, p<.01).

It is apparent from Table 4-11 that the majority of speech errors in Mandarin occur when the target and source units share the same syllable length. The error distribution in the same syllable-type groups is significantly different from the different syllable-type groups. In the same-type of syllable groups, the most common pattern is CV (N=1141, 31.8%), followed by, in order, CVN (N=900, 25.1%), CGVN (N=464, 12.9%), CVG (N=398, 11.1%), CGVG (N=213, 5.9%), CGV (N=166, 4.6%), GVN (N=147, 4.1%), V (N=65, 1.8%), GVG (N=35, 1%), GV (N=32, 0.9%), and VN (N=29, 0.8%). It is interesting to note that so far there is no evidence in support of a GV type. In the different-type of syllable groups, CGVN-CVN and CVN-CGVN are by far the most common, and this finding is very consistant in that CGVN or CVN can be the syllable that either the target or source element is pertinent to.

Although the number is too low to permit a statistical evaluation, a comparison in terms of percentages shows the difference in the different-type of syllable groups. In summary, the data from speech errors present a picture in which the target and source pairs are more likely to interact with one another when they are pertinent to the same type of syllables.

In conclusion, evidence from speech errors supports the following findings:

(1) Mandarin speakers tend to produce more phonological errors than lexical errors. In speech-error data involving phonological units, single consonant errors are in the majority.

(2) Contextual errors far outnumber non-contextual errors in speech errors in Mandarin, suggesting that source segments influencing target segments usually occur within the utterance context.

(3) Contextual errors can be measured in a syllable between source and error elements, and the distance between them does not generally exceed seven syllables.

(4) The largest proportions of speech errors involve substitutions in Mandarin. Evidence from the error corpus shows that there is a general hierarchy of error type in which substitution errors occur more frequently than addition errors, which in turn outnumber omission errors.

(5) Segments are the most fundamental phonological units in Mandarin speech errors since errors involving the whole segments by far are more common than feature errors in the present study.

(6) In whole segments involving contextual single-consonant substitution and exchange errors in Mandarin, the target and source elements display a phonetic similarity; most of them are differed by one-feature violations. This finding suggests that consonants are more likely to mutually interact with each other in errors if they are phonetically similar in Mandarin speech errors. An overall hierarchy of feature involvement in speech errors and the feature that is violated the most often in Mandarin is place of articulation and the feature VOT is the feature violated the least often.

(7) The error distribution in Mandarin speech errors honors syllable structure. The target and source segments share the same syllable structure position: an initial consonant is more likely to interact with another intial consonant, and a coda consonant is more likely to interact with another coda consonant.

(8) The majority of speech errors involve target and source units in syllable-initial positions since there is a strong tendency whereby initial consonants are more likely to slip than noninitial ones.
(9) Contextual errors can be further subdivided into anticipation and perseveration. There is a tendency towards more phonological perseverations than anticipations and exchanges in the study presented here.
(10) The majority of speech errors involve target and source segments coming from the same type of syllables, suggesting that one element is more likely to interact with one another when the target-source pairs share the same phonological environment.

CHAPTER V
RESULTS FROM APHASIC SPEECH

5.1 Overview

In this chapter, a corpus of aphasic errors made by left-brain-damaged patients in Mandarin will be examined. I will look at a number of important issues regarding the psychology of speech production and the nature of phonological representations as well as the mechanisms underlying phonological encoding in aphasic speech. The distribution of error types in aphasic speech in Mandarin will be examined first. There will then be an examination of general phonological characteristics of aphasic speech and an examination of error types which reflect a hierarchical order of difficulty in the output of aphasic speech. After discussing the general statistical properties of these errors, I will then examine the degree to which errors are well-formed linguistically. Finally, I will discuss the role of similarity in conditioning errors and the directionality of ordering errors. I will further compare the results with a similar but much larger corpus of speech errors made by normal speakers. Some basic assumptions underlying current models of speech production will be presented in Chapter VI.

In the present study, a corpus of 3000 aphasic errors drawn from native speakers of Mandarin spoken in Taiwan is provided to examine the following questions.

(1) Do aphasic patients produce an equal proportion of phonological errors and lexical errors or do they tend to produce errors of one kind more commonly than the other in Mandarin? Furthermore, in phonological units occurring in errors, which phonological elements have a wider error distribution? The rationale for this question is that phonological errors are more common than lexical errors and morphological errors, and the syntactic errors are the least common in normal speech errors (e.g., Nooteboom, 1973;

Stemberger, 1989; Wells-Jensen, 1999). Do aphasic patients share the same error properties?

(2) Do aphasic errors in the present study involve more contextual errors or non-contextual errors in Mandarin? The rationale for this question is that studies on normal speech errors have shown that source segments influencing target segments usually occur within the context of utterance (e.g., Nooteboom, 1973; Garnham et al., 1982). However, evidence from Blumstein (1973) in her aphasic corpus revealed that the preponderance of phonological errors in aphasic speech is non-contextual in English. Do aphasic errors share the error patterns with normal speech-error corpus or with the aphasic error pattern in English?

(3) What is the distance in a syllable between a source and error unit in Mandarin? The rationale for this question is that we can measure contextual errors between the source and error segments. There is usually a potential source of the error in a contextual window. A sizable proportion of the contextual errors are usually measured in a syllable. It is also found that the target and source unit usually occur in the same neighborhood; the distance between them generally does not exceed seven syllables (Nooteboom, 1973). Therefore, do aphasic errors show target-source pairs in close proximity?

(4) Do the largest proportions of errors involve substitutions in aphasic speech in Mandarin? What is the proportion of errors involving omission and addition. The rationale for this question is that studies from naturally-occurring speech errors show a general hierarchy of error type in which substitution errors occur more frequently than addition errors, which in turn outnumber deletion errors (Berg, 1987; Nooteboom, 1973; Wells-Jensen, 1999). However, studies from aphasic speech show some discrepancies. Hotpof (1980) and Berg (2006) found that omission errors constitute the absolute majority of errors produced by English-speaking aphasics. Data from other languages for which aphasic data are available confirm this pattern (e.g., Ardila et al., 1989 for Spanish; Beland et al., 1990 for French; Moen, 1993 for Norwegian; Romani & Calabrese, 1998 for Italian; Allerbeck, 2000 for German). Do aphasic errors show the same pattern?

(5) How will the aphasic data provide evidence that bears on the question as to whether segments or features are the most

fundamental phonological units in language processing in Mandarin? The rationale for this question is that most researchers in speech-error literature have found in English, that errors involving the whole segments are more common than feature errors (Fromkin, 1973a/b; Stemberger, 1983; Shattuck-Hufnagel, 1986).

(6) In whole segments involving contextual single-consonant substitution and exchange errors in Mandarin, do these segmental errors (i.e., target and source segments) display any phonetic similarity? Especially, how many feature differences are there between target and source segments? Is there any hierarchy and rank order of feature distribution in Mandarin? That is, which type of feature is violated the most often in Mandarin speech errors? The rationale for this question is that it is well-known in English, consonants are more likely to mutually interact with each other in errors if they are phonetically similar (e.g., Fromkin, 1973b; Frisch, 1997; Jaeger, 1992; Jaeger, 2004; Levitt & Healy, 1985; MacKay, 1973; Nooteboom, 1973; Stemberger, 1989; Van den Broecke & Goldstein, 1980). Also, a number of researchers have found an overall hierarchy of feature involvement in speech errors and the feature that is violated the most often is place of articulation and the feature nasality is the feature violated least often (Jaeger, 1992, 2004; Van den Broecke & Goldstein, 1980).

(7) Does aphasic speech honor syllable structure in Mandarin? That is, do the target and source segments share the same syllable structure position? The rationale for this question is that MacKay (1970) and Shattuck-Hafnagel and Klatt (1979) found almost no exceptions in their analysis of naturally-occurring speech errors in which an initial consonant interacts with another initial consonant, and a coda consonant interacts with another coda consonant. Data from Stemberger (1985) and Berg (1997) confirm this property. However, so far a few studies have reported aphasic results in terms of the parallel syllable constraint. The reported studies all found that aphasic speech is less sensitive to respecting syllable-structure position (e.g., Goldmann et al., 2001 for English; Kohn, 1989 for English; Dressler et al., 1986 for Italian; Allerbeck, 2000 for German; Knels, 2001 for German).

(8) Do the majority of aphasic errors involve target and source units occurring in syllable-initial positions or in syllable-final positions in Mandarin? The rationale for this question is that there is a strong

tendency, close to 80%, in which initial consonants are more likely to slip than noninitial ones (MacKay, 1972; Shattuck-Hufnaagel, 1986).

(9) What is the directionality of the errors occurring in aphasic speech in Mandarin? The rationale for this question is that there is a tendency toward more anticipations than perseverations and exchanges in English and other Germanic speech errors (Nooteboom, 1973; Stemberger, 1989; Dell, Burger, & Svec, 1997; Wells-Jensen 1999); however, Gandour (1977) and Wan (in press) found the opposite occurring in Thai and Mandarin tone errors, respectively, with more perseverations than anticipations and exchanges. In addition, errors from aphasiological data and acquisition data in English and other Germanic languages also show the opposite tendency (e.g., Allison & Hurwitz, 1967; Hudson, 1968; Buckingham, 1985; Kohn, 1989; Schwartz et al., 1994; Allerbeck, 2000; Knels, 2001).

(10) What is the size of source-target units in aphasic speech in Mandarin? In syntagmatic single substitution errors, do the target and source segments share the same type of syllables? What type of syllable is the most frequent? In syntagmatic errors involving larger units within syllables, is there any tendency toward a particular structure type? The rationale for this question is that although there are strong phonotactic constraints in Mandarin syllables and most speech errors involve single segments, there are occasional slips in which larger units may be affected, in particular consonant clusters such as CG, or rhyme structure such as VG or VN, acting in unison (Wan, to appear).

Each of the following subsections is devoted to the analysis of one empirical effect. The mean percentage of each error type is presented, and the frequency of error distribution is ranked for each sub-group, and the probability of occurrence for this distribution is computed.

5.2. Errors Involving Phonological Units

Regarding the major classification of error distribution produced by the aphasic subjects, in significantly more cases than is to be expected in a random distribution, the error data in Mandarin show some general patterns, as illustrated in Table 5-1 and Table 5-2. The phonological errors characteristic of aphasic speech include errors involving single consonant, single vowel, larger units involving consonant clusters, rhymes, and consonant-vowel units, syllables, features, and tones. Examples are given in (1-10).

Table 5-1: Aphasic errors

Aphasic errors	N
Phonological	3000
Lexical	429

(1) I: **tʂ**əŋ51-**t**a51 → 政大
politics-big
E: **t**əŋ51-**t**a51 (tʂ → t)
'National Chengchi University' → meaningless

Example (1) is classified as a phonological error since the phonological unit, a consonant [t], is anticipated and substitutes for another phonological unit, consonant [tʂ].

(2) I: $tʂ^h$wan35 → 船
boat
E: $tɕ^h$jɑw35 橋
bridge
'boat' → 'bridge'

Example (2) is categorized as a lexical access error in that the single lexical item [$tʂ^h$wan35] 'boat' is replaced with another single lexical item [$tɕ^h$jɑw35] 'bridge'.

Table 5-2: Phonological units occurring in errors

Phonological units	N	%
Consonants	1601	53.4
Vowels	81	2.7
Consonant clusters	67	2.2
Rhymes	185	6.1
Consonant-vowel sequences	5	0.2
Syllables	170	5.7
Features	331	11
Tones	560	18.7
Total	3000	100

(3) I: pɑŋ55-wa**n**21 → 傍晚
near-evening
E: pɑŋ55-wɑ**ŋ**21 (n → ŋ)
'dusk' → meaningless

Example (3) is of a phonological error involving consonant substitution in which the final consonant [ŋ] is perseverated and replaces another final consonant [n].

(4) I: tswɔ35-ʂ**o**w21→ 左手
left-hand
E: tswɔ35-ʂ**ɑ**w21 (o→ɑ)
'left hand'→ meaningless

Example (4) is of a phonological error involving vowel substitution in which the vowel [ɑ] replaces another vowel [o].

(5) I: ti51-**tɕʰj**ow35→ 地球
ground-ball
E: ti51-**tsʰ**ow35 (tɕʰj→tsʰ)
'globe'→ meaningless

Example (5) is of a phonological error involving consonant-cluster substitution in which the single consonant [tsʰ] replaces the consonant cluster [tɕʰj].

(6) I: xɑw21-p^h**oŋ**35-jow21→ 好朋友
good-friend-friend
E:xɑw21-p^h**ən**35-jow21 (oŋ→ən)
'good friend'→ meaningless

Example (6) is of a phonological error involving rhyme substitution in which the rhyme [ən] replaces another rhyme [oŋ].

(7) I: **ke**j21 **t^{h}a**55→ 給他
give him
E: **t^{h}a**j21 **t^{h}a**55 (ke→t^{h}a)
'for him'→ meaningless

Example (7) is of a phonological error involving consonant-vowel substitution in which the consonant-vowel sequence [t^{h}a] is anticipated and replaces another consonant-vowel sequence [ke].

(8) I: **tʂoŋ**55-wən35→ 中文
center-language
E: **pa**55-wən35 (tʂoŋ→pa)
'Chinese' → meaningless

Example (8) is of a phonological error involving syllable substitution in which the syllable [pa] replaces another syllable [tʂoŋ] without affecting the tone.

(9) I: **ts**aj51 **tɕ^h**jɛn51 → 再欠
again owe
E: **ts^h**aj51 **tɕ^h**jɛn51 (ts→ ts^h)
'(he) owed (somebody) another'→ meaningless

In (9), the onset [ts] becomes [ts^h] in anticipation of the aspiration of the following [tɕ^h] onset, and there is no [ts^h] source in the utterance.

(10) I: tɕjɛ**35**-tʂɑŋ**51**→ 結帳
end-bill
E: tɕjɛ**51**-tʂɑŋ**51** (35→51)
'to pay the bill' → meaningless

Example (10) is of a phonological error involving tone substitution in which the tone unit [51] is anticipated and replaces another tone unit [35].

In phonological units occurring in errors, most of the errors involve consonants (N=1601, 53.4%) followed by, in order, tones (N=560, 18.7%), features (N=331, 11%), rhymes (N=185, 6.1%), syllables (N=170, 5.7%), vowels (N=81, 2.7%), consonant clusters (N=67, 2.2%), and consonant-vowel sequences (N=5, 0.2%). The differential sensitivity of the sub-group error distribution is highly significant ($\chi^2(6)=2639.124$, $p<.01$). The data show that in aphasic speech, consonant errors constitute the largest proportion and the numbers of tone and feature errors are also greater. Although most errors involve single segments, it is also possible to find a number of errors involving combinations of consonants and vowels in the corpus. In error combinations of consonants and vowels, vowel-consonant (rhyme) errors far outnumber consonant-cluster errors, which in turn outnumber consonant-vowel errors (CV). Therefore, complex (combinations of consonants and vowels) errors are also likely to happen in aphasic speech. This will be further discussed in Chapter VI. In summary, estimates of the percentage of phonological errors that involve single consonants run to 53.4%.

5.3 Contextuality

The fundamental distinction between contextual and non-contextual errors will be the next focus of interest. Regarding the question of contextual influences, in speech-error data it is likely that the source and error occur within a fairly narrow window, most often restricted within the clause boundary. In the aphasic speech corpus, I will use for the same criterion to measure the contextual influences of source-target relationship. Table 5-3 presents the incidence of contextual and non-contextual errors in aphasic speech corpus. Examples are given in (11-12).

Table 5-3: Contextual influences

Aphasic errors	N	%
Contextual	536	17.9
Non-contextual	2464	82.1

(11) I: **m**jɛn51-pɑw55-**tʰ**an55→ 麵包攤
noodle-bag-stand
E: **tʰ**jɛn51-pɑw55-**tʰ**an 55 (m→tʰ)
'bakery stand'→ meaningless

The most likely interpretation of (11) is that the replacement of consonant [m] with [tʰ] is facilitated by the presence of the consonant [tʰ] in [tʰan] syllable. That is to say, the consonant [tʰ] from [tʰan] syllable is assumed to be dislocated and to oust the target segment [m]. Thus, the malfunction thus is contextually motivated.

(12) I: **tsʰ**a55-ljɛn21→ 擦臉
wipe-face
E: ʂa55-ljɛn21 (tsʰ→ʂ)
'to wipe one's face'→ meaningless

In (12) the intrusion of [ʂ] on [tsʰ] happens for no apparent reason. Since there is no identical source unit in the vicinity of the error, this error is classified as non-contextual.

If we use the same criterion in measuring the contextual influences, and the source-error pairings have to be limited within a fairly narrow window, it can be clearly seen that merely 536 (17.9%) cases involve a potential source in the context of the utterance and non-contextual errors make up a large proportion of the total number of errors in the corpus (N=2464, 82.1%). This difference is greatly significant ($\chi^2(1) = 703.409$, $p < .01$). This property has been found in many languages for which aphasic data are available. For example, Wilshire (2002) found a proportion of 17.3% contextual errors in Wernicke's and Conduction aphasics. The similar pattern is replicated by data found in Mandarin aphasic speech as well. Thus, the consensus suggests that contextuality plays less of a role in aphasic speech.

5.4 The Distance between Source and Error Units

Regarding the question of the distance between the source and error units, corpus analysis from aphasiological literature does not distinguish the distance in terms of syllable spans. The general binary division of the distance between source and error units falls into within-word and between-word categories in speech-error literature in Germanic languages, and the aphasiological studies do not regularly draw a clear dividing line between within-word and between-word paraphasias. However, in Mandarin, an element interacting with another element within a word is equivalent to the element interacting with the other element within a syllable. There are only 7 cases of within-word errors, all of which are vowel-glide metathesis errors, as shown in (13). There are very restricted phonotactic constraints in Mandarin. Differences in the ratio of error distribution would then be due to the centrality of vowel phonemes in the syllable and the different possibilities of occurrence of consonant phonemes in the syllable-initial position, but a few possibilities of occurrence of consonant phonemes, [n, ŋ, j, w], in the syllable-final position. Therefore, it is rather interesting to look at the frequency of error distribution as a function of syllable span between source and error units in between-word paraphasias. Examples are provided in (14-19). Table 5-4 presents the frequency distribution of each sub-group of aphasic errors in Mandarin in the present study in terms of the number of syllables between a source and error.

Table 5-4: Frequency distribution of errors as a function of syllable span between source and error[1]

Classification (N=536)	1	2	3	4	5	6	7
1. Consonants (N=270)	217	35	7	5	6	0	0
2. Vowels (N=19)	19	0	0	0	0	0	0
3. Rhymes (N=40)	38	2	0	0	0	0	0
4. Consonant clusters (N=12)	6	4	0	0	2	0	0
5. Syllables (N=47)	34	11	2	0	0	0	0
6. Tones (N=148)	123	21	4	0	0	0	0
7. Total	437	73	13	5	8	0	0

[1] The CV and feature errors are not related to this research question since the CV type of error is found to be non-contextual so there is no identical source in the utterance, and the feature errors are only counted as featural when there is a feature value adjacent to the target syllable, i.e., in a one-syllable span.

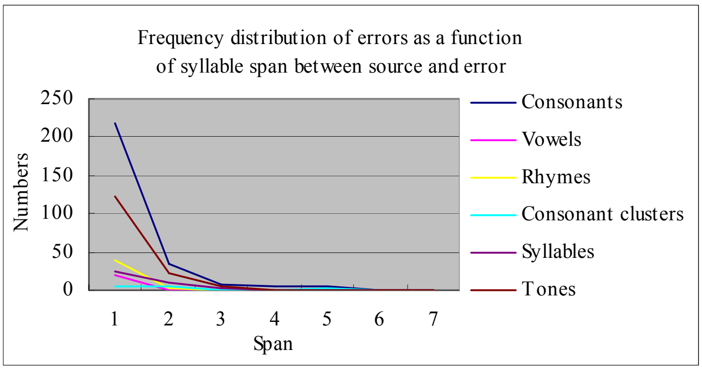

Figure 5-1: Percentage of errors as a function of syllable span between source and target

(13) I: k**w**<u>ɔ</u>35-tɕja55 → 國家
nation-family
E: k**<u>ow</u>**35-tɕja55 (wɔ → ow)
'country' → meaningless

In this example, the glide [w] and the vowel [ɔ] exchange their positions, and the vowel is phonetically realized as its correct allophone [o][2]. This error is subdivided as in a within-word category.

(14) I: zɨ51-**<u>p</u>**ən21 **<u>l</u>**jɑw51-li21→ 日本料理
Japan food
E: zɨ51-**<u>p</u>**ən21 **<u>p</u>**jɑw51-li21 (l→p)
'Japanese food '→ meaningless

In this example, the source consonant [p] is perseverated and replaces the target consonant [l]. The distance between the source and target consonants is measured in one syllable.

[2] For more discussions on vowel alternations in Mandarin speech errors, see Wan & Jaeger (2003).

(15) I: k**<u>o</u>**ŋ55-n<u>ə</u>ŋ35→ 功能
merit-ability
E: k**<u>o</u>**ŋ55-n**<u>o</u>**ŋ35 (ə→o)
'function'→ meaningless

In this example, the source vowel [o] is perseverated and substituted for the target vowel [ə]. The distance between the source and target vowels is measured in one syllable.

(16) I: k**<u>wɔ</u>**51 ma21-l**<u>u</u>**51→ 過馬路
cross horse-road
E: k**<u>u</u>**51 ma21-l**<u>u</u>**51 (wɔ→u)
'to cross a street'→ meaningless

In this example, the source vowel [u] is anticipated and replaces the target rhyme [wɔ]. The distance between the source and target element(s) is measured in two syllables.

(17) I: **<u>tɕj</u>**ɑw51-**<u>tʂ</u>**ɤ→ 叫著
call-PROG
E: **<u>tʂ</u>**ɑw51-**<u>tʂ</u>**ɤ (tɕj → tʂ)
'calling (someone) out to'→ meaningless

In this example, the source consonant [tʂ] is anticipated and replaces the target consonant clusters [tɕj]. The distance between the source and target element(s) is one syllable.

(18) I: **<u>pi</u>**21-tɕjɑw51 **<u>tɕin</u>**51→ 比較近
than-more near
E: **<u>pi</u>**21-tɕjɑw51 **<u>pi</u>**51 (tɕin→pi)
'a bit nearer'→ meaningless

In this example, the source syllable [pi] is perseverated and replaces the target syllable [tɕin]. The distance between the source and target syllables is two syllables.

(19) I: ʂɨ**<u>35</u>**-xwa**<u>51</u>**→ 實話
true-word
E: ʂɨ**<u>51</u>**-xwa**<u>51</u>** (35→51)
'the truth'→ meaningless

In this example, the source tone unit [51] is anticipated and replaces the target tone unit [35]. The distance between the source and target tones is one syllable.

It is very apparent from Table 5-4 and Figure 5-1 that aphasic errors in the present study are not distributed evenly in terms of a function of the distance between source and error. A greater proportion of errors were found to occur in the one-syllable distance than in the other syllable spans between the source and error ($\chi^2(4)=1260.274$, $p<.01$): consonants=217, 81%; vowels=19, 100%; rhymes=38, 95%; consonant clusters=6, 50%; syllables=34, 72%; tones=123, 83%). There is evidence that consonants and consonant clusters seem to span greater distances than the others (i.e., between a one-syllable-span and five-syllable-span), suggesting that the planning span in consonants and consonant clusters is much larger than in other phonological units. However, the numbers are too low to warrant a statistical comparison so standard levels of significance were not attained. In summary, aphasic errors tend to occur more in one-syllable spans than in other syllable spans.

5.5 Error Type

Regarding the error types, in cross-linguistic speech-error literature, substitution errors far outnumber any other type of error, i.e., additions or omissions (Nooteboom, 1973; Berg, 1987; Wells-Jensen, 1999), an analysis that can also be confirmed in Mandarin (Wan, to appear). In addition, there is an interesting relationship between contextuality and the rate of omissions vs. non-omissions (substitutions and additions). It has been noted that there are proportionately more omissions in the non-contextual category than in the contextual category in speech-error studies and aphasiological literature (Stemberger, 1983; Berg, 2006). The distribution of error type is based on raw scores of 2449, 165, and 248 errors for substitutions, additions, and omissions in contextual and non-contextual Mandarin aphasic errors (excluding features), as shown in the following table, and the examples are given in (20-22).

Table 5-5: Types of errors

Aphasic errors (N=2862)	Contextual	%	Non-contextual	%
Substitutions (N=2449, 85%)	441	18	2008	82
Additions (N=165, 6%)	52	32	113	68
Omissions (N=248, 9%)	43	17	205	83

(20) I: **<u>tʂʰ</u>**u35-ʂɨ55→ 廚師
kitchen-master
E: **<u>tʰ</u>**u35-ʂɨ55 ($tʂ^h$→t^h)
'cook'→ meaningless

In this example, the consonant [t^h] is substituted for another consonant [$tʂ^h$].

(21) I: jɛn21-**<u>tɕ</u>**iŋ55 → 眼睛
eyes
E: **<u>tɕ</u>**jɛn21-**<u>tɕ</u>**iŋ55 (ϕ→tɕ)
'eyes'→ meaningless

In this example, the consonant [tɕ] is added before the glide plus rhyme [jɛn].

(22) I: **<u>m</u>**jɛn51-t^hwan35 → 麵糰
noodle-ball
E: jɛn51-t^hwan35 (m→ϕ)
'dough'→ meaningless

In this example, the consonant [m] is omitted from the syllable [mjɛn].

The difference among substitutions, omissions, and additions is exceptionally large. A Chi-square test was done to compare the distribution of errors between sub-groups of errors, and the result shows a significant difference in substitution, addition, and omission ($\chi^2(2)$= 3517.801, p<.01). Substitutions (N=2449, 86%) figure more prominently than omissions (N=248, 9%), which in turn outnumber additions (N=165, 6%). Aphasic patients are likely to produce more substitution errors, such errors being more common than omission and addition errors. Moreover, it is interesting to note that there are proportionately more omissions than additions in non-contextual errors (N=205, 83% vs. N=113, 68%). The relevant discussion will be addressed in Chapter VI.

5.6 Segments vs. Features

Segmental errors and errors which involve phonetic features rather than segments are both found in English (e.g., Fromkin, 1973b; Stemberger, 1983). Although segmental-feature errors have been found in speech-error studies to be much less common than errors involving whole segments, they do occur in enough cases to warrant the independent status of features which exist as part of the internal structure of segments.

Those phonological errors that provide convincing evidence for the existence of features in cross-linguistic speech-error literature are those in which a feature value is involved in a syntagmatic error. These errors do not involve the interaction of whole segments, and there is no clear or identical whole-segment source that can be found for the error in the context of an utterance. However, these errors are not classified as non-contextual errors since there is a source segment which has a feature value that changes to match the target segment. The value of one feature can be anticipated or perseverated, and substituted for a different value of the same feature in another segment. Table 5-6 presents the incidence of contextual and non-contextual whole-segment and feature errors in aphasic speech in Mandarin. Examples of feature errors and whole-segment errors in aphasic speech in Mandarin are provided in (23) and (24).

Table 5-6: Feature errors in consonants[3]

Phonological units	N	%
Features	331	17
Segments	1601	83
Total	1932	100

(23) I: **k**ɤ55-**tʂʰ**ɑŋ51→ 歌唱
song-sing
E: **kʰ**ɤ55-**tʂʰ**ɑŋ51 (k→kʰ)
'to sing'→ meaningless

In this example, the [+aspirated] value on the VOT feature is anticipated and substituted for a [-aspirated] value of the same feature in the consonant [k]; since there is no [kʰ] source in the utterance, this is considered a feature error.

(24) I: **tʂʰ**ɑw55-**ʂ**ɨ51→ 超市
super-market
E: ʂɑw55-ʂɨ51 (tʂʰ→ʂ)
'supermarket'→meaningless

In this example, the whole-segment unit [ʂ] is anticipated and substituted for another whole-segment unit [tʂʰ]. Since there is an identical source in the utterance, this is classified as a segment error.

It can be seen that the whole-segment interaction errors comprise the majority of aphasic errors. The two data types show diametrically opposite results ($\chi^2(1)=834.834$, $p<.01$). In summary, there are proportionately more whole-segment errors than feature errors (N=1601, 83% vs. N=331, 17%).

[3] The data displayed in this study are limited to consonant errors. Vowel errors are not the focus in this section.

5.7 Similarity and Phonological Representations

In whole-segment interaction errors, it is well-known that in English, consonants are more likely to mutually interact with each other in errors if they are phonetically similar (e.g., Fromkin, 1973b; MacKay, 1973; Nooteboom, 1973; Van den Broecke & Goldstein, 1980; Levitt & Healy, 1985; Stemberger, 1989; Jaeger, 1992, 2004; Frisch, 1997). The general pattern has been replicated by the speech-error study in Chapter IV. Moreover, defining whether one segment is phonetically similar to the other is usually done by looking at how many phonetic features they share. Based on the speech-error studies in English and in Mandarin discussed in Chapter IV, I follow and adopt the same feature system and parameters used for Mandarin speech errors, as repeated in Table 5-7.

Table 5-7: Aphasic error specifications for Mandarin consonants

	p	p^h	t	t^h	k	k^h	ts	ts^h	tʂ	$tʂ^h$	tɕ	$tɕ^h$	f
P	L	L	D	D	V	V	D	D	R	R	P	P	L
N	-	-	-	-	-	-	-	-	-	-	-	-	-
V	O	A	O	A	O	A	O	A	O	A	O	A	O
C	-	-	-	-	-	-	-	-	-	-	-	-	+
F	-	-	-	-	-	-	+	+	+	+	+	+	+

	ɕ	x	s	ʂ	ʐ	m	n	ŋ	l	ɥ	j	w
P	P	V	D	R	R	L	D	V	D	L-P	P	L-V
N	-	-	-	-	-	+	+	+	-	-	-	-
V	O	O	O	O	V	V	V	V	V	V	V	V
C	+	+	+	+	+	+	+	+	+	+	+	+
F	+	+	+	+	+	-	-	-	-	-	-	-

The five parameters for Mandarin in the feature system are also repeated here. They are *place of articulation, nasality, voice onset time, continuancy,* and *frication*.

1. *Place of articulation*: this non-binary feature is divided into seven places: labial (L), dental (D), retroflex (R), labio-palatal (L-P), palatal (P), labio-velar (L-V), and velar (V).

2. *Nasality*: the three nasals, labial, dental, and velar have a positive value in regard to this feature.
3. *Voice onset time*: the dimension is divided into voiceless aspirated (A), voiceless unaspirated (O), and voiced (V); in addition, there is a two-way contrast in Mandarin stops and affricates for aspiration, but voicing contrast for fricatives and sonorants are [+voice] non-contrastive.
4. *Continuancy*: all sonorants and fricatives are labeled [+continuant]. Affricates are distinguished from fricatives by being [-continuant]; stops are [-continuant].
5. *Frication*: all fricatives and affricates are labeled as [+frication], and all others are [-frication].

The following table presents the contextual single-consonant substitution and exchange errors by the type of feature involved with some examples provided in (25-27).

Table 5-8: Consonant errors by the type of feature involved in Mandarin aphasics

Number of features	Feature(s)	N	Totals	%
1	Place	77	145	54
1	Manner	64		
1	VOT	4		
2	Place & VOT	4	99	37
2	Place & Manner	63		
2	Manner & VOT	32		
3	Place, Manner & VOT	26	46	9
Total		270	270	100%

(25) I: **<u>t</u>**ɤ35-**<u>t</u>**ɑw51 piŋ21-**<u>k</u>**an55→ 得到餅乾
get COMP cake-dry
E: **<u>t</u>**ɤ35-**<u>t</u>**ɑw51 piŋ21-**<u>t</u>**an55 (k→t)
'(he) won cookies'→meaningless

In this example, the source consonant [t] is perseverated and substituted for the target consonant [k] and these two consonants differ by a one-feature violation: place of articulation.

(26) I: **<u>tʰ</u>**oŋ35-ʂɨ51 **<u>k</u>**oŋ55-tswɔ51→ 同事工作
together-work work-work
E: **<u>tʰ</u>**oŋ35-ʂɨ51 **<u>tʰ</u>**oŋ55-tswɔ51 (k→ tʰ)
'colleague work…'→meaningless

In this example, the source consonant [tʰ] is perseverated and replaces the target consonant [k] and these two consonants are different by a two-feature violation: place of articulation and VOT.

(27) I: ʂɨ35-**<u>ʂ</u>**ɨ51-**<u>tɕʰ</u>**jow35-ʂɨ51 → 實事求是
real-matter-ask-yes
E: ʂɨ35-**<u>tɕʰ</u>**i51-**<u>tɕʰ</u>**jow35-ʂɨ51 (ʂ→tɕʰ)
'to seek truth from facts' → meaningless

In this example, the source consonant [tɕʰ] is anticipated and replaces the target consonant [ʂ] and these two consonants are different by a three-feature violation: place of articulation, manner of articulation, and VOT.

The systematic patterning of the data is readily apparent from Table 5-8. It can be seen that in aphasic speech in Mandarin, the target and source segments tend to differ by a single feature (N=145, 54%), and there is a statistically higher rate of one-feature error over the other two types ($\chi^2(2)=80.022$, $p<.01$). Furthermore, the feature [place] is the feature which differs in largest number of pairs (N=77, 53.10%), with the features [manner], continuancy, frication, and nasality, being violated less often (N=64, 44.14%); the feature [VOT] is violated the least often (N=4, 2.76%). In two-feature-difference errors, the combination of [place] and [manner] far outnumbers the rest of the two combination types (N=63, 23.33%).

The one-feature-difference errors far outnumber the two-feature-difference errors, which in turn greatly outnumber the three-feature-difference errors. In whole segments involving contextual single-consonant substitution and exchange errors, these segment errors (i.e., target and source segments) display a strong phonetic similarity in

Mandarin. Especially, the target and source segments that mutually interact with each other in errors share a one-feature violation. In addition, it is found that the feature that is violated the most often is place of articulation and the feature VOT is the feature violated least often in Mandarin, and again this property is consistent across all the languages for which speech-error data are available (Van den Broecke & Goldstein, 1980; Jaeger, 1992, 2004).

5.8 The Parallel Syllable Structure Constraint

The following examines whether there is a tendency for consonants in parallel parts of the syllable to interact. It has long been noted that syllable-initial consonants interact with syllable-initial consonants, syllable-final consonants interact with syllable-final consonants, and syllabic segments with syllabic segments in speech-error literature (e.g., Fromkin, 1973a; Cutler, 1980; Shattuck-Hufnagel, 1979, 1982; Stemberger, 1989). Table 5-9 presents paraphasic (including contextual and non-contextual consonant substitution) errors in terms of syllable position.

Table 5-9: Aphasic substitution errors involving consonants by syllable position, given as a percentage

Syllable position	N	%
Initial-Initial	1248	91
Final-Final	115	8
Initial-Final	4	1
Total	1367	100

(28) I: **l**i21-**p**aj51 → 禮拜
ceremony-worship
E: **l**i21-**l**aj51 (p → l)
'week' → meaningless

In this example, the syllable-initial consonant [l] is perseverated and substituted for another syllable-initial consonant [p].

(29) I: ʂɑ**ŋ**51-pa**n**55→ 上班
up-work
E: ʂɑ**ŋ**51-pɑ**ŋ**55 (n → ŋ)
'go to work' → meaningless

In this example, the syllable-final consonant [ŋ] is perseverated and substituted for another syllable-final consonant [n].

(30) I: jɛ**n**21-**tɕ**iŋ55 → 眼睛
eye
E: jɛ**n**21-**n**iŋ55 (tɕ → n)
'eyes' → meaningless

In this example, the syllable-final consonant [n] is perseverated and substituted for another syllable-initial consonant [tɕ].

It is apparent from Table 5-9 that syllable-initial consonants are more likely to interact with syllable-initial consonants, syllable-final consonants are more likely to interact with syllable-final consonants, and that there is a low rate of cross-position errors, i.e., initial-final interaction ($\chi^2(2)=2080.136$, $p<.01$). In summary, the target and source segments tend to originate from parallel positions in their respective syllables, and there is a remarkably low rate of cross-position errors.

5.9 Initialness

Another important issue from the error analyses is the bias existing in the domain of a syllable. Data from the above show that consonant error interactions are more likely to occur in homologous syllable positions. This section further shows that there is a strong tendency for syllable-onset errors (N=1248, 91%) to be more common than syllable-final errors (N=115, 8%). The differential sensitivity of syllable-initial errors and syllable-final errors is highly significant ($\chi^2(1)=941.811$, $p<.01$). In speech-error literature and aphasic studies, it is found that initial consonants are more likely to slip than non-initial ones. Dell and Juliano (1996) took this finding as strong evidence to support the important status of syllable initialness. They suggested that the initialness effect could be a consequence of sequential retrieval and this effect should be taken consideration in the model of phonological encoding. This finding will be addressed in more detail in Chapter VI.

5.10 Directionality

Contextual influences have been examined in the aphasic error corpus and have been subdivided according to whether the error unit precedes or follows the source element within clauses. Two major sub-types are frequently referred to: the forward (anticipatory) and backward (perseveratory) direction. The following errors are categorized by the direction of the assimilation errors made, and relevant examples are given in (31-33). Table 5-10 and Figure 5-2 show the number of errors of various directionalities. Table 5-10 shows the percentages of phonological errors of various directionalities. This table distinguishes anticipations where the error and source are both spoken before a correction, perseverations where the source comes before the error, anticipations/perseverations where there are potential sources both before and after the error, and exchanges which include both contiguous metatheses and non-contiguous reversals.

Table 5-10: Directionality of errors (N= 536)

	Consonants	Vowels	Rhymes	Consonant clusters	Syllables	Tones
Anticipation(N=267)	39	16	24	10	20	58
Perseveration (N=256)	129	3	16	2	24	82
Anticipation/ (N=8) Perseveration	0	0	0	0	3	5
Exchange (N=5)	2	0	0	0	0	3

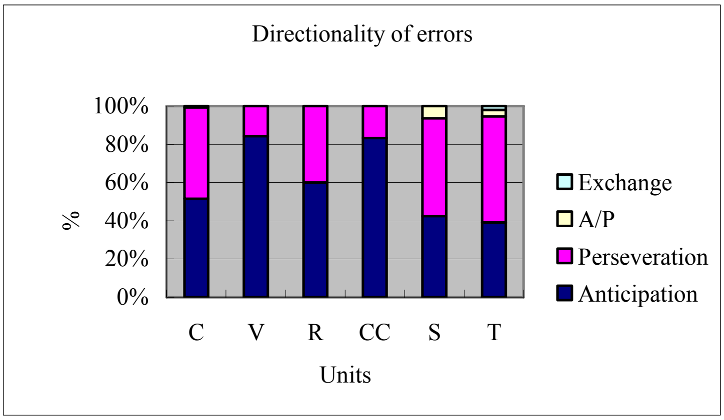

Figure 5-2: Directionality of errors

(31) I: t^{h}aj**51**-jɑŋ**35**→ 太陽
supreme-sun
E: t^{h}aj**35** jɑŋ**35** (51→35)
'the Sun' → meaningless

In this example, the tone unit [35] is anticipated and substituted for another tone unit [51].

(32) I: **p**u51-**ɕ**jɛ35→ 布鞋
cloth-shoe
E: **p**u51-**p**jɛ35 (ɕ→p)
'cloth shoes'→meaningless

In this example, the consonant [p] is perseverated and substituted for another consonant [ɕ].

(33) I: p^{h}ɑw35 u21 tɕ^{h}ɥɛn**55** ta**51**-ɥɛ**55** ʂɨ51→ 跑五圈大約是
run five circle big-brief is
E: p^{h}ɑw35 u21 tɕ^{h}ɥɛn**55** ta**55**-ɥɛ**55** ʂɨ51 (51→55)
'(how long does it take to) jog five circles?'

In this example, the tone unit [55] is either anticipated or perseverated, and replaces the target tone unit [51] and therefore there are two potential sources in the utterance.

(34) I: **t<u>h</u>**ɑw55 **tʂ<u>h</u>**u55 ər21-tɕi55 → 掏出耳機
pull out ear-machine
E: **tʂ<u>h</u>**ɑw55 **t<u>h</u>**u55 ər21-tɕi55 ($tʂ^h$ <--> t^h)
'pull out earphones' → meaningless

In this example, the two consonant units, [t^h] and [$tʂ^h$] have exchanged their positions.

It can be gleaned from Table 5-10 and Figure 5-2 that the preponderance of perseverations is less pronounced than anticipations. A Chi-square test shows a significant difference between anticipations, perseverations, A/P, and exchanges ($\chi^2(3) = 485.746$, $p < .01$): anticipations=49.82%, perseverations= 47.76%, A/P=1.49%, and exchanges=0.93%. However, it does not show a significant difference between the occurrence of anticipations and perseverations ($\chi^2(1) =.231$, p=.631). It can be seen that anticipatory errors and perseveratory errors far outnumber A/P and exchange errors. It is also interesting to note that perseverations far outnumber anticipations in tones, but in other phonological units, anticipations slightly outnumber perseverations. Most cross-linguistic data in aphasic languages have found the proclivity for perseverations (e.g., Allison & Hurwitz, 1967; Buckingham, 1985; Hudson, 1968; Schwartz et al., 1994). However, some other findings propose the opposite result, in which anticipations are in the majority in aphasic speech (e.g., Kohn, 1989; Allerbeck, 2000; Berg, 2006). Whether there is any perseveratory bias or anticipatory bias depends on a large-scale collection of contextual errors. Also, different types of paraphasic performance will need to be drawn from a discern line. Different aphasic patients with different syndromes may prefer one way to the other.

5.11 Size of Target-Error Units

The question that arises at the final point is the size of target-error units; namely, the syllable types of target and error units. There is wide agreement that the most frequent type of error found in speech-error studies involves a single segment error. However, errors involving larger-unit elements are also possible. Table 5-11 presents the syllable-type relationship between target and error in aphasic speech data in Mandarin; the target and error units involve contextual and non-contextual single-segment interaction and larger-unit interaction errors. A number of examples are provided for illustration in (35-40).

Table 5-11: Syllable type of target-source/error units N=715
(Same syllable type: 561 vs. Different syllable type: 154)

Target / Source	V	CV	GV	VG	VN	CVG	CVN	CGV	GVG	GVN	CGVG	CGVN
V	18	6										
CV	5	162				2	3	2				
GV			3			1		1				
VG						2						
VN					1		1			1		
CVG		2		2		76					2	
CVN					2	13	162					3
CGV		4	3			2		51	2		2	
GVG				1		2					5	
GVN		29							2	3		11
CGVG						21			4		33	
CGVN						8		4		5	1	52

It is apparent from Table 5-11 that the preponderant syllable-type relationship between target and source units is the one where target-source pairs are situated in the same type of syllables.

(35) I: **tɕ**jow51 ʂwej51 i55 **ɕ**jɑw21-ʂɨ35 → 就睡一小時
just sleep one little-time
E: **tɕ**jow51 ʂwej51 i55 **tɕ**jɑw21-ʂɨ35 (ɕ → tɕ)
'just sleep for one hour' → meaningless

In this aphasic example, the source consonant [tɕ] is perseverated and replaces the target consonant [ɕ]. Note that the target and source units come from the same type of syllable: CGVG.

(36) I: tɑ**ŋ**55 wa**n**21 → 當晚
that night
E: tɑ**ŋ**55 wɑ**ŋ**21 (n → ŋ)
'that night' → meaningless

In this aphasic example, the source nasal [ŋ] is perseverated and replaces the target consonant [n]. Note that the target and source nasals come from the same type of syllable: CVN.

(37) I: u21 p^h**jɛn**51 **i**55 k^hwaj51 → 五片一塊
five pieces one dollar
E: u21 p^h**i**51 **i**55-k^hwaj51 (jɛn → i)
'five pieces for one dollar' → meaningless

In this aphasic example, the source vowel [i] is anticipated and replaces the target units involving the glide plus rhyme [jɛn], and in this case, the target is in a CGVN-type of syllable and the source is in a V-type of syllable.

(38) I: **x**ən21 **t**wɔ55 → 很多
very much
E: **x**ən21 **x**wɔ55 (t → x)
'a lot' → meaningless

In this aphasic example, the source consonant [x] is perseverated and replaces the target consonant [t]. In this case, the target is in a CGV-type of syllable and the source is in a CVN-type of syllable.

(39) I: $tɕ^h$iŋ55-xa**n**35 → 清寒
poor-cold
E: $tɕ^h$iŋ55-xɑ**w**35 (n → w)
'poor' → meaningless

In this aphasic example, the glide [w] is substituted for the nasal [n]. In this case, the target unit is in a CVN-type of syllable and the error unit is in a CVG-type of syllable.

(40) I: **t**i55-**$\underline{t}^h$**ow35 → 低頭
low-head
E: **$\underline{t}^h$**i55-**$\underline{t}^h$**ow35 (t → t^h)
'to lower one's head' → meaningless

In the aphasic example, the source consonant [t^h] is anticipated and substituted for the target consonant [t]. In this case, the target consonant is in a CV-type of syllable and the source consonant is in a CVG-type of syllable.

It is interesting to note that in Table 5-11 the predominance of the same syllable-type relationship between target and error units is more extreme in aphasic speech in Mandarin. Table 5-11 depicts target-source or target-error pairing in same syllable types versus those in different ones. It shows that the proportion of the target and source/error involving the same syllable types is significantly greater than the number of target and source involving different syllable types. Calculation of χ^2 yields a highly significant difference in the same- vs. different-syllable types ($\chi^2(1) = 231.677$, $p < .01$). Among the same-type of syllable groups, CV- and CVN- types of syllables are the most common in target-source or target-error pairs (N=162, 28.88%), and the next most common type to the least common type falls in the following order: CVG (N=76, 13.55%), CGVN (N=52, 9.27%), CGV (N=51, 9.09%), CGVG (N=33, 5.88%), V (N=18, 3.21%), GVN (N=3, 0.53%), GV (N=3, 0.53%), and VN (N=1, 0.18%). So far there is no evidence in support of VG- and GVG- types. Among the different-type of syllable groups, GVN-CV (N=29, 18.83%) is probably the most common one, but the number is too low to warrant a statistical comparison so standard levels of significance were not attained. Therefore, the data from Mandarin-speaking aphasics present a picture in which the target and source pairs are more likely to interact with one another when they are from the same type of syllables.

In conclusion, evidence from aphasic studies in Mandarin support the following findings:

(1) In aphasic errors in Mandarin, phonological errors are more common than lexical errors. In phonological units occurring in errors, single consonant errors have a wider error distribution.
(2) The preponderance of phonological errors in aphasic speech is non-contextual in Mandarin.
(3) In a limited number of contextual errors, the target and source pairs are more likely to interact with each other in one-syllable spans.
(4) Substitution errors constitute the absolute majority in Mandarin-speaking aphasics, and omission errors outnumber addition errors.
(5) Aphasic errors involving whole segments are more common than feature errors, suggesting that segments are the most fundamental phonological units in language processing in Mandarin.
(6) In whole segments involving contextual single-consonant substitution and exchange errors in Mandarin, the target and source segments are more likely to interact with each other if they are phonetically similar in Mandarin; there is a one-feature difference between target and source consonants. An overall hierarchy of feature involvement in aphasic speech is as follows: [place] > [manner] > [VOT].
(7) Aphasic speech is sensitive to syllable-structure position in Mandarin. The target and source segments closely follow the parallel syllable constraint in that an initial consonant interacts with another initial consonant, and a coda consonant interacts with another coda consonant.
(8) The majority of aphasic errors involve target and source units occurring in syllable-iniitial positions in Mandarin in that initial consonants are more likely to slip than noninitial ones.
(9) Anticipations are slightly more common than perseveration errors, which far outnumber exchange and anticipation/perseveration errors.
(10) The majority of aphasic errors involve target and source segments sharing the same type of syllable size, suggesting that one element is more likely to interact with another when it has the same phonological environment.

CHAPTER VI
DISCUSSION AND CONCLUSION

6.1 Introduction

A total of 5,495 relevant speech errors from native speakers of Mandarin and 3,000 errors from Mandarin aphasic subjects, both collected by the author and her research team in a naturalistic setting, support the general findings in cross-linguistic studies. Compared with speech errors, the distribution of error types in the aphasic speech generally shares some phonological characteristics with normal speech production errors. In general, the most consistent results found in aphasic speech in Mandarin with reference to linguistic analyses is the relative uniformity of error types and error distribution in each aphasic sub-category. Due to the general applicability found in the aphasic errors with naturally-occurring speech errors in Mandarin as a comparison, these findings may contribute to the understanding of the mechanisms necessary for speech production and planning. However, there are still some significant discrepancies between the two corpora. In the following section, general comparisons will be made first, followed by the presentation of specific comparisons.

6.2 Comparisons to Speech Errors

Regarding the occurrence and distribution of error types in a jargon aphasic speech in Mandarin, an analysis of the data reveals that these aphasic errors do not occur randomly; instead, the data show a hierarchy. Specifically, the error profile for the aphasic speakers favors some particular error patterns at the expense of others. In general, there are numerically more phonological errors than lexical errors. In the occurrence at any stage of the speech production planning process, phonological errors are the major types of errors as distributed within the two error corpora. The most common phonological errors involve the interaction of a single consonant (speech errors: 51.03%; aphasic speech: 53.4%).

There is a minor discrepancy in the two error corpora. The phonological units involved in naturally-occurring speech errors are listed as follows: Consonants > Vowels > Tones > Rhymes > Consonant clusters > Features > Syllables > CV sequences, whereas the units occurring in aphasic errors do not show the same hierarchy but rather the following: Consonants > Tones > Features > Rhymes > Syllables > Vowels > Consonant clusters > CV sequences. An analysis of the data reveals that both normal and aphasic speakers produce more consonantal errors than the other types, which is not a surprising finding since cross-linguistically, consonants outnumber vowels both in terms of number of phonemes in the segment inventory and in the ratio of consonants to vowels within utterances. Therefore, phoneme frequency may appear to be the best explanation for this result.

The data from the two error corpora show that a single consonant is more likely to interact with another consonant and a single vowel interacts with another vowel, and there are not many instances of cross-category errors involving consonant-vowel substitutions in either error corpora. In general, simple single errors make up the majority of the speech-errors and in aphasic speech, the rate of complex errors is greater than that in speech-error although simple errors still comprise majority. In the two error corpora, larger units involving rhymes (VC) occur more often than CV errors. Evidence from the two error corpora in Mandarin are compatible with Dell's connection model which predicts more VC than CV errors at the phonological level which constituents the nucleus and the final codas together.

However, it is interesting to note that features are also the second dominant phonological units over the others in aphasic speech, and this might suggest that features are more likely to be produced incorrectly in aphasic patients' speech production system in Mandarin, whereas normal speakers are more likely to make single-unit errors in Mandarin; feature errors are less common. This phenomenon might explain why the majority of aphasic studies in the past decades in Mandarin have been in relation to feature, the topic of which involves voice onset time (e.g., Su 1991). In addition to consonantal errors in the two error corpora, the predominance of tone errors over the other phonological units indicates that the suprasegmentals are important units encoded in cognitive models of speech production processes.

In contextuality, it is understandable to see what is already known about the constraints imposed on source-error pairs, and about sound movement errors in influencing their encoding. Aphasic errors yield a large amount of non-contextual errors in which there is no potential source in the context of utterance. However, the majority of errors produced by normal speakers are contextual so it is quite straight-forward to find an obvious source in the context utterance, and the source and target/error are more likely to be situated within the clause boundary.

Schwartz et al. (1994) looked at a comparison between data in a naturally-occurring speech-error corpus and an aphasic speech corpus, and they suggested that there is no empirical or theoretical basis for applying a fairly narrow restriction when coding aphasic patients' errors. Therefore, in their term of contextual errors, that could be the case in which perseveratory and anticipatory influences operate within or without clauses. They re-analyzed contextual influences over a larger window, spanning the clause before and after the error, and each and every occurrence of the substituted phonetic elements in that context window was counted as a potential source for the error. That explains why Goldmann, Schwartz, and Wilshire (2001) reported a substantially lower rate of non-contextuals (25.3%) for a Wernicke's patient.

However, the contextual analysis in this study is followed what is used to be collected and categorized in naturally-occurring speech errors. I apply a fairly narrow window, mostly restricted to the clause containing the error, and the source-error pairs required that anticipatory and perseveratory sources occupy within the contextual of the utterance. Similarly, a number of researchers also adopt the same way to subdivide non-contextual errors. Wilshire (2002) found that non-contextual errors make up a large proportion of the total number of errors and there are only 17.3% contextual errors in the English aphasic studies. Another conduction aphasics, examined by Wilshire and McCarthy (1996), produced 57.6% non-contextual errors. The general pattern has also been replicated in a Japanese aphasic study (Monoi, Fukusako, Itoh, & Sasanuma, 1983). They found a very high rate of non-contextual consonant errors in Broca's aphasics. In an analysis of aphasic study in Finnish, there was a ratio of 2:3 for contextual and non-contextual errors (Niemi, Koivuselka-Sallinen, and Hanninen, 1985). A close similar rate of noncontextuals (63.8%) was reported in a sample of errors produced by a number of German-speaking aphasic patients (Allerbeck, 2000). Soderpalm (1979) reported an extreme case in which non-contextual errors account for 81% for the cases. A similar rate (82.1%) is now found in Mandarin. I thus take the cross-linguistic aphasic studies as strong evidence to claim that non-contextuality plays a more important part in the speech production of aphasic patients in Mandarin whereas contextuality is very crucial for normal speakers in Mandarin. Evidence from a substantially higher rate of contextual errors in normal production and a rather higher rate of non-contextual errors in aphasic production in Mandarin suggests that the speech is planned in clausal units in advance, and the disturbance in the speech of aphasic patients may show that they have problems monitoring larger linguistic structures functioning as units in the processes of speech production in Mandarin.

Regarding the question of the distance between the source and error units, corpus analysis from aphasiological literature so far does not distinguish the distance in terms of syllable spans since most of the language studied for all types of aphasia reports a rather lower rate of contextual errors. In normal performance errors, Nooteboom (1973) found that the distance between error and source unit does not generally exceed seven syllables in naturally-occurring errors in Dutch. The general pattern is also replicated in the Mandarin speech-error study presented here, and there is generally a monotonic decrease as the number of syllable spans increase (one-syllable-span: 61.37%; two-syllable-span: 22.21%; three-syllable-span: 8.98%; four-syllable-span: 4.39%; five-syllable-span: 2.15%; six-syllable-span: 0.63%; seven-syllable-span: 0.27%). However, this effect is not entirely replicated in aphasic data in Mandarin. There are 82.1% cases in aphasic study involving non-contextual errors, leaving 17.9% cases to be contextual errors. In the small proportion of contextual errors, one-syllable-span errors constitute the majority of error distribution in aphasic study in Mandarin (one-syllable-span: 81.53%; two-syllable-span: 13.62%; three-syllable-span: 2.43%; four-syllable-span: 0.93%; five-syllable-span: 1.49%; six-syllable-span: 0%; seven-syllable-span: 0%). Although one-syllable-span errors are in the majority in these two error corpora, these percentages demonstrate that speech errors and aphasic speech pattern differently, especially, in that the planning span in normal speakers is much larger and the planning span in aphasia is relatively small.

The analysis of the data in Berg's (2006) corpus shows a greater proportion of error occurring in the within-word category in aphasic language although his study does not specifically reveal the source-error-pair distance as measured in syllable spans. This finding suggests that the zero-syllable distance in English aphasics and one-syllable distance in Mandarin aphasics are in the absolute majority. This finding yields a similar result from the cross-linguistic data. It is found that within-word errors are more common in aphasic speech. If the data for the three syndromes are pooled together, within-word errors are in the absolute majority. Supplementary evidence comes from Soderpalm's (1979) study where Swedish paraphasias contains 10 within-word as against 3 between-word cases. This finding invites the conclusion that the span over which target-source elements may interact is much smaller in aphasic speech than in speech errors in Mandarin.

Regarding the error types, it is not surprising to find that phonological substitution errors far outnumber any other type of error, i.e., additions or omissions in English, Hindi, Japanese, Spanish, and Turkish (Wells-Jensen, 1999), the analysis of which can also be confirmed in Nooteboom's (1973) Dutch slips corpus, Berg's (1987) German's slips selection, and Jaeger's (2004) English slips collection. Evidence from Mandarin speech errors represents a most extreme case in which substitution errors account for 83.04% of the cases. The substitution figure is replicated in aphasic study in Mandarin: substitution errors (85%); however, there are proportionately more omissions (9%) than additions (6%) in aphasic speech in Mandarin. Especially, it is found that omission errors figure more prominently in the non-contextual category (83%) than in the contextual category (17%), the figure of which is much higher than that of addition errors (contextual category: 32%; non-contextual category: 68%).

Recently, a number of researchers have found a relationship between contextuality and the rate of omissions vs. non-omissions. They have found the similar pattern; that is, there are proportionately more omissions in the non-contextual category than in the contextual category (Hatfield & Walton, 1975 for Broca's aphasia in English; Shewan, 1980 also for Broca's aphasia in English; Pate et al., 1987, and Kohn, 1989, both for Conduction aphasia in English; Ardila, Montanes, Caro, Delgado, & Buckingham, 1989 for a large group of aphasics of all types in Spanish; Beland, Caplan, & Nespoulous, 1990 for a Conduction patient in French; Moen, 1993 for Norwegian-speaking Conduction aphasics; Romani & Calabrese, 1998 for Italian Broca's aphasia; Allerbeck, 2000 for German-speaking Wernicke's aphasics).

One may find that Mandarin speakers tend to produce a larger proportion of substitution errors in cross-linguistic speech-error data, and English aphasics has a larger proportion of omission errors than Mandarin aphasics do. This is possibly due to the fact that there is a strong phonotactic constraint in the Mandarin phonological system. Once a phonetic element is deleted or added, the interfering units are likely to change to their correct phonetic variants, and therefore, substitution errors are favored in the two error corpora. This property faithfully reflects the universal structure of language since substituting one segment for another causes less disruption in the phonological structure than the other two types. We may also conclude from the aphasic data that omissions play a more important part in aphasic speech than in speech errors in Mandarin. This finding by and large holds for all the language studied and all type of aphasia.

The different frequencies between the whole-segment and feature errors may suggest that features have a fairly limited functional role relative to segments in any model of speech production planning. There are proportionately more whole-segment errors than feature errors in speech errors (94.99% vs. 5.01%) as well as in aphasic speech (83% vs. 17%) in Mandarin. The figure convincingly shows that features have a cognitive status during speech production planning since feature values themselves can be involved in errors, giving evidence of the existence of features as phonological units. Feature errors are not nearly as common as segment errors in the two error corpora; however, they occur with enough frequency to support their cognitive status in processing.

Shattuck-Hufnagel and Klatt (1979) provided strong evidence against a featural analysis for segmental errors of the type in question. They looked at all the consonant exchange errors in their corpus in which the two consonants differed by at least two features (N=90), and found that the majority of errors (N=70) were eligible for single feature exchanges. If a single feature had exchanged with another, the result would have been existing English segments in legal syllable-structure positions even though neither segment would have occurred in the intended utterance. However, there were only three errors in their corpus in which features but not whole segments unambiguously exchanged, which they took as evidence that actual feature errors are rare. They further found that individual consonants were involved in the 1620 segmental substitution and exchange errors in their corpus in proportions which were statistically correlated with the frequency of occurrence of each segment in English speech. Since the frequency of occurrence of individual segments cannot be related in any consistent way to specific phonetic features, Shattuck-Hufnagel and Klatt argued that it is clearly whole segments and not features which are available to the speech production processing mechanism at the time at which these errors are made. They presented a model in which segments from underlying phonological representations are selected and inserted into syntagmatic slots by a 'scan-copier' mechanism; if segments are phonetically similar and occur in similar syllable-structure slots they are eligible for misselection and misinsertion, but features themselves are not available for such a mechanism.

Fromkin (1973b) came to a similar conclusion. She presented 265 errors involving single consonant or vowel substitutions or exchanges; of these, 55 (21%) are featural and 210 (79%) are segmental. In the case of segments, one could argue that the consonant or vowel root node is the most common unit of error, that is, the unit susceptible to being substituted, added, omitted, or exchanged; however, the fact that individual feature values can also occasionally be the error unit suggests that features exist as part of segment structure but are less available to the speech production planning mechanism. This fact suggests that features are not "independently controlled" in speech production, and therefore are not as susceptible to error as whole segments.

The framework in Dell's (1988) model does not provide feature level at the phonological level in a model of phonological encoding where speech sounds are inserted into the sound slots in a syllable frame and then decomposed into syllabic constituents such as onset and rhyme. In the model of phonological retrieval, the network contains a lexical network and a word-shape network. The lexical network connects word nodes with the sounds, and the only levels of representation are at word and phoneme levels. Therefore, a feature level is not represented in a model of phonological retrieval. In general, the selection processes operate at the level of segments and they are not involved at the level of features although the presence of feedback permits features to influence segment selection.

Therefore, the speech-error data found in the two error corpora supports their findings given the evidence for the existence of features in phonological units as well as the evidence to support the fact that features are not readily eligible for misselection and misinsertion; thus features are independent units, but they are not as independent as segments in speech production. That is, segment units are the primary planning units in speech production in Mandarin.

I then utilized a feature system developed from Van den Brocke and Goldstein (1980) and Jaeger (1992, 2004) to discuss whether there is a phonetic similarity between target and source segments. It is found that feature violations among consonant pairs in Mandarin speech errors are not distributed evenly. The largest number of errors involves consonant pairs which differ by only one feature, followed by consonant pairs which differ by two features. It is clear that such distributions cannot be entirely explained with reference to the possibility of the number of feature violations. Wan (1999) found that the majority of pairs of consonant phones show a three-feature difference tendency, and the feature [place] is the feature which differs in the largest number of consonant pairs in Mandarin. Taking this frequency into account, it would be possible to predict that a large number of errors with three-feature differences would be generated in the error distribution in Mandarin. However, the data from the two error corpora both show that errors in which only one feature is violated are the most common, supporting the hypothesis that consonants which are more phonetically similar are more likely to interact in errors. In addition, in the one-feature-difference errors, Mandarin speakers are more likely to produce errors which involve a change in the value for the [place] feature (normal speakers: 68.83% vs. aphasic patients: 53.10%), and fewer errors involving the [manner] features (normal speakers: 21.74% vs. aphasic patients: 44.14%), and relatively fewer errors involving the [VOT] feature (normal speakers: 9.43% vs. aphasic patients: 2.76%). It is also interesting to note that there are proportionately higher [manner] features in aphasic errors than in speech errors in Mandarin, and there is lower rate of [place] features in aphasic errors than in speech errors in Mandarin.

The pattern of involvement is very much determined by the pattern of a possibly-expected percentage, which is considered the inventory frequency. There is no doubt that the feature [place] is the one that is violated the most often in errors because there are in total seven feature values along this dimension including the places as labial, dental, retroflex, labial-palatal, palatal, labial-velar, and velar. Any consonants which have been randomly selected will possibly differ in regard to this feature. At the same time, the features [manner] include the features [nasality], [continuancy], and [frication]. In the two error corpora in Mandarin, nasals are more likely to interact with one another than any other consonants in syllable-final positions. As for the features [continuancy] and [frication], among the consonant pairs, about half of the consonants have [+continuant] or [+fricative] values and the other half have [-continuant] or [-fricative] values and so these features would be involved frequently by chance. There are three feature values along the [VOT] dimension including voiceless aspiration, voiceless unaspiration, and voiced. The chance rate that consonant pairs will differ in regard to this feature will not as high as the [place] and [manner] features. In summary, the patterns found in feature errors can be explained with reference to the possibility of feature violation; the frequency factor is part of the explanation. This property suggests that feature systems are in fact organized hierarchically, and such consideration most likely accounts for the findings in Mandarin and possibly also for cross-linguistic trends. In particular, this finding strongly confirms Jaeger's (2004) pattern for children's errors in English. Jaeger has made a related point and suggested that the place feature is the feature most commonly involved in speech errors of English-speaking children, which is partially due to the fact that the place feature is the easiest to violate in an error and partially due to the frequency factor. A manner difference between consonant pairs is considered a larger phonetic distinction than a place difference, and a voicing violation is regarded as a rather major mismatch between consonant pairs, and thus consonants which differ by the voice feature are less likely to interact in an error.

One of the most powerful principles governing phonological speech errors is the parallel syllable structure constraint. Segments interacting in speech errors with one another usually occupy similar positions in their respective syllables, that is, syllable-initial consonants interact with syllable-initial consonants, syllable-final consonants interact with syllable-final consonants, and syllabic segments with syllabic segments. In Mandarin speech errors, there are 67.67% errors involving onset consonants interacting with other onset consonants, 31.55% errors involving coda consonants interacting with other coda consonants, and merely 0.78% errors involving onset consonants interacting with coda consonants. The results from Mandarin aphasics are even more sensitive to the parallel syllable structure constraint. There are 91% errors involving onset consonants interacting with other onset consonants, 8% errors involving coda consonants interacting with other coda consonants and only 1% errors involving initial consonants interacting with coda consonants. It is found that aphasic errors are less sensitive to the parallel syllable structure constraint in English and German. Goldmann et al. (2001) produced 44% cross-position errors in English, and Dressler, Magno Caldognetto, and Tonelli (1986) found 32% violations in the Viennese-German paraphasias. One might feel puzzled that most of cross-linguistic studies show that paraphasias are less sensitive to the parallel syllable structure constraint than speech errors, and Mandarin seems to yield a different pattern in which the target and source segments tend to originate from parallel positions in their respective syllables in speech-error and aphasic speech data. It is possible that structural characteristics of Mandarin syllables are responsible for the lower violation rate.

There is a strong tendency for syllable-initial onset consonants to slip more than syllable-final coda ones. There are 67.67% errors that involve target and source consonants occurring in syllable-initial positions whereas there are 31.55% errors that involve target and source consonants occurring in syllable-final positions in speech-error data in Mandarin. In Mandarin aphasic speech, there is a much stronger tendency with syllable-onset errors (91%) to be more common than syllable-final errors (8%). The possibilities of the occurrence of syllable positions in Mandarin might be able to offer an explanation. In syllable-structure positions, there are more opportunities for onsets than codas to err in Mandarin. The initialness effect can be possibly attributed to the hierarchical structure of the syllables because the predominance of onset errors over coda errors can be attributed to the fact that the onset is more of a constituent than the coda is.

In cross-linguistic speech-error studies, close to 80% of the phonological errors involve consonants occurring in syllable onsets rather than in syllable codas (MacKay, 1970; Boomer & Laver, 1973; Fromkin, 1973b; Nooteboom, 1973; Shattuck-Hufnagel, 1979, 1982; Soderpalm, 1979). MacKay (1970) took this as an argument to support that the nucleus and coda consonants are closely associated in the syllable-structure position. He found that the coda is more highly integrated with the nucleus than the onset is. Speech errors usually tend not to dissociate units that are highly integrated since the errors involving syllable-coda consonants would need to break up the rhyme. It is a lot easier for syllable-initial consonants to interact with one another since they are not closely tied to the nucleus. However, experimental evidence on the detection of errors shows the opposite result (Cole, 1973; Ellis, 1985; Cutler, 1982; Shattuck-Hufnagel, 1983; Stemberger, 1983).

Syllable initialness seems to be less strong in aphasic literature than in cross-linguistic studies. They have found that the coda is more strongly impaired than the other syllabic constituents (e.g., Kohn, 1989 for English; Stark & Stark, 1990 for German; Kohn et al., 1995; Allerbeck, 2000 for German; Knels, 2001 for German; among many others). However, there are also quite a few studies showing a bias toward syllable-initialness (Berg, 2006). It seems unlikely that these divergences can be accounted for by syndrome-specificity. Different patients with the same syndrome may behave in different ways. Evidence from Mandarin aphasics shows that Mandarin aphasic patients experience less difficulty with syllable-initial loci than patients speaking other languages do, suggesting that initialness effect plays an important role in the model of phonological encoding in Mandarin.

It has been found that speakers in Germanic languages make more anticipatory errors than perseverative errors in naturally-occurring speech errors (Nooteboom, 1973; Berg, 1987; Stemberger, 1989; Wells-Jensen 1999). Berg (1987) looked at a number of different corpora and found this is to be true of all the languages that had been investigated. However, this preponderance of anticipatory errors is not found in non-Germanic languages. Gandour (1977) and Wan (in press) found the opposite direction occur in Thai and Mandarin tone errors, respectively, with more perseverations than anticipations and exchanges. In some other languages, perseverations and anticipations occur with approximately equal frequency (e.g., Abd-El-Jawad & Abu-Salim, 1987 for Arabic; Min, 1998 for Korean; Well-Jensen, 1999 for Spanish, Hindi, and Japanese; Muansuwan, 2000 for Thai). In speech-error data in Mandarin, perseveration errors (50.58%) dominate anticipation errors (39.10%). Yet, perseverations (47.76%) and anticipations (49.82%) occur with approximately equal frequency in Mandarin aphasic speech. The treatment of the directionality of errors between the two error corpora is the major difference.

The preponderance of perseverative errors is found in cross-linguistic aphasic studies (e.g., Allison & Hurwitz, 1967; Hudson, 1968;

Buckingham, 1985; Schwartz et al., 1994). However, there are also some other studies in support of anticipatory bias (e.g., Blumstein, 1973; Soderpalm, 1979; Kohn, 1989). Blumstein (1973) suggested that the predominance of anticipatory over perseverative errors was mainly due to the degree of difficulty manifested by the error in relation to programming in the process of speech production. When there are more cases involving one phoneme being substituted for another which occurs later in the utterance, such a phenomenon will indicate that the timing which determines the specific ordering of the utterance must be modified before the patterns of the relevant articulatory movements can be implemented. However, evidence from naturally-occurring errors in children's speech shows that one-year-old children make more perseverative errors than children at other ages, suggesting that the directionality of phonological ordering errors made by children is different from that in adult speech (Stemberger 1989, Jaeger 2004). Schwartz et al. (1994) and Dell et al. (1997) suggest that less practiced as well as disordered speakers produce fewer anticipations and more perseverations than more fluent speakers. They reported that adult speakers are more likely to produce more anticipation errors in that the more practiced speaker is planning ahead in longer chunks, thus causing previously activated items to be deactivated sooner. This is a possible hypothesis for processing mechanisms in Germanic languages. However, this preponderance of anticipatory errors is not found in non-Germanic languages, as claimed by Min (1998 for Korean), Wan (1999 for Mandarin), and Wells-Jensen (1999 for Spanish, Hindi, and Japanese). A possible explanation for this difference relates to the different syntagmatic organizing status of tone and stress in relation to the intonational phrase (e.g., Wan, in press). Boomer & Laver (1973) found that both the target and source of a speech error usually occur within the same tone-groups (i.e., in the intonational phrase), and that the tonic syllable is usually involved in the error utterance either as source or error, with tonic sources predominating. Thus, if a language utilizes stress as an important organizing factor, and in particular employs a tonic syllable at the end of a phrase marking new information by prosodic prominence, such a phenomenon will be a source of error, and will cause more anticipatory errors. Therefore, if there is no tonic syllable in a language, speakers will be less likely to produce anticipatory errors. It could be possible for a produced articulatory movement to contaminate one which follows, and also possible for it to affect one which has not yet occurred in the utterance, so it is more likely that an element which is activated will remain so and intrude later, causing perseveratory errors. Based on such a hypothesis, it is not surprising why aphasic speakers in Mandarin produce equal amounts of anticipatory and perseverative errors. The preponderance of perseverations is less pronounced than anticipations in Mandarin aphasic speech. The aphasic error data show a much lower proportion of contextual errors, and with a focus on the anticipatory and perseverative errors, there is no significant difference between the two sub-categories. The lower rate of contextual errors, specifically, the perseverative errors, reflects a less efficient monitoring mechanism in speech production planning and execution. Moreover, the lower rate of anticipatory errors reveals that the aphasic speakers are unlikely to plan ahead in terms of accessing the phonological representations of the words that have been accessed. Most cross-linguistic data in aphasic languages have found a proclivity for perseverations (e.g., Allison & Hurwitz, 1967; Hudson, 1968; Buckingham, 1985; Schwartz et al., 1994). However, some other findings propose the opposite result, in which anticipations are in the majority in aphasic speech (e.g., Kohn, 1989; Allerbeck, 2000; Berg 2006). Whether there is any perseveratory bias or anticipatory bias depends on a large-scale collection of contextual errors. It would seem that the predicted effect is not particularly strong and also that it is weaker in Broca's aphasia than in the other syndromes. However, a trend in the expected direction is almost discernible. Thus, it may tentatively be concluded that the anticipation-perseveration ratio in aphasia does not resume that of normal speakers. These findings discussed above, from aphasic and speech errors, lend further support to the assumption that the phonological patterns of aphasic speech in Mandarin reflect a disturbance of the phonological rather than the phonetic mechanisms of language.

There is wide agreement that the most frequent type of errors is single-segment errors in speech-error studies, and such a single-segment substitution can come from numbers of syllable types. The target and source segments may share the same syllable type or may be of different syllable types. In addition, errors involving larger-unit elements are also possible, and the interaction involving larger units may also share the same syllable type or may have different syllable lengths. It is very interesting to notice that target and source or error elements are more likely to interact with each other when they share the same phonological environment, i.e., syllable types. In the same-type of syllable groups in naturally-occurring speech errors in Mandarin, the most common pattern is CV (N=1141, 31.8%), followed by, in order, CVN (N=900, 25.1%), CGVN (N=464, 12.9%), CVG (N=398, 11.1%), CGVG (N=213, 5.9%), CGV (N=166, 4.6%), GVN (N=147, 4.1%), V (N=65, 1.8%), GVG (N=35, 1%), GV (N=32, 0.9%), and VN (N=29, 0.8%). In the different-type of syllable groups in speech errors in Mandarin, CGVN-CVN is by far the most common. Among the same-type of syllable groups in aphasic speech in Mandarin, CV- and CVN- types of syllables are the most common in target-source or target-error pairs (N=162, 28.88%), and the next most common type to the least common type is the following order: CVG (N=76, 13.55%), CGVN (N=52, 9.27%), CGV (N=51, 9.09%), CGVG (N=33, 5.88%), V (N=18, 3.21%), GVN (N=3, 0.53%), GV (N=3, 0.53%), and VN (N=1, 0.18%). Therefore, the most common syllable patterns between speech-error data and aphasic study in Mandarin are in CV- and CVN- types of syllables. Type(s) for which evidence have not been discovered are the VG-type of syllables in speech errors as well as VG- and GVG-types of syllables in aphasic speech in Mandarin.

6.3 Summary and Conclusion

In this study, ten different criteria have been used to investigate the relationship between speech errors and aphasic production deficits. This study compares data from a corpus of errors generated by aphasic speakers with data from a corpus of normal speech errors. Comparing speech errors, the distribution of error types in aphasic speech generally shares certain phonological characteristics with normal speech errors. The most consistent findings in the phonological analyses of aphasic speech are the relative uniformity of error types and error distributions in each aphasic sub-category. The present study shows that error distribution in aphasic speech closely resembles the nature of the errors made by normal speakers although there are still some discrepancies between the two error corpora. The differences suggest the ways where the speech production system of the aphasic speakers differs from that of the normal speakers. The study has provided empirical evidence for the psychological validity of phonological units encoded in cognitive models of performance, and also suggested how these two speech corpora can be mapped onto speech production models in terms of speakers' cognitive representation and processing. However, cross-linguistic psycholinguistic studies are needed to see if the patterns found in aphasic speech in Mandarin are universal in other languages.

Evidence from naturally-occurring speech errors as well as aphasic errors in Mandarin favors the connectionist approach advocated in Dell's interactive spreading activation models over the serial order mechanisms employed by Garrett (1980).

First of all, phonological segments are the fundamental units that are manipulated during phonological encoding in processing since phonological errors involving single segments range from 67.92% in speech errors to 56.1% in aphasic errors. This finding is compatible with both Garrett's and Dell's models. Secondly, substitution errors outnumber addition and omission errors, faithfully reflecting the universal structure of language, as in both the serial order models and the connectionist models, substituting one segment for another causes less disruption in the phonological structure than the other two types. Phonological substitution errors show that the similarity of segments, as defined by the number of shared features, affects the frequency with which two segments are mutually involved, i.e., segments which are phonetically more similar are more likely to interact. In the study, 72% of speech errors and 53.7% of aphasic errors show that the target and error segment share all but one feature. Wan (2005) found that similarity effects also occur in lexical substitution errors, out of which 89% in speech errors and 92% in aphasic errors show a semantic connection and 45% of all cases also show a phonological connection. However, malapropisms with a purely phonological relationship are rare. Here Dell's parallel activation model provides a better account in terms of feedback from the phonological nodes to the semantic nodes, since the model allows separate representations of the intended message to work in parallel. A serial order model has difficulty in explaining for why phonological similarity effect occurs in lexical substitution errors.

Finally, in single substitution errors where one segment substitutes for another, 99.22% of speech errors and 99.8% of aphasic speech observe syllable structures in that consonants replace consonants and vowel replaces vowels. Errors involving consonant-vowel substitution are rare. Furthermore, there is clear evidence of constituent structure in both error corpora, favoring the onset-rhyme division. Dell's model, which predicts more VC errors than CV in the structure, again affords a better account. The anticipation/perseveration ratio in aphasia does not resemble that of normal speech errors. The directionality effect supports Dell's parallel activation model in that it correctly predicts the bidirectional interaction between semantic and phonological representations, evidenced by speech and aphasic errors that exhibit both phonological and semantic properties simultaneously. This connectionist approach is especially 'economical' in its representation of principles of parallel processing in the generation of speech. In general, Dell's model of phonological encoding has better explanatory power over Garrett's serial models for the range of Mandarin speech and aphasic errors considered.

6.4 Possible Weakness and Suggestions for Further Research

A firm conclusion is hampered by a lack of large-scale collections of contextual aphasic speech. The aphasic corpus in this study may still be too small for a meaningful comparison between normal and aphasic languages to be carried out. Thus, it may tentatively be concluded that the disparity between normal and aphasic speech in Mandarin is best understood as a difference in processing efficiency, suggesting that there is an underlying similarity between normal and aphasic speakers, the analysis of which will confirm Butterworth's (1992) aphasic study. Although there are undeniable parallels between speech errors and aphasic speech, it is still true that there are quite radical differences in the linguistic patterns of the two error corpora which may not be entirely accommodated in any model of speech production.

It will come as no surprise that despite the rich sources of available literature on speech errors and aphasic speech, there are still many gaps in our knowledge which obviously limit the empirical backup for any aphasiological theory.

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Appendix I
Speech Errors

The errors listed in this Appendix are selected from a corpus of 4944 spontaneous slips of the tongue. They have been selected to show a wide variety of slips which occur in normal speech.

A. Initial Single Consonant Errors (Initial or Prenuclear glides)

1. ISCE, Substitutions, Perseverations

1. I: jow35 t̲aj21-t̲ʰu35 tɕin51 laj35 → 有歹徒進來
have hoodlum in come
E: jow35 t̲aj21-t̲u35 tɕin51 laj35 (tʰ→ t)
'There is a outlaw coming in.' → (meaningless)

2. I: tʰa55 ɕj̲ɑŋ35 ɕɥ̲ɛn21 → 她想選
she want select
E: tʰa55 ɕj̲ɑŋ35 ɕj̲ɛn21 (ɥ→ j)
'she wants to select' → (meaningless)

2 ISCE, Substitutions, Anticipations

3. I: p̲ɑŋ55 wɔ35 k̲aj21 wən35-fa21 → 幫我改文法
help I correct grammar
E: k̲ɑŋ55 wɔ35 k̲aj21 wən35-fa21 (p→k)
'help me correct my grammar' → (meaningless)

4. I: kʰaj55-tʂɤ t̲ʂ̲ʰ̲ɤ55-tsɨ t̲ow55-foŋ55 → 開著車子兜風
drive COMP car go around
E: kʰaj55-tʂɤ t̲ɤ55-tsɨ t̲ow55-foŋ55 (tʂʰ→t)
'to drive around for fun' → (meaningless)

3. ISCE, Substitutions, A/P

5. I: tʰa55 njɛn51 y21-jɛn35-ɕɥɛ35 → 她唸語言學
she major linguistics
E: tʰa55 njɛn51 y21-ɥɛn35-ɕɥɛ35 (j→ɥ)
'She majors in linguistics.' → (meaningless)

6. I: pu35 ʂɨ51 ku35-pɑw21 → 不是古堡
NEG is castle
E: pu35 ʂɨ51 pu35-pɑw21 (k→p)
'(that) is not a castle' → (meaningless)

4. ISCE, Substitution, Exchange

7. I: **tsʰ**oŋ35 **tʰ**oŋ35 i35 kɤ ti51-fɑŋ55 tʂʰu55-laj35 →
from same one-CL place come out
E: **tʰ**oŋ35 **tsʰ**oŋ35 i35 kɤ ti51-fɑŋ55 tʂʰu55-laj35 (tsʰ↔tʰ)
'(They) were from the same place' 從同一個地方出來

8. I: tʰjɑw21 tʂan51 tsɨ51 wɔ21 → 挑戰自我
challnage oneself
E: tʰjɑw21 tsan51 tʂɨ51 wɔ21 (tʂ↔ts)
'to challenge oneself' → (meaningless)

5. ISCE, Substitutions, Non-Contextual

9. I: tɕjow51 tsaj51 i35 ʂwən51-tɕjɛn → 就在一瞬間
just in one moment
E: tɕjow51 tsaj51 i35 ʂwən51-tjɛn (tɕ→t)
'just in the moment' → (meaningless)

10. I: maj51-tɤ tʂɤ51-mɤ kwej51 → 賣的這麼貴
sell LINK so expensive
E: maj51-tɤ tʂɤ51-mɤ xwej51 (k→x)
'(she) sold so expensive' → (meaningless)

6. ISCE, Additions, Perseverations

11. I: wɔ21-mən ʂwej51 tʂɑŋ51-pʰoŋ35 → 我們睡帳棚
I-PLUR sleep camp
E: wɔ21-mən ʂwej51 tʂwɑŋ51-pʰoŋ35 (ϕ→w)
'We slept in the camp.' → (meaningless)

12. I: tswɔ35-tʰjɛn55 ɕi21-lɤ i35 tsʰɨ51 → 昨天洗了一次
yesterday wash PERF one time
E: tswɔ35-tʰjɛn55 ɕi21-lɤ ɕi35 tsʰɨ51 (ϕ→ɕ)
'(I) washed it once yesterday.' → (meaningless)

7. ISCE, Additions, Anticipations

13. I: wɔ21 pɑŋ55 ni21 tɑw51-kɤ mi21-tɕjɑŋ55 → 我幫你倒個米漿
I help you serve-CL rice juice
E: wɔ21 pɑŋ55 ni21 tjɑw51-kɤ mi21-tɕjɑŋ55 (ϕ→j)
'I'll serve you a cup of rice milk.' → (meaningless)

14. I: waj51-wej35 xwan35-ljow35 → 外圍環流
peripheral circulation
E: waj51-xwej35 xwan35-ljow35 (ϕ→x)
'peripheral circulation' → (meaningless)

8. ISCE, Additions, A/P

15. I: xɑw51-tʂɨ51-kan21 twan51-kan21-lɤ → 號誌桿斷桿了
traffic sign bar break down PERF
E: xɑw51-tʂɨ51-kwan21 twan51-kan21-lɤ (ϕ→w)
'The traffic sign bar was broken.' → (meaningless)

16. I: tʂən35-li21-ɕja51 ʂu55-pɑw55 ʂwej51-lɤ → 整理下書包睡了
pack book bag sleep PERF
E: tʂən35-li21-ɕja51 ʂu55-pjɑw55 ʂwej51-lɤ (ϕ→j)
'pack your book bag and sleep' → (meaningless)

9. ISCE, Additions, Non-contextual

17. I: wən51 t^{h}i35 → 問題
question
E: <u>x</u>wən51 t^{h}i35 (ϕ→x)
'a question' → (meaningless)

18. I: jɑw51 tʂ^{h}ɨ55 wɔ21 tɕjow51 tʂu21 → 要吃我就煮
want eat I-SG then cook
E: <u>ɕ</u>jɑw51 tʂ^{h}ɨ55 wɔ21 tɕjow51 tʂu21 (ϕ→ɕ)
'(If you) want to eat, I will then cook. ' → (meaningless)

10. ISCE, Omissions, Perseverations

19. I: pən21-ts<u>w</u>ən55 tʂ^{h}u55-ɕjɛn51 lɤ → 本尊出現了
self-mastery appear PERF
E: pən21-tsən55 tʂ^{h}u55-ɕjɛn51 lɤ (w →ϕ)
'The person showed up' → (meaningless)

20. I: xu35-l<u>i</u>35-tɕ<u>in</u>55 →狐狸精
fox spirit
E: xu35-l<u>i</u>35-tɕ<u>i</u>55 (n→ϕ)
'a seductive woman' → (meaningless)

11. ISCE, Omissions, Anticipations

21. I: k^{h}ɤ21-nəŋ35 l<u>j</u>ow35-low51 tʂ^{h}u55 tɕ^{h}in35-ɕy51 →
possible reveal out emotion
E: k^{h}ɤ21-nəŋ35 low35-low51 tʂ^{h}u55 tɕ^{h}in35-ɕy51 (j→ϕ)
'may reveal the emotion' → (meaningless) 可能流露出情緒

22. I: <u>ni</u>21 kən55 <u>i</u>21-tɕ^{h}jɛn35 → 你跟以前
you with before
E: <u>i</u>21 kən55 <u>i</u>21-tɕ^{h}jɛn35 (n→ϕ)
'you used to' → (meaningless)

12. ISCE, Omissions, A/P

23. I: tɕjɑŋ21 tɤ t^{h}jɛn55-xwa55-lwan51-tʂwej51 → 講的天花亂墜
talk LINK ridiculous
E: tɕjɑŋ21 tɤ t^{h}jɛn55-xwa55-lan51-tʂwej51 (w→ϕ)
'talking ridiculously' → (meaningless)

24. I: xwɔ21-jɛn51 ʂan55 pu35 tsaj51 mjɑw35-li51 →
Huoyen mountain NEG in Miaoli (city)
E: xwɔ21-jɛn51 ʂan55 pu35 tsaj51 mɑw35-li51 (j→ϕ)
'Huoyen mountain is not in Miaoli city.' → (meaningless)
火焰山不在苗栗

13. ISCE, Omissions, Non-Contextual

25. I: tʂ^{h}wan51-ljɛn35 lɤ i55 kɤ ku51-ʂɨ51 → 串連了一個故事
connect PERF one CL story
E: tʂ^{h}wan51-jɛn35 lɤ i55 kɤ ku51-ʂɨ51 (l→ϕ)
'a series of stories' → (meaningless)

26. I:tswɔ35-t^{h}jɛn55 ni21 pu35 ʂɨ51 xən21 ʂəŋ55-**tɕ^h**i51 →
yesterday you NEG is very mad
E: tswɔ35-t^{h}jɛn55 ni21 pu35 ʂɨ51 xən21 ʂəŋ55-i51 (tɕ^h→ϕ)
'Weren't you mad yesterday?' → (meaningless)
昨天你不是很生氣

B. Final Single Consonant Errors

14. FSCE, Substitutions, Perseverations

27. I: wɔ21 pu51 kan35 fan21-k^{h}ɑ**ŋ**51 → 我不敢反抗
I-SG NEG dare resist
E: wɔ21 pu51 kan35 fan21-k^{h}an51 (ŋ→n)
'I don't dare to say no.' → (meaningless)

28. I: xən21 tɕ^{h}i35-kwa**j**51 → 很奇怪
very strange
E: xən21 tɕ^{h}i35-kwan51 (j→n)
'very strange' → (meaningless)

15. FSCE, Substitution, Anticipations

29. I: pɑŋ55 t^{h}a55 maj35 tsɑw21-ts^{h}an55 → 幫他買早餐
help he buy breakfast
E: pɑŋ55 t^{h}a55 mɑw35 tsɑw21-ts^{h}an55 (j→w)
'got breakfast for him' → (meaningless)

30. I: fɑŋ51 jɛn21 wɑŋ51 tɕ^{h}y51 → 放眼望去
put eye look go
E: fan51 jɛn21 wɑŋ51 tɕ^{h}y51 (ŋ→n)
'take a broad view' → (meaningless)

16. Final Single Consonant Errors, A/P

31. I: ʂɑŋ51 ʂan55 ʂɑŋ35 ɕɥɛ21 tɤ min35-tʂoŋ51 →
up mountain see snow GEN people
E: ʂɑŋ51 ʂɑŋ55 ʂɑŋ35 ɕɥɛ21 tɤ min35-tʂoŋ51 (n→ŋ)
'people who go up to the mountain to see the snow' → (meaningless)
上山賞雪的民眾

32. I: t^{h}a55 nan35-ʂow51 xən35 tɕjow21 lɤ → 他難受很久了
he suffer very long PERF
E: t^{h}a55 nan35-ʂon51 xən35 tɕjow21 lɤ (w→n)
'He felt bad for a long time.' → (meaningless)

17. Final single Consonant Errors, Exchange

33. I: ʂɑŋ51 tʂan51 → 上站
up website
E: ʂan51 tʂɑŋ51 (n↔ŋ)
'surf on the internet' → (meaningless)

34. I: ni35 xɑw21 fan35 fɑŋ55-i35 → 你好煩，芳儀
you very annoyed Fang-I (person's name)
E: ni35 xɑw21 fɑŋ35 fan55-i35 (n↔ŋ)
'You are very annoyed, Fang-I!' → (meaningless)

18. FSCE, Substitution, Non-Contextual

35. I: ɕi55-wɑŋ51 tʂoŋ55-koŋ51 tɑ**ŋ**55-tɕy35→ 希望中共當局
hope China-communist authority
E: ɕi55-wɑŋ51 tʂoŋ55-koŋ51 ta**n**55-tɕy35 (ŋ→n)
'hope Chinese authority…'→ (meaningless)

36. I: tsa**j**51 ta51 t^{h}aj35-pej21 ti51-tɕ^{h}y55 → 在大台北地區
in big Taipei area
E: tsɑ**w**51 ta51 t^{h}aj35-pej21 ti51-tɕ^{h}y55 (j→w)
'in the area of Taipei' → (meaningless)

19. FSCE, Additions, Perseverations

37. I: fa51-k**w**ɔ35-tɤ saj51 ma21 → 法國的賽馬
France country GEN competition horse
E: fa51-k**w**ɔ35-tɤ saj51 mɑ**w**21 (ϕ→w)
'the horse race in France' → (meaningless)

38. I: tjɛ**n**51-tɕi55 ɕi51 → 電機系
EE Dept.
E: tjɛ**n**51-tɕi**n**55 ɕi51 (ϕ→n)
'the Department of Electrical Engineering' → (meaningless)

20. FSCE, Additions, Anticipations

39. I: i51-tʂɨ35 tsaj51 tɕ^{h}jɑ**ŋ**35 tɕjɑw21 → 一直在牆角
always in wall corner
E: i**ŋ**51-tʂɨ35 tsaj51 tɕ^{h}jɑ**ŋ**35 tɕjɑw21 (ϕ→ŋ)
'always (stand) in the wall corner' → (meaningless)

40. I: wɔ21 ma55 k^{h}a**n**51-lɤ → 我媽看了
I mom see-PERF
E: wɔ21 ma**n**55 k^{h}a**n**51-lɤ (ϕ→n)
'my mother has seen…'→ (meaningless)

21. FSCE, Additions, Non-Contextual

41. I: t^{h}a55 tɕjɛ55-tɤ ʂɨ51 ʂɤ35-mɤ → 他接的是什麼
he take GEN is what
E: t^{h}a55 tɕjɛn55-tɤ ʂɨ51 ʂɤ35-mɤ (ϕ→n)
'What did he take?' → (meaningless)

42. I: t^{h}a55 pu35-xwej51 tswɔ51-ts^{h}aj51 → 她不會作菜
she NEG can cook
E: t^{h}an55 pu35-xwej51 tswɔ51-ts^{h}aj51 (ϕ→n)
'She doesn't know how to cook.' → (meaningless)

22. FSCE, Additions, A/P

43. I: jɑw35 tɕi21 ɕja51 ja35-tʂ^{h}ɨ21 tɕjow51 swan55 lɤ →
bite several CL teeth just sour PERF
E: jɑw35 tɕi21 ɕja51 jɑw35-tʂ^{h}ɨ21 tɕjow51 swan55 lɤ (ϕ→w)
'the teeth got tired after just several bites' → (meaningless)
咬幾下牙齒就痠了

44. I: ni21 tʂɤ51-ʂɨ51 njɛ51 tɕ^{h}in55 tjɛn51-tʂ^{h}ɨ35 xaj35-ʂɨ51 →
you this is Ni-MH battery or
E: ni21 tʂɤ51-ʂɨ51 njɛn51 tɕ^{h}in55 tjɛn51-tʂ^{h}ɨ35 xaj35-ʂɨ51 (ϕ→n)
'Is this the Ni-MH battery or something?' → (meaningless)
你這是鎳氫電池還是

23. FSCE, Omissions, Perseverations

45. I: i35-ta51-twej55 ʐən35 tʂwən21-pej51 → 一大堆人準備
one big CL person prepare
E: i35-ta51-twej55 ʐən35 tʂən21-pej51 (w→ϕ)
'a lot of people prepare'→ (meaningless)

46. I: pa21 la51-jow35 lɑw55 tjɑw51 → 把辣油撈掉
BA spicy oil scoop
E: pa21 la51-jow35 la55 tjɑw51 (w→ϕ)
'to scoop up the spicy oil' → (meaningless)

24. FSCE, Omissions, Anticipations

47. I: tɕʰiŋ55-ɕi21 → 清洗
clean-wash
E: tɕʰi55-ɕi21 (ŋ→ϕ)
'wash' → (meaningless)

48. I: aj55-ma51 tɤ tow55 ʂɨ51 wɔ21 → 挨罵的都是我
scold GEN all is I-SG
E: a55-ma51 tɤ tow55 ʂɨ51 wɔ21 (j→ϕ)
'the one who get scolded is always me' → (meaningless)

25. FSCE, Omissions, A/P

49. I: tʂan51 tsaj51 mən35 pjɛn55 xən21 ljɑŋ35-kʰwaj51 →
stand in door side very cool
E: tʂan51 tsaj51 mən35 pən55 xən21 ljɑŋ35-kʰwaj51 (j→ϕ)
'It was cool standing by the door (for the temperature)' → (meaningless)
站在門邊很涼快

50. I: wɔ21-tɤ tɕjɑw21 tsow21-tɤ xɑw21 tʰoŋ51 →
I-SG GEN feet walk LINK very hurt
E: wɔ21-tɤ tɕjɑ21 tsow21-tɤ xɑw21 tʰoŋ51 (w→ϕ)
'My feet were so hurt by walking.' → (meaningless)
我的腳走的好痛

26. FSCE, Omission, Non-Contextual

51. I: tɕɥɛn55 tɕʰjɛn35 kej21 tsʰɨ35-ʂan51 tɕi55 kwan55 →
donate money give charity institution
E: tɕɥɛn55 tɕʰjɛn35 kej21 tsʰɨ35-ʂan51 tɕi55 kwa55 (n→ϕ)
'donate money to charities' → (meaningless)
捐錢給慈善機關

52. I: tɕjɑŋ51-liŋ21 tʰwej51-ɕjow55 → 將領退休
general retire
E: tɕjɑŋ51-li21 tʰwej51-ɕjow55 (ŋ→ϕ)
'The generals retired.' → (meaningless)

C. Single Vowel Errors

27. SVE, Substitutions, Perseverations

53. I: tɑw51 ɕjɑw51-ɥɛn35 ʐɑw51 i51-tʂow55 → 到校園繞一週
arrive campus around one circle
E: tɑw51 ɕjɑw51-ɥɛn35 ʐɑw51 i51-tʂɑw55 (o→ɑ)
'take a walk on campus' → (meaningless)

54. I: san55-kɤ ɕjɑw21-xaj35 wɔ21 tswej51 kwaj55 →
three-CL kid I most good
E: san55-kɤ ɕjɑw21-xaj35 wɔ21 tswej51 kwej55 (a→e)
'I am the best among three kids' → (meaningless)
三個小孩我最乖

28. SVE, Substitutions, Anticipations

55. I: tɕʰy21-tɑw51 ni21-tɤ ʐən35 → 娶到妳的人
marry-COML you-GEN guy
E: tɕʰi21-tɑw51 ni21-tɤ ʐən35 (y→i)
'the guy who married you'→ (meaningless)

56. I: ly51 xwɑŋ35 sɤ51 ʂu55-tsʰaj51 → 綠黃色蔬菜
green yellow color vegetable
E: ly51 xwɑŋ35 su51 ʂu55-tsʰaj51 (ɤ→u)
'green and yellow vegetables' → (meaningless)

29. Single Vowel Errors, Substitutions, A/P

57. I: xwɑŋ35 tow51 ja35 → 黃豆芽
yellow bean sprouts
E: xwɑŋ35 tɑw51 ja35 (o →ɑ)
'yellow bean sprouts' → (meaningless)

58. I: taj51-pu21 i51-miŋ35 → 逮捕一名
arrest one-CL
E: taj51-pa21 i51-miŋ35 (u→a)
'(the police) arrested a (guy)' → (meaningless)

30. Single Vowel Errors, Substitution, Non-Contextual

59. I: pa21 tʂɤ51 tʂəŋ21-kɤ tɕ^{h}y55-y51 → 把這整個區域
BA this whole area
E: pa21 tʂɤ51 tʂəŋ21-kɤ tɕ^{h}i55-y51 (y→i)
'make this whole area…' → (meaningless)

60. I: tɕ^{h}jɑŋ35-tjɑw51 tan55-wej51 → 強調單位
emphasize unit
E: tɕ^{h}jɑŋ35-tjow51 tan55-wej51 (ɑ→o)
'emphasize the unit' → (meaningless)

31. Single Vowel, Additions, Perseverations

61. I: k^{h}ɤ21-ʂɨ51 na51 ʂɨ51 jɑw51 ɕi35 kej21 ta51-tɕja55 tɤ →
but that is want wash for everybody
E:k^{h}ɤ21-ʂɨ51 na51 ʂɨ51 jɑw51 ɕjɛ35 kej21 ta51-tɕja55 tɤ (ϕ→ɛ)
'but that was washed for everybody' → (meaningless)
可是那是要洗給大家的

62. I: ej55 aj55 t^{h}i55 → 美國在台協會
A I T
E: ej55 aj55 t^{h}ej55 (ϕ→e)
'American Institute in Taiwan' → (meaningless)

32. Single Vowel, Omissions, Perseverations

63. I: tow55 fej55-tʂ^{h}ɑŋ35 lej51 lɤ → 都非常累了
all very tired PERF
E: tow55 fej55-tʂ^{h}ɑŋ35 li51 lɤ (e→ϕ)
'all felt very tired' → (meaningless)

64. I: ni21 tɕin51-ʂɨ51 k^{h}an51 pu35 tɕjɛn51 → 你近視看不見
you near-sighted see NEG see
E: ni21 tɕin51-ʂɨ51 k^{h}an51 pu35 tɕin51 (ɛ→ϕ)
'You cannot see because you are near-sighted.' → (meaningless)

33. Single Vowel, Omissions, Anticipations

65. I: swɔ35-jow21 ɕin55-ʂən55 → 所有新生
all new-student
E: su35-jow21 ɕin55-ʂən55 (ɔ→ϕ)
'all freshmen' → (meaningless)

66. I: tɕja55-tɤ mjɛn51-ɕjɑŋ51 xən35 xɑw21 →佳的面相很好
Chia-GEN physiognomy very good
E: tɕja55-tɤ min51-ɕjɑŋ51 xən35 xɑw21 (ɛ→ϕ)
'Jia just has a lucky face' → (meaningless)

34 Vowel & Glide Interaction

67. I: pej51 koŋ55-pu51 → 被公佈
PASS announce
E: pej51 koŋ55-pi51 (u→j→i)
'be announced' → (meaningless)

68. I: jow51-jɑw51 tʂwən21-pej51 ɕja51 ɕɥɛ35-tɕʰi35-lɤ →
again-need prepare next semester-PERF
E:jow51-jɑw51 tʂwən21-pej51 ɕja51 ɕɥɛ35-tɕʰy35-lɤ (i→ɥ→y)
'(I) need to prepare work for next semester again!' → (meaningless)
又要準備下學期了

D. Larger Unit Errors

35. LUE, Substitutions, Perseverations

69. I: pjɛ35 xwa55 tɕʰjɛn35 lɑŋ51-fej51 lɤ → 别花錢浪費了
NEG spend money waste PERF
E: pjɛ35 xwa55 tɕʰjɛn35 lɑŋ51-xwej51 lɤ (f→xw)
'Don't waste too much money on it.' → (meaningless)

70. I: ni35 i21-tɕʰjɛn35 jow21 ɕɥɛ35-ma → 你以前有學嗎
you before have learn-question mark
E: ni35 i21-tɕʰjɛn35 jow21 ɕjow35-ma (ɥɛ→jow)
'Have you learned it before?' → (meaningless)

36. LUE, Substitutions, Anticipation

71. I:mej21-kwɔ35 jow35 **m**ej21-**kw**ɔ35-tɤ xɑw21→美國有美國的好
    US has US GEN good
    E: mej21-kwɔ35 jow35 **kw**ej21-**kw**ɔ35-tɤ xɑw21 (m→kw)
    'The U.S. has something nice.' → (meaningless)

72. I: kən55 t^h**a**55 ʂ**wɔ**55 jɛ21 pu35 xwej51 toŋ21→ 跟她說也不會懂
    with her say also NEG can understand
    E: kən55 t^h**wɔ**55 ʂ**wɔ**55 jɛ21 pu35 xwej51 toŋ21 (a→wɔ)
    'even talking to her, she won't be able to get it' → (meaningless)

37. LUE, Substitutions, A/P

73. I: **jow**35 s**wɔ**21 tɕ^h**jow**35 → 有所求
    have so ask
    E: **jow**35 ɕ**jow**21 tɕ^h**jow**35 (wɔ→jow)
    'have something to ask' → (meaningless)

74. I: t^{h}a55 p**ən**21-l**aj**35 tɕjow51 x**ən**21 p**ən**51 → 她本來就很笨
    she originally exactly very stupid
    E: t^{h}a55 p**ən**21-l**ən** 35 tɕjow51 x**ən**21 p**ən**51 (aj→ən)
    'She is always stupid.' → (meaningless)

38. LUE, Substitutions, Non-contextual

75. I: na51-kɤ i55-fu35 na35-li21 xwej51 xən21 **kw**ej51 →
    that-CL cloth why can very expensive
    E: na51-kɤ i55-fu35 na35-li21 xwej51 xən21 **p**ej51 (kw→p)
    'That cloth is not as expensive as you think.' → (meaningless)
    那個衣服哪裡會很貴

76. I: tʂɨ21 x**ɤ**55-lɤ i51 k^{h}ow21 → 只喝了一口
    only drink one mouth
    E: tʂɨ21 x**wa**55-lɤ i51 k^{h}ow21 (ɤ→wa)
    'only drink a little' → (meaningless)

39. LUE, Anticipations, Omissions

77. I: sw**<u>ən</u>**55 jɛn51 tsɨ55 → 孫燕姿
Suen Yan Zi (person's name)
E: s**<u>u</u>**55 jɛn51 tsɨ55 (ən→u)
'Suen Yan Zi (a singer's name)' → (meaningless)

78. I: kən55 tʰa55 l**<u>jɛn</u>**35-lwɔ51 kan21-tɕɥɛ35 kwaj51-kwaj51 tɤ →
with he contact feel strange
E: kən55 tʰa55 l<u>i</u>35-lwɔ51 kan21-tɕɥɛ35 kwaj51-kwaj51 tɤ
'(I) feel a little strange to contact him.' → (meaningless) (ɛn→i)
跟他連絡感覺怪怪的

<u>E. Whole Syllable Errors</u>

40. WSE, Substitutions, Perseverations

79. I: **<u>kɤ</u>**55 ni21 <u>tu</u>51-tsɨ ɤ51 tsɨ51-tɕi21 tʂʰɨ55 →
brother you stomach hungry yourself eat
E: **<u>kɤ</u>**55 ni21 **<u>kɤ</u>**51-tsɨ ɤ51 tsɨ51-tɕi21 tʂʰɨ55 (tu→kɤ)
'Brother, if you are hungry, help yourself' → (meaningless)
哥你肚子餓自己吃

80. I: **<u>ɕi</u>**51 ʂɑŋ51 jow21-kɤ **<u>ʂɨ</u>**35-jɛn51-ʂɨ51 → 系上有個實驗室
department in has CL lab
E: **<u>ɕi</u>**51 ʂɑŋ51 jow21-kɤ **<u>ɕi</u>**35-jɛn51-ʂɨ51 (ʂɨ→ɕi)
'There is a lab in the department'→ (meaningless)

41. WSE, Substitutions, Anticipations

81. I: jow21 <u>i</u>51-tɤ **<u>tɕʰɥɛn</u>**35-li51 → 有益的權利
have benefit-LINK right
E: jow21 **<u>tɕʰɥɛn</u>**51-tɤ **<u>tɕʰɥɛn</u>**35-li51 (i→tɕʰɥɛn)
'get a right benefit' → (meaningless)

82. I: pu51 **<u>na</u>**35 ʂow21-tʰɑw51 xən35 **<u>lən</u>**21-jɛ → 不拿手套很冷耶
NEG take gloves very cold-particle
E: pu51 **<u>lən</u>**35 ʂow21-tʰɑw51 xən35 **<u>lən</u>**21-jɛ (na→lən)
'It's very cold without gloves!' → (meaningless)

42. WSE, Exchanges

83. I: **tsɨ**51 wɔ21 **tɕjɛ**51-ʂɑw51 → 自我介紹
REF I introduce
E: **tɕjɛ**51 wɔ21 **tsɨ**51-ʂɑw51 (tsɨ↔ tɕjɛ)
'introduce yourself' → (meaningless)

84. I: tsɑw35-**tɕjɛn**21-**kɑŋ**55 mej35 tʂʰɨ55 tɑw51 → 草翦剛沒吃到
Person's name NEG eat COMP
E: tsɑw35-**kɑŋ**21-**tɕjɛn** 55 mej35 tʂʰɨ55 tɑw51 (tɕjɛn↔kɑŋ)
'Cao Jian-Gang missed eating' → (meaningless)

F. Tone Errors

43. TE, Substitutions, Perseverations

85. I: wɔ21 tsɨ51-tɕi**35** ta**21**-tjɛn51-xwa51 → 我自己打電話
I REFL make phone call
E: wɔ21 tsɨ51-tɕi**35** ta**35**-tjɛn51-xwa51 (21→35)
'I made a phone call by myself.' → (meaningless)

86. I: njɛn**35**-tɕi**51** jɛ21 kʰwaj51 san55-ʂɨ35 → 年紀也快三十
age also close thirty
E: njɛn**35**-tɕi**35** jɛ21 kʰwaj51 san55-ʂɨ35 (51→35)
'(her) age was almost 30' → (meaningless)

44. TE, Substitutions, Anticipations

87. I: na51 kɤ**55** jow21 kow51 nan**35** tʰiŋ55 → 那歌有夠難聽
that song have enough hard listen
E: na51 kɤ**35** jow21 kow51 nan**35** tʰiŋ55 (55→35)
'That song is really terrible.' → (meaningless)

88. I: wɔ21 xaj35 i**21**-wej35 tʰa**55** xwej51 ɕi21-xwan55 wɔ21 →
I-SG still think (wrongly) he will like I
E: wɔ21 xaj35 i**55**-wej35 tʰa**55** xwej51 ɕi21-xwan55 wɔ21
'I thought that he would like me' → (meaningless) (21→55)
我還以為他會喜歡我

45. TE, Substitutions, A/P

89. I: tu55-ʂɨ**51** tɕi**51**-xwa**51** kwej**55**-xwa**51**-tɤ xən35 xɑw21 →
city plan design -LINK very good
E: tu55-ʂɨ**51** tɕi**51**-xwa**51** kwej**51**-xwa**51**-tɤ xən35 xɑw21
'The city plan is well-designed.' → (meaningless) (55→51)
都市計劃規劃的很好

90. I: tɕjɑw**51** ni**21** ti**51**-ti laj35 pɑŋ55-mɑŋ35 → 叫你弟弟來幫忙
call you brother come help
E: tɕjɑw**51** ni**51** ti**51**-ti laj35 pɑŋ55-mɑŋ35 (21→51)
'call your brother for help' → (meaningless)

46. TE, Exchanges

91. I: ljɑŋ**35** wan**21** t^{h}ɑŋ55 mjɛn51 → 兩碗湯麵
two bowl soup noodle
E: ljɑŋ**21** wan**35** t^{h}ɑŋ55 mjɛn51 (21↔35)
'two bowls of noodle soup' → (meaningless)
92. I: pən**21**-laj**35** wɔ21 tɕjow51-ʂɨ51 tʂɤ51-jɑŋ51 ɕjɑŋ21 →
originally I just this think
E: pən**35**-laj**21** wɔ21 tɕjow51-ʂɨ51 tʂɤ51-jɑŋ51 ɕjɑŋ21 (21↔35)
'That was exactly what I thought.' → (meaningless)
本來我就是這樣想

47. TE, Non-Contextual

93. I: ni21-mən tɕjow51 tʂɨ**21** xwej51 → 你們就只會
you-PL just only can
E: ni21-mən tɕjow51 tʂɨ**55** xwej51 (21→55)
'you can only' → (meaningless)

94. I: tsɑw21-ts^{h}an**55** tow55-ʂɨ51 kej21 t^{h}a55 taj51-tʂɤ →
breakfast all give he bring COMP
E: tsɑw21-ts^{h}an**35** tow55-ʂɨ51 kej21 t^{h}a55 taj51-tʂɤ (55→35)
'always bring the breakfast for him' → (meaningless)
早餐都是給他帶著

48. Syntagmatic Blends (Telescopings)

95. I: kən55 **tɕ**jɛ35 **i55**-mwɔ35-i35-jɑŋ51 → 跟姊一模一樣
with sister one-size-one-kind
E: kən55 **tɕi55**-mwɔ35-i35-jɑŋ51
'exactly the same as my sister' → (meaningless)

96. I: xoŋ35 s**ɤ51** **tʂ^{h}**ɤ55-tsɨ → 紅色車子
red color car-noun suffix
E: xoŋ35 **tʂ^{h}ɤ51**-tsɨ
'a red car' → (meaningless)

G. Feature Errors

49. FE, Aspirations

97. I: **tʂ**wa55 **k^{h}**waj51 **t^{h}**u21-sɨ55 mjɛn51-pɑw55 →
grab CL toast bread
E: **tʂ^{h}**wa55 **k^{h}**waj51 **t^{h}**u21-sɨ55 mjɛn51-pɑw55 (tʂ→tʂ^{h})
'grab a piece of toast' → (meaningless)
抓塊土司麵包

98. I: **tʂ**ən21-t^{h}jɛn55 **tɕ**jow51 **p^{h}**ɑw51-t^{h}ɑŋ55 → 整天就泡湯
all day just gone
E: **tʂ**ən21-t^{h}jɛn55 **tɕ**jow51 **p**ɑw51-t^{h}ɑŋ55 (p^{h}→p)
'the whole day has just gone' → (meaningless)

50. Place of articulation

99. I: **k**waj51 **t^{h}**a55 → 怪她
blame her
E: **k**waj51 **k^{h}**a55 (t^{h}→k^{h})
'blame her' → (meaningless)

100. I: wej51-ʂɤ35-**m**ɤ jɑw51 **m**aj21 **t**jɛn51-tʂ^{h}ɨ35 →為什麼要買電池
why need buy battery
E: wej51-ʂɤ35-**m**ɤ jɑw51 **m**aj21 **p**jɛn51-tʂ^{h}ɨ35 (t→p)
'why need to buy a battery?' → (meaningless)

51. Multiple errors

101. I: p̲ən55-tɑw51 **k̲o̲w̲**35 ɕjɛ21 → 碰到狗血
touch dog blood
E: **p̲**ən55-tɑw51 **p̲w̲ɔ̲**35 ɕjɛ21
'touched the dog's blood' → (meaningless)

102. I: ʂwɔ̲51-ʂɨ51 jɑw51 n**j̲ɛ̲**n51 → 碩士要念
master need study
E: ʂw**e̲j̲**51-ʂɨ51 jɑw51 n**j̲ɛ̲**n51
'to fulfill MA degree needs…'→ (meaningless)
([jɛ] is anticipated, and then [j] and [ɛ] exchange to produce [ej])

H. Lexical Access Errors

52. Word Blends

103. I: wɔ35 ɕjɑŋ21 t^h**a̲n̲3̲5̲**/**ʂ̲**wɔ55 → 我想談/說
I-SG want talk/speak
E: wɔ35 ɕjɑŋ21 **ʂ̲a̲n̲3̲5̲**
'I want to talk' → (meaningless)

104. I: xən21 m**a̲n̲**51 /**p̲**ən51 → 很慢/笨
very slow / stupid
E: xən21 **p̲a̲n̲**51
'very slow/stupid' → (meaningless)

53. Word Errors, Deletions

105. I: ni21 jow51 pu51 **x̲ɤ̲5̲5̲** k^ha55-fej55 →
you then NEG drink coffee
E: ni21 jow51 pu51 k^ha55-fej55
'You didn't drink coffee at all.' → (meaningless)
你又不喝咖啡→你又不咖啡

106. I: tsaj51 **k̲ʰ̲ɤ̲5̲1̲**-t^hiŋ55 k^han51 tjɛn51-ʂɨ51 →
PREP living room watch TV
E: tsaj51 t^hiŋ55 k^han51 tjɛn51-ʂɨ51
'watching TV in the living room' → (meaningless)
在客廳看電視→在廳看電視

54. Word Errors, Additions

107. I: jɛ21 ljɛn35-**taj51** tʂɤ ni21 tɤ miŋ51-ɥən51 →
also involve COMP you GEN destiny
E: jɛ21 **taj51**…ljɛn35-**taj51** tʂɤ ni21 tɤ miŋ51-ɥən51
'Your destiny is also involved.' → (meaningless)
也連帶著你的命運→也帶..連帶著你的命運

108. I: tʂɤ51-kɤ ti51-fɑŋ55 ta51-kaj51 xən21-**twɔ55** ɕjɑŋ55 tʂən51 →
this place possibly very much village town
E: tʂɤ51-kɤ ti51-fɑŋ55 ta51-kaj51 **twɔ55** xən21-**twɔ55** ɕjɑŋ55 tʂən51
'There are possibly many villages and towns here.' → (meaningless)
這個地方大概很多鄉鎮→這個地方大概多..很多鄉鎮

55. Morphology

109. I: tʂɑw51 tɕi21-**tʂɑŋ55** ɕjɑŋ51 → 照幾張相→照幾隻相
take several-CL picture
E: tʂɑw51 tɕi21-**tʂɨ55** ɕjɑŋ51
CL
'take some (pieces) pictures' → 'take some (this CL is only used for animals since the topic in the utterance is about dogs)'

110. I: wɔ21-mən tow55-ʂɨ51 ni21-**tɤ** ow21-ɕjɑŋ51 →
I -PL all are you-GEN idol
E: wɔ21-mən tow55-ʂɨ51 ni21-**mən** ow21-ɕjɑŋ51
PLUR
'we are all your (single) idol' → 'we are all your (plural) idol'
我們都是你的偶像→我們都是你們偶像

56. Lexical Substitution Errors

111. I: mej35 jow21 i35-kɤ **kʰoŋ55**-tɤ→
NEG have one-CL empty GEN
E: mej35 jow21 i35-kɤ **man21**-tɤ
full
'There was no empty (bottle.)' → 'There was no full (bottle.)'
沒有一個空的→沒有一個滿的

112. I: ɕɥɛ35-ɕjɑw51-tɤ **tɕin51-tu51** →
school -GEN schedule
E: ɕɥɛ35-ɕjɑw51-tɤ **tɕin51-pu51**
progress
'the schedule of school' → 'the progress of school'
學校的進度→學校的進步

57. Lexical Access Errors, Exchanges

113.I:**k^han51** kwɔ35-wən35 pu35 jɑw51 **t^hiŋ55** ʂow55-in55-tɕi55 →
see Chinese NEG need listen to radio
E: **t^hiŋ55** kwɔ35-wən35 pu35 jɑw51 **k^han51** ʂow55-in55-tɕi55
listen to see
'Don't listen to the radio when studying Chinese' → 'Don't study the radio when listening to Chinese'
看國文不要聽收音機 → 聽國文不要看收音機

114.I:i51-tʂɨ55 **mu**35 kow21 ʂən55-lɤ san55-tʂɨ55 **ɕjɑw**35 kow21→
one-CL female dog bear-PERF three-CL little dog
E: i51-tʂɨ55 **ɕjɑw**35 kow21 ʂən55-lɤ san55-tʂɨ55 **mu** 35 kow21
little female
'one dog gives birth to three puppies→one puppy gives birth to three (female) dogs'一隻母狗生了三隻小狗 → 一隻小狗生了三隻母狗

58. Syntagmatic Lexical Errors

115. I: wɔ21 tswej51-tɕin51 $tʂ^h$ɑŋ35 tsaj51 **pi35-tsɨ** ʂɑŋ51 tʂɑŋ21
I recently often prog nose prep grow
t**ow51-tsɨ** →
pimples
E: wɔ21 tswej51-tɕin51 $tʂ^h$ɑŋ35 tsaj51 tʂɑŋ21 **pi35-tsɨ**
nose
'Recently I often have pimples on my nose.' → 'Recently I often have nose.' 我最近常在鼻子上長痘子→ 我最近常在長鼻子

116. I:jɑw55-$tɕ^h$jow35 **ɕyn51-ljɛn51** tow55 xwej51 xən21 **jɛn35-kɤ35**
request train all will very strict
→ E: jɑw55-$tɕ^h$jow35 tow55 xwej51 xən21 **ɕyn51-ljɛn51**
train
'The required trainings will all be very strict' → 'The request will be trained.' 要求訓練都會很嚴格→ 要求都會很訓練

59. Syntactic Errors

117. I: t^ha55 i21-tɕiŋ55 aj55 t^ha55 pa51-pa-tɤ ma51-lɤ →
she already PASS she father GEN blame-PERF
E: t^ha55 i21-tɕiŋ55 **pej51** aj55 t^ha55 pa51-pa-tɤ ma51-lɤ
PASS PASS
'she was already scolded by her father' → (ungrammatical)
她已經挨她爸爸的罵了→ 她已經被挨她爸爸的罵了

Appendix II
Aphasic Errors

The errors listed in this Appendix are selected from a corpus of 3000 paraphasias in Mandarin. They have been selected to show a wide variety of errors which occur in aphasic speech.

A. Initial Single Consonant Errors (Initial or Prenuclear glides)

1. ISCE, Substitutions, Perseverations

1. I: **x**wej55-**f**u51 → 恢復
recover
E: **x**wej55-**x**u51 (f→x)
'recover'→(meaningless)

2. I: **l**i51-**ʐ**wən51 → 利潤
profits
E: **l**i51-**l**wən51 (ʐ→l)
'profits'→meaningless

2. ISCE, Substitutions, Anticipations

3. I: kwan55-**tɕ**jɛn51-**ɕ**iŋ51 → 關鍵性
key character
E: kwan55-**ɕ**jɛn51-**ɕ**iŋ51 (tɕ→ɕ)
'a crucial point'→meaningless

4. I: ljɛn35-**ɕ**y51-t**ɕ**y51 → 連續劇
serial opera
E: ljɛn35-**tɕ**y51-t**ɕ**y51 (ɕ→tɕ)
'soap opera'→meaningless

3. ISCE, Substitutions, A/P

5. I: **p**a55-**f**ən55-**p**ɑw21 → 八分飽
   eight- -full
   E: **p**a55-**p**ən55-**p**ɑw21 (f→p)
   'the 80% full'→meaningless

4. ISCE, Substitution, Exchange

6. I: tsaj51 **ts**wɔ51-**k**wɔ51-tɕʰy51→再坐過去
   again sit-past-go
   E: tsaj51 **k**wɔ51-**ts**wɔ51-tɕʰy51 (ts↔k)
   'sat over there'→meaningless

5. ISCE, Substitutions, Non-Contextual

7. I: ma21-**l**u51 → 馬路
   horse-road
   E: ma21-**x**u51 (l→x)
   'a road'→meaningless

8. I: **tʂʰ**ɑw55 pi21-tɕi51 → 抄筆記
   copy pen-note
   E: **kʰ**ɑw55 pi21-tɕi51 (tʂʰ→kʰ)
   'take notes'→meaningless

6. ISCE, Additions, Perseverations

9. I: **pʰ**iŋ35-wən21 → 平穩
   equal-stable
   E: **pʰ**iŋ35-**pʰ**wən21 (ϕ→pʰ)
   'steady' →meaningless

7. ISCE, Additions, Anticipations

10. I: jɛ51-**tɕ**jɛn55-pu51 → 夜間部
    evening department
    E: **tɕ**jɛ51-**tɕ**jɛn55-pu51 (ϕ→tɕ)
    'evening school'→meaningless

11. I: i21-**tɕ**i35 → 以及
and
E: **tɕ**i21-**tɕ**i35 (ϕ→tɕ)
'and'→ meaningless

8. ISCE, Additions, A/P

12. I: jow35-laj35-jow35-tɕʰy51 → 游來游去
swim come swim go
E: **l**jow35-laj35-**l**jow35-tɕʰy51 (ϕ→l)
'swimming back and forth'→meaningless

9. ISCE, Additions, Non-contextual

13. I: wɔ51-ʂow21 → 握手
grasp-hand
E: **k**wɔ51-ʂow21 (ϕ→k)
'shake hands'→meaningless

14. I: wan21-ʂɑŋ51 → 晚上
night-up
E: **f**wan21-ʂɑŋ51 (ϕ→f)
'night'→meaningless

10. ISCE, Omissions, Non-Contextual

15. I: **l**jɑw35-tʰjɛn55 → 聊天
chat
E: jɑw35-tʰjɛn55 (l→ϕ)
'chat'→meaningless

16. I: **n**jow21-ɥɛ55 → 紐約
New York
E: jow21-ɥɛ55 (n→ϕ)
'New York'→meaningless

B. Final Single Consonant Errors

<u>11. *FSCE, Substitutions, Perseverations*</u>

17. I: pɑŋ55-wa**<u>n</u>**21 → 傍晚
    evening
    E: pɑŋ55-wɑ**ŋ**21 (n→ŋ)
    'nightfall'→meaningless

<u>*12. FSCE, Substitution, Anticipations*</u>

18. I: kwa**<u>n</u>**55-kwɑ**ŋ**55 wən55-tɕʰɥɛn35 → 觀光溫泉
    sght-seeing warm spring
    E: kwɑ**ŋ**55-kwɑ**ŋ**55 wən55-tɕʰɥɛn35 (n→ŋ)
    'the hot SPA spring'→meaningless

19. I: tʰa**<u>n</u>**35 kɑ**ŋ55**-tɕʰin35 → 彈鋼琴
    play piano
    E: tʰɑ**ŋ**35-kɑ**ŋ55**-tɕʰin35 (n→ŋ)
    'play the piano'→meaningless

<u>*13. FSCE, Substitution, Non-Contextual*</u>

20. I: tɕʰiŋ55-tɑ**<u>w</u>**51-fu55 → 清道夫
    clean road man
    E: tɕʰiŋ55-ta**<u>j</u>**51-fu55 (w→j)
    'street cleaners'→meaningless

<u>*14. FSCE, Additions, Perseverations*</u>

21. I: tɕjɑ**<u>w</u>**21-tʰa51-tʂʰɤ55 → 腳踏車
    foot step car
    E: tɕjɑ**<u>w</u>**21-tʰɑ**<u>w</u>**51-tʂʰɤ55 (ϕ→w)
    'a bicycle'→meaningless

15. FSCE, Additions, Anticipations

22. I: ma21 iŋ55-tɕjow21 → 馬英九
Ma Ying-jeou (Taipei mayor)
E: ma**n**21 iŋ55-tɕjow21 (ϕ→n)
'Ma, Ying-jeou' →meaningless

16. FSCE, Additions, Non-Contextual

23. I: ʂa51-tʂʰɤ55 → 煞車
brake
E: ʂa**n**51-tʂʰɤ55 (ϕ→n)
'to put on the brakes'→meaningless

17. FSCE, Omissions, Perseverations

24. I: tɕi55-tɕi**n**55-xwej51 → 基金會
foundation
E: tɕi55-tɕi55-xwej51 (n→ϕ)
'Foundation'→meaningless

25. I: ta51-pa**j**35-tsʰaj51 → 大白菜
big-white-vegetable
E: ta51-pa35-tsʰaj51 (j→ϕ)
'cabbages'→meaningless

18. FSCE, Omissions, Anticipations

26. I: li**n**35 tɑw51 y̬21 → 淋到雨
sprinkle COMP rain
E: li35 tɑw51 y̬21 (n→ϕ)
'to get wet in the rain'→meningless

19. FSCE, Omission, Non-Contextual

27. I: pʰi**ŋ**35-tʂʰɑŋ35 → 平常
usual
E: pʰi35-tʂʰɑŋ35 (ŋ→ϕ)
'as usual'→meaningless

28. I: kɑŋ55-tɕ^{h}i**n**35 → 鋼琴
steel-piano
E: kɑŋ55-tɕ^{h}i35 (n→ϕ)
'the piano'→meaningless

C. Single Vowel Errors

20. SVE, Substitutions, Perseverations

29. I: tsɨ51-tɕ**i**21 p^{h}ɑw21-tɕ^{h}**y**51→自己跑去
self run-go
E: tsɨ51-tɕ**i**21 p^{h}ɑw21-tɕ^{h}**i**51 (y→i)
'go there by himself'→meaningless

30. I: koŋ55-n**ə**ŋ35 → 功能
function
E: koŋ55-n**o**ŋ35 (ə→o)
'function'→meaningless

21. SVE, Substitutions, Anticipations

31. I: tɕ**i**51-ɕ**y**51 → 繼續
continue
E: tɕ**y**51-ɕ**y**51 (i→y)
'continue'→meaningless

32. I: tsw**ɔ**51-tɤ -x**ɑ**w21 → 做得好
do- LINK well
E: tsw**ɔ**51-tɤ -x**o**w21 (ɑ→o)
'well-done'→meaningless

22. Single Vowel Errors, Substitution, Non-Contextual

33. I: ɕ**i**21-xwan55 → 喜歡
like
E: ɕ**y**21-xwan55 (i→y)
'like'→meaningless

34\. I: tɕ^{h}i51-**ɤ**35 → 企鵝
penguin
E: tɕ^{h}i51-**ɚ**35 (ɤ→ɚ)
'a penguin'→menaingless

23. Single Vowel, Additions, Anticipations

35\. I: ts^{h}u55-ts^{h}**ɑ**w55 → 粗糙
coarse
E: ts^{h}**ɑ**w55-ts^{h}**ɑ**w55 (ϕ→a)
'rugged'→meaningless

36\. I: kw**ɔ**51 ma21-l**u**51 → 過馬路
cross horse road
E: k**u**51 ma21-l**u**51 (ɔ→ϕ)
'cross the street'→meaningless

24. Single Vowel, Addition, Non-contextual

37\. I: pi21-tɕi51 → 筆記
pen note
E: p**e**j21-tɕi51 (ϕ→e)
'note'→meaningless

38\. I: taj51 tɕ^{h}**jɛ**n35 → 帶錢
bring money
E: taj51 tɕ^{h}in35 (ϕ→ɛ)
'bring money'→meaningless

25. Single Vowel, Omissions, Anticipations

39\. I: ɕj**ɛ**21 p**i**21-tɕjɑw51 ʂɑw21→寫比較少
write more few
E: ɕi21 p**i**21-tɕjɑw51 ʂɑw21 (ɛ→ϕ)
'write fewer'→meaningless

26. Vowel & Glide Interaction

40. I: **y**21-**j**ɛn35 tʂɨ51-ljɑw35 → 語言治療
language therapy
E: **i**21-**j**ɛn35 tʂɨ51-ljɑw35 (y→j→i)
'language therapy'→meaningless

D. Larger Unit Errors

27. LUE, Substitutions, Non-contextual

41. I: **tɕʰj**ow35-ɥɛn35 → 球員
ball staff
E: **tʂʰ**ow35-ɥɛn35 (tɕʰj→tʂʰ)
'ball-game player'→meaningless

42. I: **ɕj**ɑw21-ɕɥɛ35 → 小學
small learn
E: **s**ɑw21-ɕɥɛ35 (**ɕ**j→s)
'elementary schools' → meaningless

28. WSE, Substitutions, Anticipations

43. I: **pej**21-fej55-tjɛ35-iŋ21 → 北非諜影
north Africa agent shadow
E: **tjɛ**21-fej55-tjɛ35-iŋ21 (pej→ tjɛ)
' Casablanca' → meaningless

44. I: **mej**21-kɤ **xaj**35-tsɨ → 每個孩子
every CL child
E: **xaj**21-kɤ **xaj**35-tsɨ (mej→xaj)
'every child'→meaningless

F. Tone Errors

29. TE, Substitutions, Perseverations

45. I: **tɕ^{h}**i**35**-tʂ^{h}ɤ**55** → 騎車
ride vehicle
E: **tɕ^{h}**i**55**-tʂ^{h}ɤ**55** (35→55)
'ride a bike'→meaningless

46. I: xɤ**55**-wan**35** → 喝完
drink finish
E: xɤ**55**-wan**55** (35→55)
'finish the drink'→meaningless

30. TE, Substitutions, Anticipations

47. I: t^{h}aj**35**-wan**55** → 台灣
Taiwan
E: t^{h}aj**55**-wan**55** (35→55)
'Taiwan'→ meaningless

48. I: tɕjɛ**55**-tɑw**51**→接到
receive COMP
E: tɕjɛ**51**-tɑw**51** (55→51)
'catch'→meaningless

31.TE, Substitutions, A/P

49. I: p^{h}ɑw35 u21-tɕɥɛn**55** ta**51**-ɥɛ**55** ʂɨ51 → 跑五圈大約是
run five CL probable is
E: p^{h}ɑw35 u21-tɕɥɛn**55** ta**55**-ɥɛ**55** ʂɨ51 (51→55)
'running five circles is about'→meaningless

32.TE, Exchanges

50. I: i**51**-tɕi**35** → 亦即
is
E: i**35**-tɕi**51** (51 ↔35)
'that is'→meaningless

51. I: xən**35** t^{h}ɑw21-jɛn**51** → 很討厭
    very hateful
    E: xən**51** t^{h}ɑw21-jɛn**35** (35↔51)
    'hateful'→meaningless

33.TE, Non-Contextual

52. I: ɕjɑw**55**-fɑŋ35 → 消防
    delete protect
    E: ɕjɑw**51**-fɑŋ35 (55→51)
    'fire fighting' →meaningless

53. I: san**55**-t^{h}jɛn55 → 三天
    three day
    E: san**51**-t^{h}jɛn55 (55→51)
    'three days'→meaningless

34. TE, Additions

54. I: na51-kɤ→那個
    that
    E: na51-kɤ**35** (ϕ→35)
    'that'→meaningless

G. Feature Errors

35. FE, Aspirations

55. I: **p**u35-**k^{h}**an51 → 不看
    not-look
    E: **p^{h}**u-**k^{h}**an51 (p→p^{h})
    'don't watch'→meaningless

56. I: **p**ɑw55 **tɕ^{h}**i21 → 包起
    pack up
    E: **p^{h}**ɑw55- **tɕ^{h}**i21 (p→p^{h})
    'to pack'→meaningless

36. Place of articulation

57. I: **t**a21-pʰaj35 → 打牌
hit card
E: **p**a21- pʰaj35 (t→p)
'play poker'→meaningless

58. I: **t**ʰaj35-pej21 → 台北
Taipei
E: **p**ʰaj35-pej21 (tʰ→pʰ)
'Taipei'→meaningless

37. Multiple Errors

59. I: tɕin55-tʰjɛ**n 55** → 今天
today
E: tɕin55-tʰjɛ**35** (n →ϕ; 55 → 35)
'today'→meaningless

60. I: ts<u>wɔ</u>51 tʂʰɤ55 → 坐車
sit vehicle
E: ts**ow21** tʂʰɤ55 (w↔ɔ; 51 → 21)
'by bus'→meaningless

H. Lexical Access Errors

38. Morphology

61. I: i35-<u>kɤ</u> ʂwej35-tʰoŋ21 一個水桶→一條水桶
one-CL water bucket
E: i35-**tʰjɑw35** ʂwej35-tʰoŋ21
'a bucket' → meaningless

62. I: tʰa55-<u>tɤ</u>→ 他的→他們
he-GEN
E: tʰa55-**mən**
he-PLUR
'his'→'they'

<u>39. Lexical substitution errors</u>

63. I: ʂɑŋ51-li21-paj51→ 上禮拜→下禮拜
last week
E: **<u>ɕja51</u>**-li21-paj51
next
'last week→next week'

64. I: kʰan51 ʂu55→ 看書→看電視
watch book
E: kʰan51 **<u>tjɛn51-ʂɨ51</u>**
TV
'read books' → 'watch TV'

<u>40. Lexical Access Errors, Exchanges</u>

65. I: **<u>fu51-tɕin51</u>** -tɤ **<u>lin35-tɕy55</u>**→ 附近的鄰居→鄰居的附近
attach-close-GEN neighbor
E: **<u>lin35-tɕy</u>**55-tɤ **<u>fu51-tɕin51</u>**
neighbor-GEN attach-close
'the neighbors in the vicinity' → 'close by the neighbor'

66. I: **<u>ɚ35</u>** **<u>ny21</u>**→ 兒女→女兒
son daughter
E: **<u>ny21</u>** **<u>ɚ35</u>**
daughter son
'child' → 'daughter'