PERCEPTION OF FOREIGN-ACCENTED CLEAR SPEECH BY YOUNGER AND OLDER ENGLISH LISTENERS

by

Chi-Nin Li

B.Sc., University of Victoria, 1996
M.A., Simon Fraser University, 2000
M.Sc., University of British Columbia, 2007

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

In the
Department of Linguistics

SIMON FRASER UNIVERSITY

Spring 2009

APPROVAL

Name: **Chi-Nin Li**

Degree: **Doctor of Philosophy**

Title of Thesis: **Perception of foreign-accented clear speech by younger and older English listeners**

Examining Committee:

Chair: **Dr. Nancy Hedberg**
Associate Professor of Linguistics

____

Dr. Murray Munro
Senior Supervisor
Professor of Linguistics

____

Dr. Zita McRobbie
Supervisor
Associate Professor of Linguistics

____

Dr. Wendy Thornton
Internal/External Examiner
Assistant Professor of Psychology

____

Dr. Melanie Campbell
External Examiner
Assistant Professor of Speech Pathology and Audiology
University of Alberta

Date Approved: April 6, 2009

ABSTRACT

Naturally produced English clear speech has been shown to be more intelligible than English conversational speech. However, little is known about the extent of the clear speech effects in the production of nonnative English, and perception of foreign-accented English by younger and older listeners. The present study examined whether Cantonese speakers would employ the same strategies as those used by native English speakers in producing clear speech in their second language. Also, the clear speech effects on sentence intelligibility of Cantonese-accented English for younger and older English-speaking listeners were explored.

In the production study, native speakers of Cantonese and English produced English sentences conversationally and clearly. Some productions were subjected to acoustical measurements and selected for a subsequent perceptual task. Both groups of speakers showed a decrease in speaking rate and in articulation rate, and an increase in total pause time and in sentential fundamental frequency in their clear speech productions. However, the Cantonese speakers spoke slower in both speaking styles and lengthened the pauses significantly more than did the English speakers in clear speech.

In the perception study, selected conversational and clear sentences were duplicated and mixed with 12-talker babble at a constant signal-to-babble ratio, and presented along with noise-free stimuli to English-speaking younger and older adults. The listeners assessed intelligibility by transcribing the sentences and verifying their truth value. Results showed that overall, clear speech was better perceived than conversational speech. The Cantonese speakers' utterances were less intelligible than those of the English speakers in all conditions. The performance of the older listeners was poorer than that of the younger listeners, especially in noisy conditions. Native-produced English clear speech was more intelligible than conversational speech, but no significant difference in intelligibility was found between conversational and clear Cantonese-accented English for both groups of listeners.

Overall, the findings suggest that the acoustic-phonetic characteristics of the conversational-to-clear speech transformations are in general similar for nonnative and native English speakers in producing clear speech. Nonetheless, a clear speaking style adopted by nonnative English speakers seems not to be an effective speech intelligibility enhancement strategy for native English listeners.

Keywords: Clear speech; Speech production; Speech perception; Foreign-accented English; Speech intelligibility; Older adults

Subject Terms: English language -- Pronunciation by foreign speakers; speech perception; Speech -- Physiological aspects

ACKNOWLEDGEMENTS

I will lift up mine eyes unto the hills,
from whence cometh my help.
My help cometh from the Lord,
which made heaven and earth.
Psalm 121: 1-2

I would like to thank my supervisor, Dr. Murray Munro, for reading and commenting on all the drafts of this thesis.

I would also like to thank the other members of my examining committee, Dr. Zita McRobbie, Dr. Wendy Thornton, and Dr. Melanie Campbell for their valuable comments.

My heartfelt thanks go to Dr. Wyn Roberts for all his help, support, encouragement, and all the interesting intellectual discussion throughout the years of my graduate studies at Simon Fraser University. My gratitude is beyond description.

I am grateful to the following individuals who helped me recruit English-speaking older adults: Executive Members of Burnaby Seniors Outreach Services Society; Ms. Melanie Graham, STAR Program Coordinator, Sunset Towers; Ms. Charlene McAllister, Life Unlimited Coordinator, West End Seniors'

Network; Ms. Julia Renner, Coordinator, Confederation Community Centre. In addition, my sincere thanks go to all the research participants in this study.

Thanks also go to the Department Linguistics (SFU) and Dr. Murray Munro for providing me with the financial support in the forms of university fellowships, teaching and research assistantships during my academic years.

I would also like to say “thank you” to all the friendly staff of the department for their help throughout all these years: Carol, Gladys, Grace, Rita, and Sheilagh.

Last but not least, I am very grateful to Connie, as she has been an unfailing source of support, help, and encouragement throughout these years.

TABLE OF CONTENTS

LIST OF FIGURES

.

LIST OF TABLES

CHAPTER 1: INTRODUCTION

When explicitly instructed to speak as clearly as possible, as if communicating with a hearing-impaired listener or in difficult communication environments, talkers will adopt a speaking style so as to be understood more easily. This type of clearly articulated speech, referred to as “clear speech”, has been found to be more intelligible than conversational speech (Bradlow & Bent, 2002; Caissie, Campbell, Frenette, Scott, Howell, & Roy, 2005; Ferguson, 2004; Helfer, 1998; Krause & Braida, 2002, 2004; Payton, Uchanski, & Braida, 1994; Picheny, Durlach, & Braida, 1985, 1989; Schum, 1996; Smiljanic & Bradlow, 2005; Uchanski, 2005; Uchanski, Choi, Braida, Reed, Durlach, 1996). The latter is defined as a speaking style adopted by talkers in casual conversation situations without any given instructions or any special speaking effort (Uchanski, 2005). Studies in the past two decades have demonstrated significant differences in the acoustic properties of clear and conversational speech (Caissie et al., 2005; Ferguson, 2004; Ferguson & Kewley-Port, 2002; Krause & Braida, 2002; Picheny, Durlach, & Braida, 1986; Smiljanic & Bradlow, 2005; Uchanski, 2005). In addition, a clear speech perceptual advantage has been found to be beneficial to younger or older listeners with normal hearing or impaired hearing in different listening situations such as in quiet, noisy, or reverberant conditions, or in environments with a combination of noise and reverberation (Bradlow & Bent, 2002; Caissie et al., 2005; Ferguson, 2004; Ferguson & Kewley-Port, 2002;

Helfer, 1998; Krause & Braida, 2002; Payton et al., 1994; Picheny et al., 1985, 1989; Schum, 1996; Smiljanic & Bradlow, 2005; Uchanski, 2005; Uchanski et al., 1996).

It is well known that in general, speech understanding ability gradually declines with age. Previous research has demonstrated that older adults experience greater difficulty with speech understanding than do younger listeners, especially in degraded listening conditions (Burda, Scherz, Hageman, & Edwards, 2003; Cheesman, 1997; CHABA, 1988; Crandell, Henoch, Dunkerson, 1991; Gordon-Salant, 1986; Gordon-Salant & Fitzgibbons, 2001; Halling & Humes, 2000; Jerger, Jerger, Oliver, Pirozzolo, 1989; Schneider, Daneman, & Pichora-Fuller, 2002; Tun, Kane, & Wingfield, 2002; Yanz & Anderson, 1984; among others). This fact has considerable social relevance in multicultural societies such as Canada. We have more and more immigrants who speak English with foreign accents. Thus, English-speaking older adults have more opportunity to interact with nonnative English speakers in daily situations. For instance, many immigrants work as health care providers, such as nurses or medical doctors, and thus have frequent contact with English-speaking elderly patients. Miscommunication between English-speaking older adults and these heath care professionals, for whom English is a second language, may sometimes have critical consequences (e.g., dosage of medication for elderly patients).

It is also noteworthy that in the area of second language speech studies, almost all studies have employed English-speaking younger adults as listeners to evaluate speech intelligibility of nonnative English speakers (e.g., Derwing & Munro, 1997; Munro, 1998; Munro & Derwing, 1995a, 1995b, 1998; among others). Only a few, to date, have investigated how English-speaking older adults perceive utterances produced by nonnative speakers of English (e.g., Burda et al., 2003; Mahendra, Bayles, & Tomoeda, 1999). With these considerations in mind, it seems to be important to further examine speech intelligibility of nonnative English speakers for English-speaking older adults in adverse listening environments. Also, it is an important empirical question whether the use of clear speech by nonnative English speakers has actual advantages for elderly listeners.

The purpose of this chapter is to discuss the acoustic and perceptual characteristics of clear speech. A review of previous studies of speech intelligibility of nonnative English speakers for elderly listeners and perception of foreign-accented English in noise will be presented, followed by a section on purposes for this thesis.

1.1. Acoustic Characteristics of Clear Speech

Studies of clear speech production have found that, compared to conversational speech, this clear-style speech is characterised by several distinct acoustic parameters. The acoustic changes from conversational to clear speech include, but are not limited to, slower speaking rate, reduced articulation rate, an increase in pause length, and an increase in fundamental frequency (F0) values (Caissie et al., 2005; Krause & Braida, 2002; Picheny et al., 1986; Smiljanic & Bradlow, 2005; Uchanski, 2005). As a follow-up to their perceptual study of clear speech (Picheny et al., 1985), Picheny et al. (1986) performed acoustic analyses of 50 nonsense sentences spoken clearly and conversationally by three male American English speakers, all of whom were college students. When recording sentences produced in a conversational manner, the speakers were told to recite the stimulus sentences as if they were engaged in ordinary conversation. For the elicitation of clear speech, the speakers were explicitly instructed to produce the sentences as clearly as possible, as though they were talking with a listener with impaired hearing or in noisy conditions. The researchers found that the mean speaking rate for clear speech was 97.7 words/min with a range from 91 to 101 words/min, whereas the speaking rate for conversational speech ranged from 160 to 205 words/min with a mean speaking rate of 188 words/min. As was the case for speaking rate, the mean articulation rate for clear speech (1.8 syll/s) was slower than that of the conversational sentences (3.6 syll/s), indicating an increase in duration of the syllables (Picheny et al., 1986). Moreover, the authors reported that the duration of pauses and fundamental frequency values were greater in sentences spoken clearly than those produced in a conversational manner, although no descriptive statistics on the data were given.

In a recent study, Krause and Braida (2004) attempted to identify inherent characteristics of clear speech, other than speaking rate, that may contribute to improved intelligibility. The researchers acoustically examined nonsense sentences, identical to those used by Picheny and colleagues (1985, 1986), spoken clearly and conversationally by five native English speakers (4 female and 1 male). The five talkers, who had considerable public speaking experience were successfully trained to produce clear speech (mean rate of 174 words/min) and conversational speech (mean rate of 179 words/min) at a normal speaking rate. As in previous studies, they were also requested to read the sentences in a clear speaking style without any restriction on speaking rate (mean rate of 100 words/min). The latter was comparable to the speaking rate for clear speech as reported by Picheny et al. (1986). Krause and Braida (2004) found that only two of the five talkers exhibited significantly higher mean F0 values in the clear speech at normal rate than in conversational speech at normal rate. Also, only three talkers showed significantly greater mean F0 value in clear speech at slower rate than conversational speech at normal rate. Their findings suggest that not all speakers increase mean fundamental frequency values in producing clear speech. Thus, an increase in mean F0 value may not be, by itself, an important contributor to improved intelligibility of clear speech (Uchanski, 2005). Consistent with the results of Picheny et al. (1986), Krause and Braida (2004) found a significant increase in pause duration in clear speech at a slower rate relative to clear speech speaking at a normal rate. However, there were no significant differences in pause duration between speech spoken clearly and produced conversationally at normal rates by the five talkers. This pattern of results was not surprising. As indicated by Krause and Braida (2004), the absence of increased pause duration in clear speech was due to the constraint on speech rate that was imposed on the speakers (i.e., clear speech spoken at a normal rate).

It has been noted that most studies have investigated the acoustic characteristics of clear speech produced by talkers right after being given simple instructions to speak as clearly as possible or clear speech production training. However, few data have been obtained regarding the long-term effect of training on speaker consistency in clear speech production. Caissie et al. (2005) examined acoustic differences between conversational speech and clear speech produced over a period of one month by two male English-speaking older adults, one of whom received intensive intervention on producing clear speech. Both the speakers had no previous speech training. Recordings were made in three different sessions during three separate visits. Stimulus sentences spoken in a conversational manner were recorded in the first visit, and sentences produced in a clear speaking style were recorded one week and one month after the first session, respectively. One of the speakers, the experimental talker, received intervention on clear speech immediately after the first recording session. He was given information about the concept of clear speech, speech rate, pausing, placing emphasis on key words, and a demonstration of how clear speech (e.g., vowels and consonants) should be produced. He was told to practice speaking as clearly as possible on a daily basis, and was given written information and exercises on techniques for producing clear speech. In addition, he was reminded of the skills in producing clear speech before recordings in the subsequent sessions. In contrast, the control talker, as in other studies, was simply instructed to speak as clearly as possible during recordings in each of the three sessions, receiving no intervention on clear speech. The authors found that the speaking rates of clear speech produced by both the experimental and control talkers in the second and third recording sessions were significantly slower than those of the conversational speech recorded during the first recording. For the experimental talker, no significant difference in speaking rate was found in his clear speech recorded one week post-intervention relative to that made one month post-intervention. However, it was found that clear sentences produced by the control talker in the third session (i.e., one month post-instruction) were significantly faster than those recorded in his second session (i.e., one week post-instruction). For mean fundamental frequency values, both talkers exhibited significantly higher mean F0 values in the second and third sessions (i.e., clear speech) than in the first recording (i.e., conversational speech). For the experimental talker, as was the case for the measures of his speaking rates, there was no significant difference in mean F0 values in clear speech between the second and the third recording sessions. In contrast, the control talker exhibited a higher mean F0 value in the third recording than in the second session. As suggested by Caissie et al. (2005), overall, the talker who received intervention appeared to produce clear speech in a more consistent manner than the one who was simply given explicit instruction throughout all the recording sessions.

As mentioned earlier, previous data on clear speech have all been obtained with speakers or listeners who were native English-speaking adults. Few studies, to date, have examined production and perception of clear speech in a language other than English. Smiljanic and Bradlow (2005) performed a comparative examination of acoustic features of conversational-to-clear speech transformations in Croatian and in English. Five native speakers of Croatian whose ages ranged from 18 to 25 years served as talkers for the clear speech production study. A comparison group of native English speakers between 28 and 48 years was also recruited. Twenty nonsense sentences in each language having similar numbers of syllables in each of the sentences were used as stimuli. As in previous studies, all the speakers were required to read the sentences once in a conversational manner and once in clear speech mode. Results showed that the speaking rate in Croatian, defined by Smiljanic and Bradlow (2005) as the number of syllables per second excluding all pauses of 5 ms or more, was significantly slower in clear speech than in conversational speech. However, no significant difference in speaking rate was found between the two languages (i.e., Croatian and English) regardless of speaking styles. The researchers stated that the mean pause duration for all the talkers, Croatian and English, was longer in clear speech than in conversational speech; however, no statistical data were given. In agreement with the findings of previous studies, Smiljanic and Bradlow indicated that the clear speech produced by the two groups of native speakers was characterised by an increase in segmental durations and pause durations in clear speech relative to conversational speech. In addition, their study showed that the extent of conversational-to-clear speech modifications for talkers of a language other than English is comparable to that of native English speakers.

1.2. Perceptual Characteristics of Clear Speech

Previous studies of perception of clear speech have demonstrated substantial intelligibility differences between speech spoken clearly and speech spoken in a conversational style (Bradlow & Bent, 2002; Caissie et al., 2005; Krause & Braida, 2002; Picheny et al., 1985, 1989; Schum, 1996; Smiljanic & Bradlow, 2005; among others). Picheny et al.'s (1985) research can be regarded as a landmark study of the perception of clear speech. As previously mentioned, in that study, three male American English speakers each read 50 nonsense sentences once in a conversational manner and once in clear speaking style. The conversational and clear sentences were presented at two frequency-gain characteristics (i.e., simulated amplification systems) and three intensity levels to five native English-speaking listeners with varying degrees of hearing impairment. The listeners repeated orally or wrote down what they heard. Intelligibility was measured in terms of the percentage of keywords (i.e., nouns, verbs, and adjectives) correctly recognised. As emphasized by Picheny et al. (1985), the most important finding of their study was an intelligibility difference of 17 percentage points between clear speech and conversational speech, and that this clear speech advantage was independent of listeners, speakers, frequency-gain characteristics, and intensity levels.

Picheny et al. (1986) observed that a decrease in speaking rate appears to be one of the most obvious characteristics tied to improved intelligibility of speech for hearing-impaired listeners. Those researchers performed a perceptual study attempting to determine the extent to which speaking rate contributed to the intelligibility differences between clear and conversational speech (Picheny et al., 1989). In that study, a talker recorded 100 semantically anomalous sentences conversationally and clearly, similar to those used in Picheny et al. (1985, 1986). To assess the effects of speaking rate on intelligibility differences, sentences produced in a conversational style (200 words/min) were processed to conform to the durational properties of clear speech (100 words/min) and vice versa, through a uniform time-scaling algorithm. Moreover, the durations of the two types of sentences were restored to their original values, the purpose of which was to examine the presence of any artifactual distortions due to the processing algorithm. As a result, three sets of sentences (i.e., unprocessed, altered, and restored) were presented to the same hearing-impaired listeners who participated in the first of the series of studying intelligibility of clear speech (Picheny et al., 1985). It was found that the listeners scored poorly for the processed sentences in terms of keyword intelligibility. In addition, the scores of the restored sentences were somewhat lower than those of the unprocessed stimulus sentences, suggesting minimal unintended signal processing distortions (Picheny et al., 1989). As noted by the researchers, their findings demonstrated that using a uniform time-scaling algorithm had deleterious effects on intelligibility on both conversational and clear speech. In particular, neither increasing the speech rate of clear speech to match that of the conversational speech nor decreasing the rate of conversational speech to match that of the clear sentences enhanced speech intelligibility.

To further study the role of speaking rate on speech intelligibility, Uchanski et al. (1996) conducted an experiment to investigate to what extent segment durations affect intelligibility differences between clear and conversational speech. To this end, an attempt was made to equate the segmental-level durations of clear and conversational sentences using a nonuniform time-scaling algorithm. That is, each conversational sentence was processed in a way that its segmental durations matched those of clear speech. As well, the segmental durations of clear speech were processed to match those of conversational sentences. These two types of processed stimuli were created from those originally recorded by the three male speakers in Picheny et al. (1985), and were presented along with other unprocessed sentences spoken clearly and conversationally. Four hearing-impaired listeners were tested in quiet and five listeners with normal hearing were tested in noisy conditions. As in previous studies, all the listeners were asked to respond by typing or by orally repeating what was said. For the four listeners with a hearing loss, it was found that, in agreement with the findings of earlier studies, the unprocessed clear sentences were more intelligible than the naturally spoken conversational utterances by 15 percentage points. The two types of processed sentences received scores lower than did the original unprocessed sentences. For instance, the mean score for the slowed-down conversational speech was lower than the unprocessed conversational sentences by 5 percentage points, while the faster clear speech was 24 percentage points lower than the clear speech. As noted by Uchanski et al. (1996), similar patterns of results were found for the five normal-hearing listeners. Compared to the findings of the earlier investigation (Picheny et al., 1989), Uchanski et al. (1996) noted that the effects of nonuniform time-scaling on speech intelligibility were less deleterious than those of the uniform time-scaling algorithm. The findings demonstrated that the extent of changes in durations of different segments is not identical in conversational-to-clear speech transformations.

As mentioned earlier, almost all previous findings of perception of clear speech have been obtained from listeners who were native speakers of English, but less is known about whether nonnative speakers of English also benefit from the clear speech intelligibility advantage. In a study by Bradlow and Bent (2002), 32 nonnative speakers of English and a comparison group of native English-speaking listeners all with normal hearing evaluated the intelligibility of native-produced clear and conversational speech. Recordings were made of two native speakers of American English (one female and one male) producing lists of sentences once in a conversational manner and once in a clear speaking style. The recorded stimulus sentences were digitally mixed with white noise at two different signal-to-noise ratios. Bradlow and Bent (2002) found that, overall, the group of nonnative listeners scored much lower in terms of keywords correct than did the native English listeners across speaking styles, speakers, and listening conditions (i.e., signal-to-noise ratio). More importantly, they found a perceptual benefit of clear speech for both groups of listeners. However, the size of intelligibility advantage was greater for the native English listeners than for the nonnative listeners. They therefore proposed that the clear speech effect is essentially a native-listener oriented phenomenon, suggesting that only those with extensive knowledge of the target language will derive a substantial benefit from the conversation-to-clear speech transformations.

In a more recent study, Smiljanic and Bradlow (2005) performed a cross-linguistic study of perception of clear speech in English and Croatian. As mentioned earlier, recordings were made of five native speakers of Croatian and five native English speakers producing nonsense sentences in their own native language once in a conversational mode and once in clear speaking style. Stimulus sentences were digitally mixed with white noise at a constant signal-to-noise ratio. The Croatian and English listeners evaluated the intelligibility of the stimulus materials in their native language. Smiljanic and Bradlow found that overall, clear speech was more intelligible than conversational speech. More importantly, there were no significant differences in intelligibility benefits afforded by clear speech relative to conversational speech between the two languages (i.e., Croatian and English). As the researchers suggested, the overall findings indicated that the clear speech intelligibility advantage is not English-specific, and that the general phenomenon of clear speech is essentially a native listener-oriented, speech intelligibility enhancement strategy that exists in other languages as well.

1.3. Intelligibility of Foreign-Accented English for Older Adults

Everyday listening conditions are typically characterized by background noise or reverberation, or a combination of noise and reverberation that can interfere with speech understanding. It has been well demonstrated that older adults have greater trouble than younger adults understanding speech in daily conversational exchanges, especially in degraded listening environments (Burda et al., 2003; CHABA, 1988; Cheesman, 1997; Crandell et al., 1991; Gordon-Salant, 1986; Pichora-Fuller, Schneider, & Daneman, 1995; Tun, 1998). Attempts have been made over the past decades to account for the disproportionate difficulties experienced by older listeners (CHABA, 1988; Crandell et al., 1991; Jerger et al., 1989; Schneider et al., 2002; Weinstein, 2002). Firstly, the age-related difference in speech perception is likely due to a change in the peripheral auditory system that results in elevated hearing thresholds, changes in audibility, and deficits in spectral and/or temporal processing of speech. Secondly, speech understanding difficulty for elderly individuals in adverse listening environments may be due to a gradually deteriorating central auditory nervous system. Lastly, greater difficultly faced by older individuals may be due to reduced cognitive ability as a result of the normal aging process.

As mentioned earlier, almost all speech intelligibility data for nonnative English speakers have been obtained from younger English-speaking listeners. There is a paucity of research on the perception of foreign-accented English by native English-speaking older adults. In one study, however, Mahendra et al. (1999) examined the perception of fluent Hindi-accented speech by native English listeners with a mean age of 75 years. They all passed a hearing screening and a simple test for cognitive function. In that study, two different tests were involved in which the speaker, who was instructed not to use any hand or facial gestures, interacted face-to-face with each of the listeners in a quiet, well-lit room. In the first one, the Speech Discrimination Test, the listeners repeated stimulus word pairs. In the second test, the Phrase Repetition test, they repeated a list of short, non-meaningful phrases with a length of six or nine syllables. Half the testing sessions were administered by a native English speaker, while the other half was administered by a nonnative English speaker whose first language was Hindi. For the Speech Discrimination Test, the mean score for the native English speaker was significantly higher than that of the nonnative English speaker. For the Phrase Repetition test, the native English speaker received a significantly higher score than did the nonnative English speaker. The findings of that study provided evidence of the adverse effect of foreign accents on speech recognition for healthy, native English-speaking older adults.

In a more recent study, Burda et al. (2003) examined age-related differences in understanding foreign-accented English as compared with native English productions. Two nonnative English speakers, a Taiwanese speaker and a Spanish speaker, were asked to produce a short passage and extemporaneous utterances. Two raters judged the foreign accentedness of their English on a 5-point scale from 1 (no accent) to a maximum of 5 (very strong accent). The Taiwanese speaker's English was rated to be less accented (3 on the 5-point scale) than that of the Spanish speaker (4 on the scale). Individual recordings were then made of the two speakers and a native English speaker producing 20 mono- and bisyllabic words and 10 short sentences each of six to 10 words. Three listener groups, consisting of younger adults, middle-aged, and older adults, served as listeners for this study. All listeners passed a hearing screening before participating in the listening tasks. In the perceptual task, the listeners were requested to write down what they heard from the stimulus materials. Results for word intelligibility showed that the performance of the older adults was significantly poorer than that of the younger adults and the middle-aged, independent of the native language of the speaker. In addition, the mean scores for the Taiwanese speaker and Spanish speaker were significantly lower than that for the native English speaker, regardless of the age of the listeners. However, there was no significant interaction between the native language of the speaker and the age of the listeners.

The patterns of results for sentence intelligibility were exactly the same as those for the word identification task. The older adults performed significantly less well than did the younger adults and the middle-aged, regardless of the native language of the speaker. In addition, the mean score obtained for the native English speaker was significantly higher than the scores for the Taiwanese speaker and for the Spanish speaker, independent of the age of the listeners. As was the case for the word identification, no significant interaction was found between the native language of the speaker and the age of the listeners. Overall, it was found that the English-speaking older adults had greater difficulty understanding speech than younger and middle-aged listeners, and that foreign-accented English, as produced by the Taiwanese and Spanish speakers, was less intelligible than the native-produced speech for all the native English listeners.

1.4. Intelligibility of Foreign-Accented English in Noise

As already mentioned, perception of foreign-accented speech in adverse listening conditions has been given relatively little attention in studies of second language speech intelligibility. Lane (1963) examined perception of foreign-accented speech under degraded listening environments. In that experiment, one native English speaker and three nonnative speakers (Serbian, Punjabi, and Japanese) with a strong accent in English were recorded producing lists of English monosyllabic words that were subsequently mixed with varying levels of white noise. It was found that correct identification scores for all speakers' productions decreased as the level of the masking noise increased. Moreover, the nonnative utterances were much less intelligible than was the native speech under all the listening conditions (i.e., four different signal-to-noise ratios).

The adverse effects of background noise on perception of nonnative-produced English were examined in another study (Munro, 1998). Ten native speakers of Mandarin (five female and five male) and a comparison group of native English speakers were recorded producing a list of 40 simple true and false English sentences. Some of the recorded utterances from each speaker were duplicated and mixed with cafeteria noise at a mean S/N ratio of +7.9 dB. The processed sentences were presented along with unmasked statements to a new group of 24 native English-speaking younger adults. The intelligibility of the sentences was assessed through a sentence-verification task (indicating whether statements were true and false) and a sentence-transcription task. The findings suggested that the cafeteria noise did degrade the intelligibility of sentences produced by both native and nonnative English speakers. However, it was found that in both tasks, Mandarin speakers' sentences were less intelligible than those of the native productions in both noise-free and noisy conditions. In addition, even for those utterances that were completely intelligible in the noise-free condition, the Mandarin accented sentences were more susceptible to the masking noise (i.e., less intelligible) than were the statements produced by the native English speakers.

1.5. Goals of this Research

A review of the literature reveals that almost all studies associated with clear speech have been carried out with native speakers of English. To date, few studies have examined the acoustic characteristics and intelligibility of foreign-accented clear speech perceived by English-speaking adults. The main goals of this study are to examine whether nonnative speakers will employ the same strategies as those used by native English speakers in producing clear speech in their second language, and to explore whether there is any clear speech effect on intelligibility of foreign-accented English for younger and older English-speaking listeners.

Specifically, the present study aims at determining whether there are any acoustic differences between clear and conversational speech spoken by nonnative speakers of English and the extent to which the conversational-to-clear speech modifications for nonnative English speakers will be different from those of native productions. Previous work has not determined whether clear speech spoken by nonnative English speakers will be more intelligible than their conversational speech for native English listeners. It is also not known whether there will be any differences in the perceptual advantage of foreign-accented clear speech for older and younger English listeners.

Also, as pointed out in previous studies, clear speech has been found to be more intelligible than conversational speech. Also, it has been demonstrated that a clear speaking style plays an important role in enhancing speech communication for older adults with or without a hearing loss. However, the majority of all previous studies associated with clear speech have been conducted with native English speakers and/or listeners. In addition, a number of investigations of speech intelligibility of nonnative English speakers have employed English-speaking younger adults as listeners. It is obvious that there is a paucity of data on nonnative clear speech production and on the perception of foreign-accented clear speech for English-speaking older adults.

In view of the above, the following research questions will be addressed in the present study:

(1) Will there be any acoustic differences between clear and conversational speech spoken by Cantonese speakers of English in terms of speaking rate, articulation rate, total pause time, and sentential fundamental frequency?

(2) To what extent will there be differences in conversational-to-clear speech transformations between Cantonese speakers of English and native English speakers in terms of speaking rate, articulation rate, total pause time, and sentential fundamental frequency?

(3) Will clear speech spoken by Cantonese speakers of English be more intelligible than their sentences produced in a conversational manner for native English listeners?

(4) Will there be any differences in the clear speech intelligibility benefit for older and younger English listeners when listening to English sentences spoken clearly and conversationally by Cantonese speakers of English?

In the present experiment, an attempt is made to examine the production and perception of clear speech produced by Hong Kong Cantonese speakers of English. In the production study, several global acoustic parameters associated with clear speech, speaking rate, articulation rate, total pause time, and fundamental frequency, are examined and compared in sentences produced conversationally by native Cantonese and native English speakers. In the perception study, the sentence-length utterances are presented with or without multibabble noise to English-speaking younger and older listeners for evaluation of intelligibility employing standard procedures commonly used in second language speech studies.

CHAPTER 2: PRODUCTION OF CLEAR SPEECH

The purpose of this part of the study is to examine the effects of the clear speaking style on the acoustic properties of sentences spoken by Cantonese speakers of English. Previous studies concerning clear speech over the past few decades have focused on speech produced by native speakers (Bradlow & Bent, 2002; Ferguson, 2004; Ferguson & Kewley-Port, 2002; Picheny et al., 1986, 1989, 1996). However, little is known about the effects of this speaking style on speech produced by nonnative speakers. It is important to examine whether nonnative speakers of English will employ strategies similar to those used by native English speakers in producing clear speech.

In this part of the study, six native Hong Kong Cantonese speakers (3 female, 3 male) read aloud a list of 48 simple declarative English sentences, once in a conversational manner and once in a clear speaking style. A group of six native Canadian English speakers balanced for gender served as a comparison group. Speaking rate, articulation rate, total pause duration, and fundamental frequency values were measured and computed from four different productions from each speaker as produced in the two speaking styles. Findings from previous studies of clear speech production indicate that speaking rate and articulation rate for utterances tend to decrease substantially (Krause & Braida, 2002, 2004; Picheny et al., 1986), while duration of pause and fundamental frequency tend to increase (Picheny et al., 1986). It is thus anticipated that the subjects in this experiment will tend to exhibit slower speech rates, longer pauses and higher fundamental frequency values in clear speech than in conversational speech.

In addition, results from studies of second language speech demonstrate that speech rates for nonnative speakers of English are generally slower than those for native English speakers (Anderson-Hsieh & Koehler, 1988; Guion, Flege, Liu, & Yeni-Komshian, 2000; Li, 2000; Munro, 1995; Munro & Derwing, 1998), and that Chinese speakers of English exhibit higher fundamental frequency values than do their native counterparts (Li, 2000; Munro, 1995). In view of the above, it is expected that the Cantonese speakers will produce the sentence-length utterances at a slower rate than will the native English talkers in each of the speaking styles. As mentioned in Chapter 1, Munro and Derwing (1998) reported no significant difference between native and nonnative English speakers in total pause time in reading a short narrative in each of the two rate conditions. It is expected that for the present study, there will be no significant differences between the two groups of speakers in the total pause time in sentences produced in each of the speaking styles. Also, since Mandarin and Cantonese are related Chinese languages, it is not unreasonable to posit that the Cantonese speakers here, like the Mandarin speakers, might be expected to exhibit higher fundamental frequency values (mean F0) than those of the native speakers of English. Interactions between the speaking styles and the native language of the speakers for the two respective measures will be investigated.

2.1. Method

2.1.1. Participants

Six native Hong Kong Cantonese speakers, three female and three male, were recruited as subjects. The speakers were selected to ensure that all of them had some degree of Hong Kong Cantonese accent in English. They had all been born and raised in Hong Kong, and had not lived for an extended time in any English speaking area besides Canada. Before coming to Canada, they had grown up in Hong Kong, receiving education from kindergarten to at least part of Form Five (the highest grade in high school). All participants started learning English in kindergarten. At the time of study, they had a mean age of 20.7 years with a range of 19 to 23 years. They had lived in Canada for a mean of 29.2 months with a range of 16 to 47 months.

Six native speakers of English (3 female, 3 male) served as a comparison group. All the English participants were speakers of Canadian English who had been born and raised in British Columbia. The mean age was 24.8 years with a range from 18 to 30 years. Both native and nonnative speakers were undergraduate students at Simon Fraser University. None of the speakers in either group exhibited any voice or speech anomalies.

All speakers first completed a Language Background Questionnaire (LBQ) that was created by the experimenter (see Appendix 1 for Cantonese speakers and Appendix 2 for English speakers). They all passed a pure-tone hearing screen (250, 500, 1000, 2000, and 4000 Hz at 25 dB HL) binaurally administered with a Maico MA 25 audiometer prior to performing the production tasks. All speakers participated for approximately one hour, and each was paid a $15 honorarium.

2.1.2. Stimulus Sentences

A list of 24 true and 24 false sentences served as the basis for the present study. The truth value of all the statements could be easily determined on the basis of general knowledge (e.g., “A tiger is bigger than a cat”, or “You can tell time with a kettle”) (see Appendix 3). Half of the true and half of the false statements among these 48 sentences had been used in previous experiments (Derwing, Munro, & Wiebe, 1998; Munro, 1998; Munro & Derwing, 1995b). The remainder were constructed by the experimenter and were used in Li (2000). Each item was a single clause sentence of four to eight words. The number of syllables ranged from five to 12. All vocabulary items in the statements were listed as high frequency words by Sakiey and Fry (1979).

Six different randomized lists of stimuli (i.e., List A, B, C, D, E, and F) were prepared for the speakers. The set of 48 statements was printed in random order on three pieces of paper with eight statements on each side of the paper. To avoid any possible list-initial and list-final effects on reading (Cooper, Eady, & Mueller, 1985; Leder & Spitzer, 1993), the fourth and the fifth statements were duplicated, and arranged to become the last and the first sentence on each page. These two sentences were not used for acoustic measurements nor for subsequent perception tasks. Thus, there were ten statements altogether on each side of the stimulus sheet. All pieces of paper were laminated, and were put on a desktop document holder that was placed at a distance where each speaker could clearly see the sentences.

2.1.3. Recordings

Individual recordings were made in a sound-treated room in the Phonetics Laboratory at Simon Fraser University. Participants wore an MB Quart K800 headset equipped with a boom microphone, and their speech was recorded onto Compact Disk (CD) using a Marantz CDR300 CD Recorder. Recordings were completed in two sessions. Prior to the recordings, the participants were given the list of 48 stimulus sentences, and instructed to read through it silently. So that speakers could give their best possible rendering of each sentence, they were permitted to practice reading several sentences immediately before the actual recording was made in each of the recording conditions (i.e., speaking styles). It was also during this period that gain levels were adjusted as appropriate.

During actual recording, the experimenter monitored the correct production of each sentence using a reading list monitoring sheet (see Appendix 4). Six versions of the sheet were prepared for each of the randomized lists. The participants read the 48 stimulus sentences in the test lists using two speaking styles: conversational (Con) and clear (Clr). The speakers were randomly assigned to read one of the six randomized lists of stimuli in each of the two speaking style conditions. For each speaker, no two stimulus lists had sentences in identical order in both speaking styles. In the first session, all speakers were instructed to read the sentences in a conversational speaking style similar to the way they talked in everyday situations (Bradlow & Bent, 2002; Ferguson, 2004;

Ferguson & Kewley-Port, 2002; Krause & Braida, 2004; Picheny et al., 1985, 1986; Schum, 1996). For the clear speaking style, speakers were asked to say the sentences as clearly as possible, and to avoid slurring of words, as if they were talking to a hearing-impaired individual (Bradlow & Bent, 2002; Ferguson, 2004; Ferguson & Kewley-Port, 2002; Picheny et al., 1985; Schum, 1996). The instructions were given in English by the experimenter. All speakers were given a 30-second break after reading each page. In addition, a 5-minute break was provided between recordings in the two speaking style conditions. During the 30-second breaks in the second recording session for clear speech, the speaker was reminded to say the sentences in a clear speaking style. In the event of any reading errors or hesitations, the speaker was asked to repeat the sentence until a correct and fluent utterance was produced. Utterances containing any reading errors or hesitations were discarded.

2.1.4. Acoustical Measurements

A number of acoustical analyses were performed in an attempt to determine the differences between conversational speech and clear speech. All utterances were digitally sampled at 44.10 kHz with a resolution of 16 bits using GoldWave 5.14, and were saved as wav files. From each of the 12 speakers, four different productions (two true and two false) in each of the conversational and clearly speaking styles were selected, for a total of 96 utterances (6 speakers x 2 speaker groups x 4 sentences x 2 speaking styles) (see Section 3.1.2). The four sentences chosen from each speaker in the conversational mode were identical to those in the clear speaking mode.

In this experiment, several acoustic parameters were measured and computed in every sentence: speaking rate, articulation rate, total pause time, and mean fundamental frequency value (Krause & Braida, 2004; Li, 2000; Munro, 1995; Munro & Derwing; 1998; Picheny et al., 1986). To compute the speaking rate, the number of syllables in each of the 96 utterances was divided by the total speaking time for each sentence for each speaker (Anderson-Hsieh & Koehler, 1988; Munro, 1995; Munro & Derwing, 1998). Duration for each sentence, measured to the nearest 0.01 second, was made from inspection of the time waveform combined with wide band spectrogram using speech analysis software (Praat version 4.2.17). Following Munro and Derwing (1998), articulation rate was computed by first excluding all pauses longer than 0.05 second from each of the sentences and measuring the duration (i.e., articulation time) using Praat, and then dividing the number of syllables by the articulation time. Also, total pause time for each of the 96 sentences was computed by subtracting the articulation time from the original sentence duration (Munro & Derwing, 1998).

Fundamental frequency (F0) values were obtained so as to explore differences in the sentence productions in the two different speaking styles. Measurements of the mean F0 values for each sentence, based on the waveform for duration measurement, were made with the PitchEditor in Praat using the autocorrelation algorithm. At this stage, if any token exhibited excessive vocal fry that resulted in a spurious F0 value, it was excluded so as to avoid difficulty for acoustic analysis (Kehoe, Stoel-Gammon, & Buder, 1995). The token in question was replaced with another sentence produced by the same speaker. About 4% of all tokens were substituted. The analysis filter was set from 70- to 300-Hz for the male voices and 135- to 535-Hz for the female voices at every 40 ms (Loren, Colcord, & Rastatter, 1986; Rivers & Rastatter, 1985). It has been suggested by Fry (1992) that vocal fry (or creaky voice) is heard at the end of utterances where the fundamental frequency falls to a low level in the range of 20 to 60 Hz, and that it should not be taken into account in measurement of fundamental frequency. Finally, the data were submitted to statistical analyses using statistical software (StatView version 5.0).

2.2. Results

2.2.1. Speaking Rate

The mean speaking rate (syll/s) of the four sentences (two true and two false) in each of the two speaking styles was determined for each speaker. The overall mean speaking rates for the female and male speakers of the two groups are illustrated in Figure 1. In the clear speech mode, the speaking rates for the Cantonese female speakers (M = 2.33 syll/s) and the Cantonese male speakers (M = 2.49 syll/s) were slower than those for the English female speakers (M = 3.64 syll/s) and the English male speakers (M = 3.94 syll/s). Similarly, in the conversational style, the native English participants spoke at a faster rate (M = 5.87 syll/s for English females and M = 6.22 syll/s for English males) than did the native Cantonese speakers (M = 3.72 syll/s for Cantonese females and M = 4.79 syll/s for Cantonese males). The data were submitted to a mixed-design analysis of variance with Native Language of Speakers (NL), English and Cantonese, and

Gender (GD), female and male, as between-subjects factors and Speaking Style (SS), Conversational (Con) and Clear (Clr), as a within-subjects factor. The analysis yielded a significant effect of NL, $F(1,8) = 32.74$, $p < 0.001$, indicating that the English speakers did speak at a faster rate than the Cantonese speakers of English in the two speaking styles, and a significant effect of SS, $F(1,8) = 136.91$, $p < 0.0001$, indicating that both groups of speakers spoke significantly slower in the clear speech mode than in the conversational mode. However, there was no significant effect of GD, $F(1,8) = 2.89$, $p > 0.05$, suggesting that the female speakers did not significantly differ from their male counterparts in speaking rates. In addition, none of the 2-way interactions reached statistical significance (NL x GD, SS x NL, and SS x GD, $Fs(1,8) = 0.28$, 1.37, and 1.94, $ps > 0.05$), nor was there a 3-way interaction (SS x NL x GD, $F(1,8) = 1.51$, $p > 0.05$). These results indicated that there were no significant between-group differences in the extent to which the speakers slowed down in their productions of clear speech.

2.2.2. Articulation Rate

As was the case with speaking rate, the mean articulation rate (syll/s) of each of the four sentences produced by each speaker in each of the two speaking styles was measured and computed. The overall mean articulation rates for the female and male speakers of the two groups are illustrated in Figure 2. It was observed that the articulation rates for clear speech for the Cantonese speakers ($M = 2.71$ syll/s) and for the English speakers ($M = 3.94$ syll/s) (collapsed across gender) were substantially slower than those for their conversational speech (*M* = 4.29 syll/s for Cantonese speakers and *M* = 6.07 syll/s for English speakers). In the clear speech mode, the articulation rates for the Cantonese female speakers (*M* = 2.60 syll/s) and the Cantonese male speakers (*M* = 2.82 syll/s) were slower than those for the English female speakers (*M* = 3.81 syll/s) and the English male speakers (*M* = 4.07 syll/s). Similarly, in the conversational style, the native English participants spoke at a faster rate (*M* = 5.89 syll/s for English females and *M* = 6.26 syll/s for English males) than did the native Cantonese speakers (*M* = 3.75 syll/s for Cantonese females and *M* = 4.84 syll/s for Cantonese males). The data were submitted to another mixed-design ANOVA with Native Language of Speakers (NL), English and Cantonese, and Gender (GD), female and male, as between-subjects factors and Speaking Style (SS), Conversational (Con) and Clear (Clr), as a within-subjects factor. As in previous analyses on speaking rate data, a significant effect of NL was found, $F\ (1,8) = 34.80$, $p < 0.001$, indicating that the English speakers' articulation rate was faster than the Cantonese speakers of English in the two speaking styles. In addition, there was a significant effect of SS, $F\ (1,8) = 152.39$, $p < 0.0001$, indicating that the articulation rates of the two groups of speakers were significantly slower in the clear speaking mode than in the conversational mode. As in the analysis of speaking rate, neither the effect of GD ($F\ (1,8) = 3.60$, $p > 0.05$) nor any interaction effects (NL x GD, SS x NL, SS x GD, and SS x NL x GD *Fs* (1,8) = 0.44, 3.39, 2.62 and 1.52, *ps* > 0.05) were found to be significant.

2.2.3. Pause Time

As mentioned in the previous section, pause time is calculated by subtracting the articulation time (i.e., after removal of all the pauses that are longer than 0.05 s) from the original duration of each of the sentences. The mean total pause time (second) per utterance from each of the 12 speakers in each of the two speaking styles is shown in Figure 3. Collapsed across gender, the total pause times for conversational speech for the Cantonese speakers (M = 0.02 s) and for the English speakers (M = 0.01 s) were shorter than those for their clear speech (M = 0.46 s for Cantonese speakers and M = 0.09 s for English speakers). In the conversational mode, the pause times for female and male Cantonese speakers (M = 0.02 s, respectively) were greater than those for both female and male English speakers (M = 0.01 s, respectively). Also, the total pause time in the clear speech sentences produced by the English speakers (M = 0.11 s for English females and M = 0.06 s for English males) was shorter than that for the Cantonese speakers' productions (M = 0.38 s for Cantonese females and M = 0.53 s for Cantonese males). The computed data were submitted to another mixed-design ANOVA using the same factors as before. The analysis yielded a significant effect of NL, $F(1,8) = 7.32$, $p < 0.05$, and a significant effect of SS, $F(1,8) = 14.77$, $p < 0.01$. There was also a significant two-way interaction (SS x NL), $F(1,8) = 7.27$, $p < 0.05$, indicating that the speaking style appeared to have a stronger effect on the total pause time in Cantonese speakers' clear speech, such that it contained significantly more pause time than that of the English productions.

In contrast, no significant effect of GD was found, F (1,8) = 0.16, $p > 0.05$. There were no other significant 2-way interactions (NL x GD and SS x GD, Fs (1,8) = 0.55 and 0.72, $ps > 0.05$), nor a 3-way interaction (SS x NL x GD, F (1,8) = 0.49, $p > 0.05$).

2.2.4. Sentential Fundamental Frequency Values

As already mentioned, four different productions (two true and two false) were selected from each speaker in each of the conversational and clear speaking styles. The mean F0 values from the two groups of speakers in each of the two speaking styles are shown in Figure 4. Collapsed across gender, it was found that the mean F0 values for the clear speech for the Cantonese speakers (M = 191.2 Hz) and for the English speakers (M = 169.1 Hz) were higher than those of conversational speech (M = 180.4 Hz for Cantonese speakers and M = 159.7 Hz for English speakers). The mean sentential F0 values were submitted to a mixed-design ANOVA with Native Language of Speakers (NL), and Gender (GD), as between-subjects factors, and Speaking Style (SS), as a within-subjects factor. It has been well documented that regardless of speaker's native languages, the F0 value of male speech is generally lower than that of female speech (Fry, 1992; Ladefoged, 1993). Despite this well-know phenomenon, the factor of Gender (female or male) was included as an independent variable here and in the subsequent statistical analyses in order to give a better overall picture of the observations and findings. Only the main effects for two of the three independent variables were found to be significant. As expected, a significant effect of GD was found, F (1, 8) = 41.05, $p < 0.001$, showing that the mean F0 value of female speech was significantly higher than that of their male counterparts. In addition, the analysis revealed a significant effect of SS, $F(1, 8) = 7.13$, $p < 0.05$, indicating that the mean sentential F0 values in clear speech produced by Cantonese speakers (M = 233.4 Hz for females, M = 149.0 Hz for males) and by English speakers (M = 217.6 Hz for females, M = 120.6 Hz for males) were significantly higher than those in conversational speech spoken by Cantonese speakers (M = 231.8 Hz for females, M = 129.1 Hz for males) and by English speakers (M = 209.6 Hz for females, M = 109.9 Hz for males). In short, all sub-groups exhibited sentential mean F0 values that were higher in clear speech than in conversational speech. The other factor, NL, failed to reach significance, $F(1, 8) = 0.19$, $p > 0.05$. In addition, as in the analyses with speaking and articulation rates, there were no significant 2-way interactions (NL x GD, SS x NL, and SS x GD, $Fs(1,8) = 0.25$, 0.04, and 1.95, $ps > 0.05$), nor was there a significant 3-way interaction (SS x NL x GD, $F(1,8) = 1.09$, $p > 0.05$).

2.3. Discussion and Conclusions

In agreement with findings reported in the previous literature (Picheny et al., 1986, 1996; Uchanski, 2005), all of the speakers in the present study slowed down their speech rate significantly in the clear speaking mode compared to the speech rate in the conversational style. The speaking rates from conversational speech to clear speech decreased by 57% for the Cantonese speakers and by 63% for the English speakers. However, an examination of the sentences revealed increases in duration from conversational to clear speech that averaged 85% for the Cantonese speakers and 61% for the English speakers. As in

Picheny et al. (1986), all the sentences spoken clearly, on average, were at least twice as long as the utterances spoken conversationally.

More importantly, when they were given simple instructions to speak clearly that were the same as those used in previous studies (Bradlow & Bent, 2002; Ferguson, 2004; Ferguson & Kewley-Port, 2002; Picheny et al., 1985; Schum, 1996), the Cantonese speakers of English in the present study substantially slowed down their speech in the clear speech mode. As far as speaking rate is concerned, this suggests that nonnative English speakers are able to employ similar speaking strategies to those of the native English speakers to produce clear speech in their second language.

As in the previous studies, the native English speakers spoke at a significantly faster rate than did the native Cantonese speakers in both the speaking styles. This should not be surprising, as it has been reported that nonnative speakers of English typically speak more slowly than do native English speakers (Munro & Derwing, 1998). The slower-produced English sentences may be due in part to the different rhythmic patterns in the L1 and L2 of the native speakers of Cantonese (or Chinese, in general). Roach (1982) indicated that syllable-timed languages have simpler syllable structure, but that stress-timed languages, such as English, exhibit more vowel reduction in unstressed syllables. Also, it has been suggested that for syllable-timed languages, all syllables are given equal amounts of time, while for stress-timed languages, more time is allotted to stressed and less to unstressed syllables (Roach, 1982). He (1987) observed that Chinese learners of English tend to mark stress on every syllable, and attempt to articulate every word (content and function) when producing English sentences. In view of the above, the Cantonese speakers in this study might have employed the same strategy. Also, the nonnative speakers might have had less articulatory control in their production of L2 speech. As a result, they may not have been able to speak as quickly as the native English speakers do. In addition, the differences in speaking rates may be due to longer vowels and sonorants in sentences produced by nonnative English speakers (Guion et al., 2000).

As mentioned in the previous chapter, articulation rate was calculated to determine the extent to which the reduced rate used in clear speech is due to the insertion of more and longer pauses in the utterances. Articulation time for each of the test sentences was determined by excluding all pauses that were longer than 0.05 s, and articulation rate was thus computed by dividing the number of syllables by the articulation time of the specific sentence (Munro & Derwing, 1998).

As was the case for speaking rate, articulation rates for clear speech were slower than those for conversational speech for both native and nonnative speakers of English. These findings were again in agreement with what Picheny et al. (1986) found. It was noted that in producing clear speech, the Cantonese speakers slowed to a mean articulation rate of 64% of conversational speech, while the English speakers slowed down to a mean rate of 65% of their conversational productions. The decrease in articulation rate in clear speech suggested that when asked to speak clearly, the talkers succeeded in producing clear speech not only by inserting or lengthening pauses, but also by increasing the durations of words, or perhaps, individual speech sounds (Picheny et al., 1985; 1986). It has been well demonstrated that these strategies can enhance intelligibility in clear speech produced by native speakers (Bradlow & Bent, 2002; Ferguson, 2004; Ferguson & Kewley-Port, 2002; Picheny et al., 1985; Schum, 1996; Unchanski, 2005).

Furthermore, it is noteworthy that Cantonese speakers of English did substantially decrease their articulation rates in their clear speech productions. This implied that Cantonese speakers of English, when instructed to speak clearly, did not simply increase or lengthen the pauses in the sentences to slow down their speech (discussed below).

As described earlier, for the purposes of this study, a pause is defined as any silent interval greater than 0.05 s between words in each sentence, and total pause time was calculated by subtracting the articulation time (i.e., after removal of all the pauses) from the original duration of each of the sentences (Munro & Derwing, 1998).

In the present study, it was found that all of the speakers lengthened the pauses in their clear speech productions, thus further providing supportive evidence that there are longer pauses in clear speech than in conversational speech (Picheny et al., 1985, 1986; Uchanski, 2005). For the Cantonese speakers of English, the total pause time, averaged across gender, ranged from 0.02 s in conversational speech to 0.46 s in their clear speech productions;

however, the total pause time for the native English speakers increased from 0.01 s in their conversational speech to 0.09 s in the sentences spoken clearly.

Despite the fact that both groups of speakers increased the pause durations in their sentences as one of the strategies to produce clear speech, the Cantonese speakers lengthened the pauses significantly more than the native English speakers did. This finding was different from the result reported by Munro and Derwing (1998). In that study, they found that both their Mandarin speakers of English and native English speakers slowed down their utterances by adding more or less the same total pause time when reading narrative in a self-selected slow-speech rate. The reasons for the discrepancies are not fully known. It may be due to the differences in the speech materials used (narrative vs. sentences), and the types of speech elicited (slow speech vs. clear speech).

With respect to F0, the results are consistent with earlier research findings (Krause & Braida, 2004; Picheny et al., 1986) showing that, as expected, the mean F0 significantly increased when the speakers spoke clearly. Higher F0 may help enhance speech intelligibility when talking to a hearing-impaired person or when speaking in an adverse communication situation (Uchanski, 2005).

As was the case for speaking rate, articulation rate, and total pause time, Cantonese speakers of English appeared to employ the same strategies as the ones used by native English speakers in increasing F0 in clear speech productions. However, a closer look at the data revealed that, as can be seen in Figure 4, there is a non-significant tendency for the mean F0 values of the Cantonese speakers of English to be higher than those of the native English speakers. The reason for the observed difference is not fully understood. However, it is possible that the difference may rest on the structural characteristics of the speakers' native languages. As is the case for Japanese, a syllable-timed pitch accent language (Yamazawa & Hollien, 1992), the tone aspect of Cantonese may account for the addition of higher frequencies that leads to the higher mean Fo relative to that of the native English speakers. Fry (1968) noted that Cantonese tones are less modified by intonation in Cantonese sentences. If this is the case, it is likely that some carryover from the first language for the Cantonese speakers influences their English productions in such a way that the sentential Fo tends to be higher than that of the native English speakers. Nevertheless, this language-dependent phenomenon needs further research. It is desirable to have more speakers in each speaker group to further examine the clear speech effect on fundamental frequency in sentence productions.

Overall, the findings of this clear speech production study confirmed that nonnative English speakers utilize strategies the same as those employed by native English speakers in producing sentences in a clear speaking manner. Both groups of speakers showed a decrease in speaking rate and in articulation rate, and an increase in total pause time and in sentential fundamental frequency in going from conversational speech to sentences spoken clearly.

Figure 1. Mean speaking rate (syll/s) according to the native language and gender of speakers in the two speaking styles: Conversational (Con) and Clear (Clr).

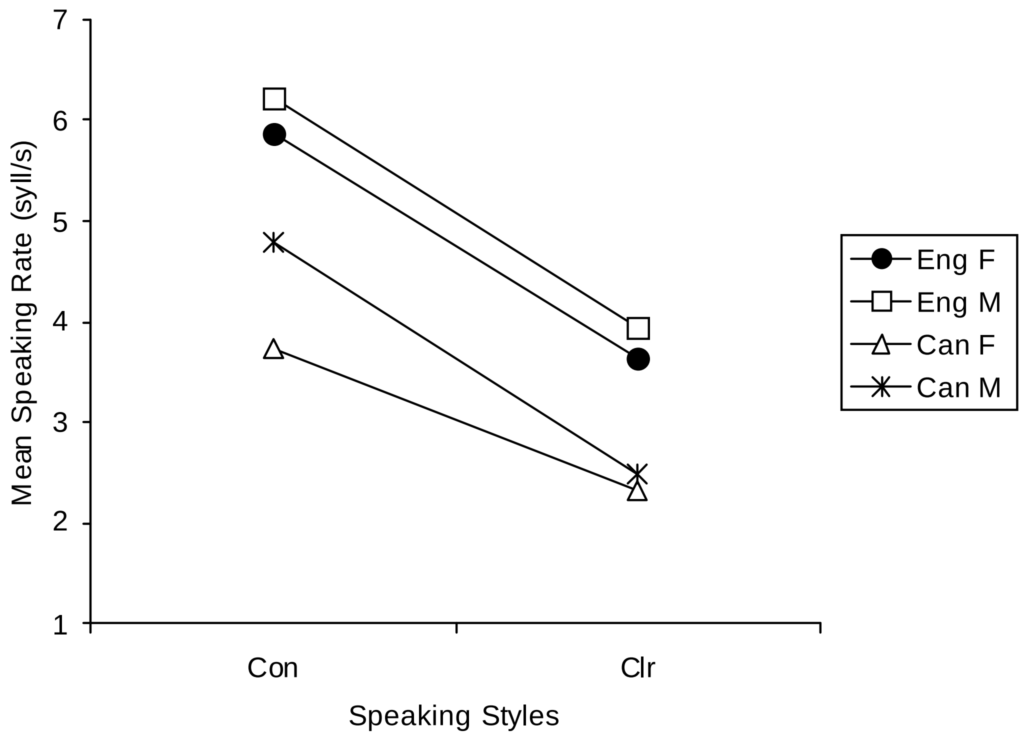


Figure 2. Mean articulation rate (syll/s) according to the native language and gender of speakers in the two speaking styles: Conversational (Con) and Clear (Clr).

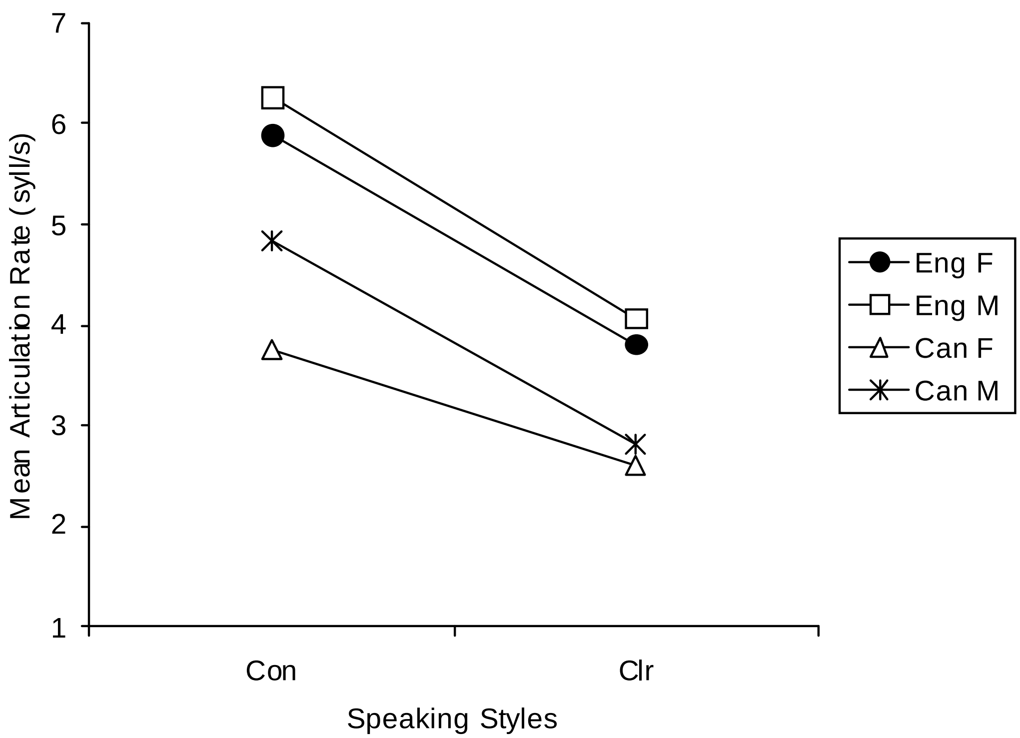


Figure 3. Mean total pause time (second) per utterance according to the native language and gender of speakers in the two speaking styles: Conversational (Con) and Clear (Clr).

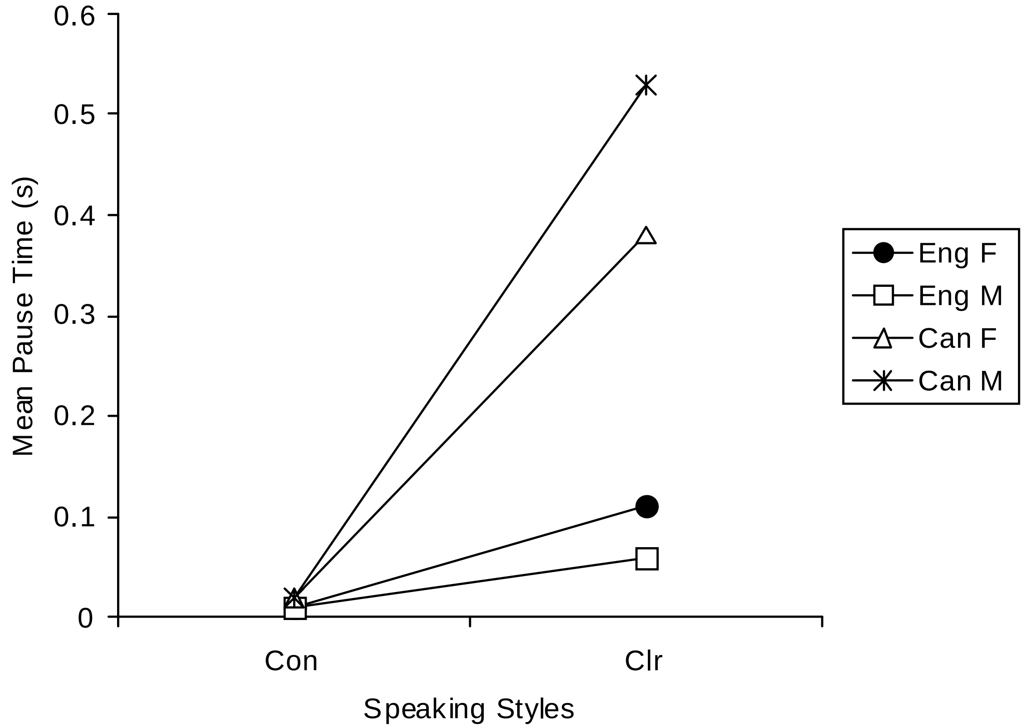
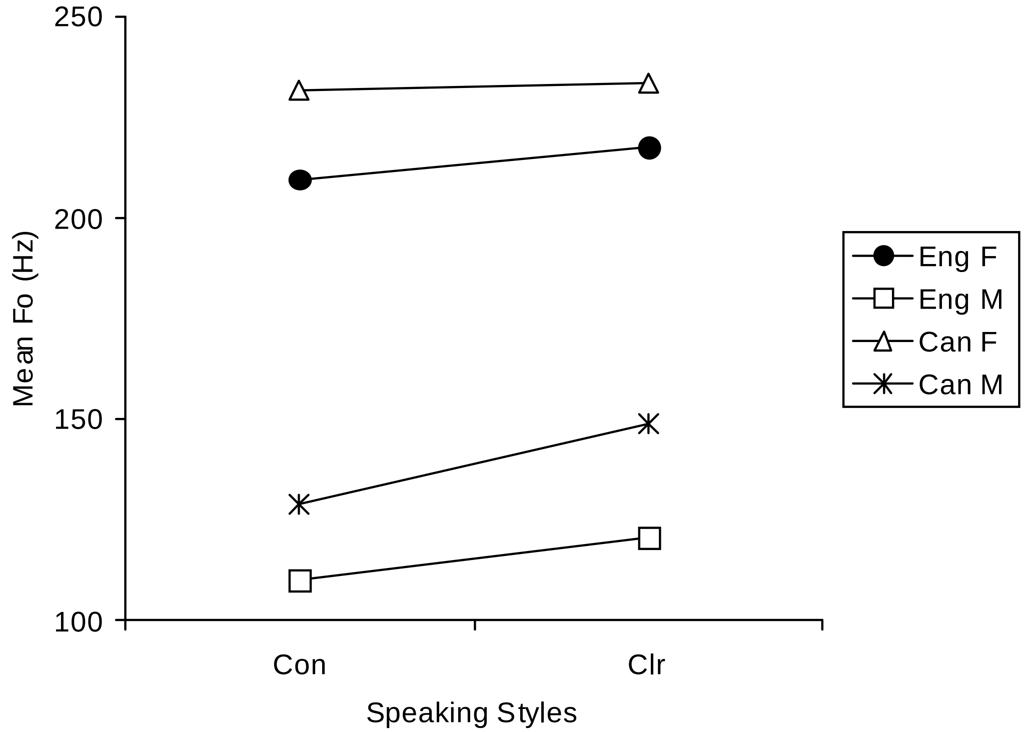


Figure 4. Mean fundamental frequency (Hz) according to the native language and gender of speakers in the two speaking styles: Conversational (Con) and Clear (Clr).



CHAPTER 3: PERCPETION OF CLEAR SPEECH

The purpose of this perceptual experiment is to investigate the effects of a clear speaking style on intelligibility of sentences spoken by nonnative speakers of English perceived by English-speaking older adults. In this experiment, two groups of native English-speaking listeners, younger and older adults, were presented with the clear and conversational sentences selected for acoustical measurements in Experiment 1. The sentences were duplicated and mixed with 12-talker babble at a fixed signal-to-babble ratio, and were presented with the original, unmasked sentences, all normalized for the same root-mean-square amplitude. The listeners assessed the intelligibility of the speech in a sentence-transcription task and a sentence-verification task.

As already mentioned in Chapter 1, there is a paucity of research examining the intelligibility of foreign-accented clear speech. Furthermore, none, if any, has studied the clear speech effect on foreign-accented speech perceived by English-speaking older individuals. Nonetheless, an overview of the findings of other relevant studies will be briefly presented. First, the extensive literature on second language speech studies has demonstrated that nonnative English is less intelligible than native-produced English (Anderson-Hsieh & Koehler, 1988; Burda et al., 2003; Derwing & Munro, 1997; Derwing et al., 1998; Mahendra et al., 1999; Munro, 1995, 1998; Munro & Derwing, 1994, 1995a, 1995b, 1998). It is thus expected that in this study, the speech produced by the Cantonese speakers will be perceived to be less intelligible than the sentences produced by the native English speakers in both speaking styles and listening conditions.

Second, previous work has also established that older English listeners experience greater difficulty understanding speech than younger adults do (Burda et al., 2003; CHABA, 1988; Cheesman, 1997; Pichora-Fuller et al., 1995). It is thus anticipated that in the present study, the older adults will perform more poorly than the younger adults in perceiving the sentences produced by both groups of speakers (native English speakers and Cantonese speakers of English). Moreover, greater differences in speech perception abilities have consistently been found between younger and older individuals in degraded listening conditions (Burda et al., 2003; Cheesman, 1997; Crandell et al., 1991; Tun, 1998). Therefore, it is highly likely that in the current study, the performance of the older adults will be worse than that of the younger adults when the speech samples are masked with multibabble noise.

Third, it has been well demonstrated that naturally produced English clear speech is significantly more intelligible than utterances spoken conversationally in quiet and in noisy environments (Bradlow & Bent, 2002; Caissie et al., 2005; Ferguson, 2004; Ferguson & Kewley-Port, 2002; Helfer, 1998; Krause & Braida, 2002; Payton et al., 1994; Picheny et al., 1985, 1989; Schum, 1996; Smiljanic & Bradlow, 2005; Uchanski et al., 1996). For the native English speakers in the present study, it is anticipated that their clear speech will be more intelligible than their conversational speech for the younger and older listeners.

Last, previous studies have found a significant clear speech effect in the perception of a native language other than English (Smiljanic & Bradlow, 2005) and a small clear speech benefit in native-produced English sentences perceived by nonnative English listeners (Bradlow & Bent, 2002). However, to date, few studies have examined the intelligibility benefit of clear speech spoken by nonnative English speakers for older and younger English-speaking adults. It is not yet known to what extent the native English listeners will derive benefit from the clear speech produced by Cantonese speakers of English. This will be explored in the current study.

3.1. Method

3.1.1. Listeners

Twelve older individuals ranging from 65 to 80 years of age (*M* = 72.9 years) and 12 younger adults ranging from 18 to 29 years of age (*M* = 21.8 years) served as listeners for the present study.

The older adults (11 female, 1 male) were recruited from community and recreation centres for elderly people. Each of the older adults had at least high school education, and they self-reported their overall health condition as either very good (*n* = 5) or good (*n* = 7). The younger listeners (8 female, 4 male) were undergraduate students and staff recruited from Simon Fraser University. All subjects were native speakers of English and reported themselves to be in good health without histories of neurological deficits. Tables 3-1 and 3-2 show the demographic characteristics for the younger and older listeners, respectively. As in the production task, all participants were screened for hearing acuity using the same audiometer. The mean pure-tone air-conduction hearing thresholds for the younger and older listeners are tabulated in Table 3-3. None of the listeners had ever worn any hearing aid(s) before. Each of the younger adults passed a pure-tone audiometric hearing screening at 25 dB between 250-4000 Hz bilaterally. The three-frequency pure tone average (500, 1000, and 2000 Hz) for the right ear ranged from -5 dB HL to 10 dB HL (M = 4.0 dB HL) and for the left ear it ranged from -6.7 dB HL to 15 dB HL (M = 2.5 dB HL). It is a well-known fact that it is highly likely for elderly individuals to have some hearing loss (Burda et al., 2003; Shadden, 1988). Following the criteria used in previous studies (ASHA, 1989; Burda et al., 2003; Kemper, Herman, & Lian, 2003; Tun, 1998), older adults were recruited as listeners as long as their hearing thresholds were at 40 dB or better bilaterally between 250 Hz and 4000 Hz[1]. The mean pure tone average for the right ear was 22.4 dB HL ranging from 11.7 dB HL to 31.7 dB HL, and that of the left ear was 20.1 dB HL with a range from 8.3 dB HL to 30.0 dB HL.

As discussed in Chapter I, reduced speech recognition ability in elderly listeners may be caused by deficits in cognitive function (CHABA, 1988; Coughlin, Kewley-Port, & Humes, 1998; Crandell et al., 1991; Pichora-Fuller, 1997, Pichora-Fuller et al., 1995; Van Rooij & Plomp, 1991). Following the subject selection criteria for elderly individuals used in previous research

---

[1] For the present study, it would have been better if all the older listeners had normal hearing thresholds as the younger listeners. An effort was made to find older adults with good hearing sensitivity. However, owing to lack of resources, only 13 older listeners were successfully recruited over a period of 8 months in the Lower Mainland.

(Coughlin et al., 1998; Feeney & Hallowell, 2000; Fitzgibbons & Gordon-Salant, 1994, 2004; Gordon-Salant & Fitzgibbons, 1993, 2001; Jerger & Chmiel, 1997; Mahendra et al., 1999; McGuire, Morian, Codding, & Smyer, 2000; Phillips, Gordon-Salant, Fitzgibbons, & Yeni-Komshian, 2000), in addition to the audiologic criteria, all older adults were required to pass a brief screening test for general cognitive function. For the present study, the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975) was adopted. As shown in Appendix 5, the MMSE is a brief, simple test containing 11 items evaluating orientation, memory, attention, recall, and language (Folstein et al., 1975). The score ranges from 0, indicating worst cognitive functioning to a maximum of 30, indicating best cognitive functioning (Folstein et al., 1975). A score of 24 or less is suggestive of probable cognitive impairment (Espino et al., 1998; Jerger & Chmiel, 1997; Kurlowicz & Wallace, 1999). In the current study, the MMSE was conducted following the hearing screening, and it took about 5 - 10 minutes to administer. All older adults passed this cognitive screening with a mean score of 29.7 with a range of 29 to 30. Moreover, they were required to have sufficient motor control skills to provide a legible written response to the speech stimuli. This was determined through a practice session prior to the actual experiment. All the listeners' handwritten responses were legible and none of them were excluded from participating in the perceptual experiment.

None of the participants spoke Cantonese or had any prior knowledge of the list of statements to be used for the experiment. They completed a Personal Background Questionnaire (Appendix 6) similar to the one filled out by the speakers in the production study. None had previously participated in any speech experiment of a similar nature. All listeners, including those for the pilot testings (see below), were paid $15 upon completion of the experiment.

3.1.2. Stimulus Preparation

The true and false sentences produced by the speakers in the production experiment were used as stimuli for the perception task. As already mentioned in Chapter Two, the truth value of all the statements could be easily determined by individuals on the basis of general knowledge (e.g., “A tiger is bigger than a cat”, or “You can tell time with a kettle”). To create the full stimulus set, four different sentences (two true and two false) produced in each of the two speaking styles (Clear and Conversational) were selected from each of the 12 speakers for a total of 96 utterances (6 speakers x 2 speaker groups x 4 sentences x 2 speaking styles). From each speaker, the four specific sentences produced in the clear speaking style (Clr) were identical to those spoken in the conversational manner (Con). The four pairs of statements (Clr versus Con) were duplicated and masked with 12-talker babble at a fixed signal-to-babble (S/B) ratio (discussed below) for a total of 192 sentences. As a result, for any specific sentence, there were four different sentence conditions: Clear without noise (Clr-N), Conversational without noise (Con-N), Clear with noise (Clr+N), and Conversational with noise (Con+N). All the sentences were arranged in a way that there were ultimately four complete lists of 48 stimulus sentences for the actual experiment.

To eliminate differences in amplitude values among the clearly spoken and conversationally spoken sentences, the root-mean-square (RMS) amplitude for each of the 96 original statements (i.e., Clr-N and Con-N) was first determined and equated using Praat (Bradlow & Bent, 2002; Ferguson, 2004; Ferguson & Kewley-Port, 2002; Smiljanic & Bradlow, 2005).

It was found that the mean RMS amplitude value for the sentences in Clr-N was 61.60 dB, while the mean for Con-N was 61.56 dB. On the basis of the computed RMS amplitudes for the sentences in Clr-N and Con-N, the RMS amplitudes for all the stimulus sentences were rescaled to a level of 62 dB before adding the 12-talker babble. As described above, one token of each sentence was kept in its original noise-free form, and a duplicate token of each statement was prepared for mixing with the babble noise.

The multitalker noise was generated by asking each of the 12 speakers who participated in the production task to record a simple, short paragraph in a conversational manner at the end of the recording session. All speakers were provided with different passages from Aesop's fables (Ash & Higton, 1990; Fulvio, 1989). After the recordings were made, the speech files were mixed with one another using GoldWave and rescaled to different RMS amplitude values using Praat for the determination of appropriate S/B ratio via pilot testings (see below).

3.1.3. Piloting

In this research, three pilot perceptual experiments were carried out for two different purposes. First, two trial listening tests were conducted to ensure the intelligibility of the noise-free clearly spoken and conversationally spoken utterances, respectively. For these two pilot testings, two complete lists of the 48 stimulus sentences were created. One list contained all the sentences spoken clearly (Clr-N) by the two groups of speakers. For the other list, all the sentences were produced by the Cantonese and English speakers in a conversational style (Con-N). Half were true utterances and half were false with a balance in the speakers' L1. The specific sentences from each speaker were the same for these two lists. This preliminary examination of the clean speech (i.e., without noise) seemed to be necessary; any subsequent analysis of listeners' scores on the noisy utterances in the actual experiment would be pointless if the noise-free stimulus sentences were unintelligible at the outset. Second, before the multibabble noise was digitally mixed with the speech signals for the actual perceptual experiment, an appropriate level of noise had to be determined. The proper level was selected with the underlying rationale that the noisy sentences would neither be too easy nor too difficult for the listeners to verify. In the subsequent piloting sessions, an S/B ratio was established that would lead to a moderate amount of degradation in which between 70% and 80% of the noisy sentences still remained partially or completely intelligible at the selected level of the masking noise (Munro, 1998). The stimuli for the last pilot study contained both Clear speech and Conversational speech mixed with the 12-talker babble; a full list of 48 trial utterances was made up of sentences selected from both Clr-N and Con-N. Again, half were true utterances and half were false with a balance in the speakers' L1. All sentences were saved as computer audio files so that they could be randomly presented to the listeners through ExperimentMFC, a Multiple Forced Choice listening experiment program available in Praat.

The babble noise added to the sentences was extracted from a 30-second-long sample, the amplitude of which was adjusted in accordance with the trial S/B ratios using Praat. The mixing of the speech signals with the babble noise at any particular noise level was done using GoldWave. Details will be discussed later in this section.

A sentence-verification task was used to assess the intelligibility of the sentences throughout the three pilot studies (Li, 2000; Munro, 1998). Details are given in section 3.1.5, as this task was also used in the actual perceptual experiment. Briefly, upon listening to the stimulus sentence once, listeners in all the pilot tests had to determine the truth value of the sentence by selecting one of three buttons ("True", "False", or "Unknown") on the computer screen. The verification scores were based on the number of correct true and false responses (Munro, 1998).

The first pilot listening task pertained to the intelligibility of the clean Clear speech. A male native English listener who was an undergraduate student at Simon Fraser University voluntarily participated in this trial session. The subject was 21 years of age and passed a pure-tone hearing screening (250, 500, 1000, 2000, and 4000 Hz at 25 dB HL) bilaterally prior to performing the perceptual experiment. It was found that for the clean Clear speech, the overall correct verification score (pooled over the two speaker groups) was 95.8%. As already mentioned, in this list of 48 Clr-N sentences, half of them were produced by the native English speakers, while the rest were produced by the Cantonese speakers of English. The subject failed to correctly verify two (out of 24) sentences produced by the Cantonese speakers, while he obtained 100% correct verification score on the native-produced utterances.

For the second pilot session, a new male native English listener served as research participant. The subject was 21 years of age and was an undergraduate student. He passed the pure-tone hearing screen prior to the listening task. This time, the subject was asked to verify the truth value of all the clean utterances spoken conversationally by the Cantonese speakers of English and native English speakers. It was found that he correctly verified all the 24 Con-N sentences spoken by the non-native English speakers and those produced by the native English speakers (i.e., overall 100%). From the results of these two pilot experiments, the degree of intelligibility of the clean Clear speech (Clr-N) and clean Conversational speech (Con-N) produced by the Cantonese speakers of English and the native English speakers could be considered acceptable for this research.

The final piloting session was used to evaluate the intelligibility of the noisy sentences at three different S/B ratios: 0, -1, and -2dB. In other words, the RMS amplitudes (dB) of the multibabble were 62 dB, 63 dB, and 64 dB, respectively, with the speech signals being fixed at the target level of 62 dB. A complete list of 48 noisy sentences was used as stimuli. For each S/B ratio, 16 sentences were mixed with the appropriate level of babble noise. Within each of the three sets of 16 sentences, the truth value (True vs. False), the speaking style (Clr vs. Con), and speakers' L1 (Cantonese vs. English) were all counterbalanced.

Two new native English listeners (one female, one male) served as research participants in this last trial experiment. Both were undergraduate students at Simon Fraser University. The female listener was 35 years of age, and the male participant was 18 years of age. Both of them passed the pure-tone hearing screening (≤ 25 dB HL at octave intervals between 250 Hz and 4000 Hz). Again, neither of them had participated in any speech experiment involving noise.

The mean percentage score (pooled over the two listeners) for the verification task at 0 dB S/B ratio was 78.1%. The values at -1 dB and -2 dB S/B ratios were 59.4% and 34.4%, respectively. On the basis of these results, it was decided that in order to meet the target of 70 – 80% correct verifications, the S/B ratio should be set at 0 dB. In other words, the RMS amplitude of the babble should be identical to that of the speech signal. To achieve this, they both were set at 62 dB.

3.1.4. Creation of Stimulus Lists

As mentioned in section 3.1.2., the four pairs of statements (Clr versus Con) were duplicated for a total of 192 sentences, half of which (i.e., 96 speech files) were masked with 12-talker babble at a fixed signal-to-babble (S/B) ratio (i.e., 0 dB) using GoldWave. As in previous studies (Bradlow & Bent, 2002;

Ferguson, 2004; Ferguson & Kewley-Port, 2002; Smiljanic & Bradlow, 2005), each of the 96 duplicated speech files was mixed with a segment selected from a random location within the 30-second babble, preceded and followed by 500 milliseconds. After the mixing process, all the noisy sentences were again equated in terms of overall RMS amplitude at the same level as that of the clean statement (i.e., 62 dB) using Praat.

Four separate stimulus lists were prepared according to the following criteria. Each list consisted of the full complement of 48 test items (24 true, 24 false). Individual speakers were represented by four sentences (i.e., two true and two false statements). Each of the stimulus sets was balanced for speakers' L1 and gender, as well as sentence conditions. Half the utterances (12 true, 12 false) were spoken by the native English speakers, and half were produced by the native speakers of Cantonese. Of the sentences spoken by each group of speakers, twelve (6 true, 6 false) were produced by female speakers and the others were produced by male speakers. Moreover, six utterances (3 true, 3 false) were presented in each of the four sentence conditions (i.e., Clr-N, Clr+N, Con-N, and Con+N). In addition, the same specific sentence spoken by a speaker in each of the four sentence conditions was arranged in each the four lists of stimuli. For instance, sentence No. 1 was spoken by speaker A. The Clr-N and Con+N for sentence No. 1 were found in List 1 and List 2, respectively, while Clr+N and Con-N were in Lists 3 and 4, respectively.

To summarize, the stimuli fell into eight categories (two groups of speakers and four sentence conditions): (1) native Cantonese Clear speech without noise (NC: Clr-N), (2) native Cantonese Clear speech with noise (NC: Clr+N), (3) native Cantonese Conversational speech without noise (NC: Con-N), (4) native Cantonese Conversational speech with noise (NC: Con+N), (5) native English Clear speech without noise (NE: Clr-N), (6) native English Clear speech with noise (NE: Clr+N), (7) native English Conversational speech without noise (NE: Con-N), and (8) native English Conversational speech with noise (NE: Con+N). In addition, the younger and older adult listeners in groups of three were randomly assigned to listen to one of the four lists of stimuli.

3.1.5. Listening Procedures

Individual listening sessions were held in a sound-treated room or in a quiet room. Stimuli presentation was manipulated by ExperimentMFC program available in Praat. The sound files were presented through AKG K55 headphones via a Toshiba laptop computer at a comfortable listening level set by the experimenter (Bradlow & Bent, 2002; Smiljanic & Bradlow, 2005). The entire stimulus set was played only once with the tokens being randomized for each listener. During the intelligibility task, after hearing an item, the listeners were expected to write out the statement in standard orthography on booklets with numbered spaces for transcriptions of each of the 48 utterances (Appendix 7). In the event that the listeners understood only part of the sentence, they were told to write out as many words as possible. If any word or the whole sentence was unintelligible, they should indicate this by drawing a blank line. Immediately after each orthographic transcription, the participants had to verify the truth value of the statement by selecting one of three screen buttons that could be pressed using the mouse (“True”, “False”, or “Unknown”). The latter was available to discourage the participants from consistently choosing “False” when an utterance was unintelligible, as in Munro (1998).

Before completing the actual experiment, the listeners completed a practice session during which they heard a random presentation of eight statements not used in the actual experiment (see Appendix 8). Four were true sentences, and four were false sentences. Half of the true and half of the false items were mixed with the masking noise in the same manner as the experimental stimuli. The sentences were produced by four new speakers, two (1 female, 1 male) of whom were native speakers of Canadian English and two (1 female, 1 male) of whom spoke with a Cantonese accent. Each speaker was represented by one true statement and one false statement. This practice set served to familiarize the listeners with the masking noise in the speech samples, and with the experimental procedure. Immediately afterwards, they completed the listening task. The total time required averaged about 30-45 minutes.

3.2. Results

The assessment of intelligibility of the speech samples was based on the listeners’ scores on two different tasks: transcription and verification. For the transcription task, two scoring procedures were employed. In the exact word match (EWM) procedure (Derwing & Munro, 1997; Li, 2000; Munro & Derwing, 1995a, 1995b; Munro, 1998; Tun, 1998), a correct transcription had to correspond exactly to the actual sentence. In the content word match (CWM), procedure, only correctly-identified content words, such as nouns, verbs, adjectives, and adverbs (Gordon-Salant & Fitzgibbons, 2001; Li, 2000; Munro & Derwing, 1995a; Palmer, 1981; Quach, 1998), but not function words, in the sentence were counted. Content words are more important for intelligibility because they carry most of the “content “of the sentences. This procedure was undertaken to compare the results with those of the exact word match. The latter task is more rigorous because it penalizes the listeners for transcription mistakes that may not be related to intelligibility. All the words considered content words are italicized and shown in Appendix 3. Following Munro (1998), scores were assigned to each transcribed sentence by computing the percentage of words (or content words) in the sentence that was correctly written out. Certain minor errors, however, were ignored (e.g., the use of a singular form instead of a plural or any trivial spelling mistake). As in Munro (1998), for the verification task, the scores were determined by summing the number of correct true and false responses; the choice of “Unknown” was considered incorrect.

3.2.1. Scores for True and False Sentences

It has been reported in one study (Pisoni & Dedina, 1986) that truth value (i.e., True or False) of sentences may affect speech comprehension in a sentence verification task. Transcription (exact word and content word matches) and verification scores obtained by the two groups of listeners for the true condition were compared with those for the false condition (pooled across the two speaker groups and the four sentence conditions). Figure 5 and Figure 6 show the mean scores for the two transcription tasks, respectively. The correct verification scores between the two types of sentences are shown in Figure 7.

The data were submitted to a mixed-design ANOVA with Age of Listeners (i.e., Younger vs. Older) as a between-subjects factor and Truth Value (True vs. False) as a within-subjects factor. Results revealed a significant effect of Age of Listeners for the exact word match, $F\ (1, 22) = 56.55$, $p < 0.0001$, and for the content word match, $F\ (1, 22) = 53.35$ $p < 0.0001$. However, no significant differences were found between the true and false utterances in the exact word match ($M = 75.7\%$ for True and $M = 74.4\%$ for False, overall) and in the content word match ($M = 76.3\%$ for True and $M = 74.1\%$ for False, overall), $Fs\ (1, 22) =$ 1.92 and 3.36, $ps > 0.05$. Nor was there a significant interaction between Truth Value and Age of Listeners for each of the exact word and content word matches, $Fs\ (1, 22) = 1.80$ and 1.36, $ps > 0.05$.

A parallel test on the verification scores for the true ($M = 70.3\%$) and false sentences ($M = 65.3\%$) was conducted. The main effects of each of the two factors were significant, $F\ (1, 22) = 17.16$, $p < 0.001$ for Truth Value, and $F\ (1, 22) = 57.54$, $p < 0.0001$ for Age of Listeners. In addition, Truth Value interacted significantly with Age of Listeners, $F\ (1, 22) = 17.16$, $p < 0.001$, due to the fact that the older adults performed slightly poorer in verifying the false sentences than in verifying the true utterances, while the scores for the younger adults were identical for both true and false statements.

Overall, the older adults scored much lower than the younger adults for the two types of sentences (i.e., True and False) in all three tasks. For the exact word and content word matches, the results were similar to the findings of previous studies (Li, 2000; Munro, 1998; Munro & Derwing, 1995b) in that no significant differences were found in transcription scores (EWM and CWM) between the true and false sentences for the older and younger adults. However, this was not the case for the verification task in which the older adults obtained a significantly lower score for the false sentences than for the true statements.

3.2.2. Transcription Scores

The mean scores (in percent) achieved by the younger and older adults in the exact word match (EWM) for the two groups of speakers, native English (NE) and native Cantonese (NC), under the four sentence conditions (i.e., Clr+N, Clr-N, Con+N, and Con-N) are shown in Figure 8. It can be readily seen that there were differences in the performance between the two listener groups, and in transcription scores for the NE and NC sentences. Overall, the younger adults achieved higher scores than did the older adults. The transcription scores on the Cantonese-accented utterances were lower than those on the native English utterances across all sentence conditions. Sentences produced in a clear speaking style were more intelligible than the utterances spoken conversationally. Also, it was obvious that clean sentences were better perceived than were those masked with multibabble noise.

The exact-word matching scores for each listener were submitted to a mixed-design ANOVA with Age of Listeners (AL) (i.e., Younger vs. Older) as a between-subjects variable and Native Language of Speakers (NL) (i.e., Cantonese vs. English), Speaking Style (SS) (Clear vs. Conversational), and

Listening Condition (LC) (Clean vs. Noisy) as within-subjects factors[2] (see Table 4). Analysis revealed that the main effects for each of the variables were significant: Age of Listeners, F (1,22) = 56.55, $p < 0.0001$; Native Language of Speakers, F (1,22) = 15.13, $p < 0.001$; Speaking Style, F (1,22) = 11.55, $p < 0.01$; Listening Condition, F (1,22) = 293.21, $p < 0.0001$. In addition, Listening Condition interacted significantly with Age of Listeners, F (1,22) = 59.76, $p < 0.0001$, indicating that the multibabble noise has a more deleterious effect on the older adults than on the younger adults (see Figure 9). As shown in Figure 10, the Native Language of Speakers by Speaking Style interaction was also found to be significant, F (1,22) = 13.53, $p < 0.01$, indicating that the native English speakers, but not the Cantonese speakers of English, elicited a significant clear speech effect. However, interactions between NLxAL, SSxAL, SSxLC, NLxSSxAL, SSxLCxAL, NLxLCxAL, NLxSSxLC, as well as NLxSSxLCxAL, failed to reach significance, *ps* > 0.05, with the interaction of NLxLC approaching significance, F (1,22) = 3.73, $p = 0.06$, suggesting a tendency that fewer sentences produced by the Cantonese speakers were correctly transcribed in the noisy conditions.

Figure 11 shows the mean scores obtained by the younger and older adults in the content word match (CWM) for the two groups of speakers under the four sentence conditions. Another mixed-design ANOVA on the content word

---

[2] It was noted that the mean EWM score of the younger listeners for NE: Clr-N was 100%. Following Munro (1998), a t-test for difference scores between NE:Clr-N and NE: Clr+N by the older and younger listeners was conducted to ensure the findings of the ANOVAs were not unwarranted. Analysis revealed significant difference between the two groups of listeners, t (22) = 6.60, $p < 0.0001$.

match was conducted using the same factors as those for the exact word match[3] (see Table 5). The pattern of results in CWM was similar to that observed in EWM. Results revealed significant main effects of AL, $F\,(1,22) = 54.10$, $p < 0.0001$, NL, $F\,(1,22) = 82.93$, $p < 0.0001$, SS, $F\,(1,22) = 8.44$, $p < 0.01$ as well as LC, $F\,(1,22) = 314.85$, $p < 0.001$. As in EWM, the interaction between LC and AL was significant, $F\,(1,22) = 55.72$, $p < 0.0001$, indicating that the younger adults were less susceptible to the masking noise than were the older listeners (see Figure 12). Moreover, as can be seen in Figures 13 and 14, the 2-way interactions (NL x SS and NL x LC) were found to be significant, $Fs\,(1,22) = 5.71$ and 7.62, $ps < 0.05$, suggesting that only the English speakers elicited a significant clear speech effect, and that significantly fewer of the Cantonese speakers' utterances were correctly transcribed in the noisy conditions. In contrast, no significant interactions were found for NLxAL, SSxAL, NLxSSxAL, NLxLCxAL, SSxLC, SSxLCxAL, NLxSSxLC, and NLxSSxLCxAL, $ps > 0.05$.

3.2.3. Verification Scores

Verification scores in percent (i.e., the number of times that each subject assigned correct truth value to the sentences) obtained by the two groups of native English listeners (older vs. younger) for the sentences, with and without masking noise, spoken clearly and conversationally by Cantonese speakers of English and native English speakers are shown in Figure 15.

---

[3] As in EWM, the mean CWM score of the younger listeners for NE: Clr-N was 100%. another t-test for difference scores between NE:Clr-N and NE: Clr+N by the older and younger listeners was conducted, revealing significant difference between the two groups of listeners, $t\,(22) = 6.18$, $p < 0.0001$

As was the case in EWM and CWM, it can be seen that overall, sentences spoken by the native Cantonese speakers were correctly verified much less frequently than were the sentences spoken by the native English speakers. The younger listeners achieved better scores than did the older adults in all sentence conditions. Sentences spoken clearly were correctly verified more often than those produced in a conversational manner. Also, as expected, sentences presented without the multibabble were correctly perceived to a greater extent than those presented in a noisy background.

Data from the two groups of listeners were submitted to a mixed-design ANOVA employing the variables identical to those used in EWM and CWM[4] (see Table 6). The statistical analysis yielded significant main effects of each of the variables, AL, $F(1,22) = 57.79$, $p < 0.0001$, NL, $F(1,22) = 37.50$, $p < 0.0001$, SS, $F(1,22) = 12.48$, $p < 0.01$ as well as LC, $F(1,22) = 497.61$, $p < 0.001$. As shown in Figures 16 and 17 respectively, significant interaction effects for LC x AL, $F(1,22) = 68.96$, $p < 0.0001$, and for NL x LC, $F(1,22) = 11.44$, $p < 0.01$ were found, indicating that the older listeners' performance was more vulnerable to the masking noise than that of their younger counterparts, and that the multibabble had a more deleterious effect on the sentences produced by the Cantonese speakers of English than those spoken by the native English speakers.

In addition, a three-way interaction, LC x SS x AL, was found to be significant, $F(1,22) = 7.86$, $p < 0.05$. Two separate analyses were carried out to

[4] For the younger listeners, the mean verification scores for NC: Clr-N and NE: Clr-N were 100%. Two separate t-tests for difference scores by the older and younger listeners were conducted. Significant differences were found for NC: Clr-N, $t(22) = 6.20$, $p < 0.0001$, and for NE: Clr-N, $t(22) = 8.28$, $p < 0.0001$.

further explore the performance of the older and younger listeners on verifying sentences spoken clearly and conversationally in the Clean condition and in the Noisy condition, respectively. Figure 18 illustrates the listeners' scores obtained in the Clean listening condition. It was found that that the verification scores achieved by the younger adults for the sentences spoken clearly (M = 100 %) and conversationally (M = 95.83 %) were greater than those by the older adults (M = 90.97 %, Clear; M = 79.17 %, Conversational). A mixed-design ANOVA was carried out with AL, as a between-subjects factor, and SS, as a within-subjects factor. Analysis revealed significant main effects of AL, F (1,22) = 11.42, $p <$ 0.01, and of SS, F (1,22) = 7.14, $p < 0.05$, indicating that the younger adults achieved significantly higher scores than did the older listeners, and that the clearly spoken sentences were significantly verified more often than were the sentences produced conversationally. However, the interaction between AL and SS failed to reach significance, $p > 0.05$.

The mean verification scores obtained by the two groups of listeners in the Noisy listening condition are depicted in Figure 19. As in the Clean listening condition, the performance of the younger listeners (M = 74.13 %, Clear; M = 61.81 %, Conversational) was better than that of the older adults (M = 22.92 %, Clear; M = 16.67 %, Conversational). Data were submitted to another ANOVA employing the same factors as those for the Clean condition. The main effect of AL was significant, F (1,22) = 11.42, $p < 0.0001$, indicating that the younger listeners scored significantly higher than did the older adults. There was also a significant effect of SS, F (1,22) = 14.14, $p < 0.01$, suggesting that the sentences spoken clearly received significantly higher scores than those produced in a conversational manner. However, no significant interaction between AL and SS was found, $p > 0.05$.

On the basis of all the above analyses, it appears that the interaction was due to the fact that the younger listeners derived a greater clear speech effect in noisy conditions than in clean conditions. In contrast, for the elderly listeners, the size of clear speech advantage was greater in noise-free conditions than in the noisy conditions.

3.3. Discussion and Conclusions

First of all, some interesting patterns of results existed for the perception of the stimulus sentences based on their truth value (i.e., True vs. False). Previous research has found no significant difference between true and false sentences perceived by younger English-speaking listeners in both transcription and verification tasks (Li, 2000; Munro, 1998; Munro & Derwing 1995b). In the present study, no significant differences between the two types of sentences were found in any of the tasks for the younger English listeners. For the elderly listeners, there were no significant differences in scores for the true and false sentences in the two transcription tasks (EWM and CWM). For the verification task, however, the older adults' score on the true sentences (57%) was significantly higher than that on the false sentences (47%).

To account for the different patterns of responses for the older English adults on the two tasks (transcription vs. verification), two possible explanations can be offered – nature of the tasks and age-related differences in decision criteria. First, in the orthographic transcription task, what the listeners needed to do was simply to write down as many words as they could, upon listening to a stimulus sentence. They did not have to give much thought to verify the truth value of the sentence. Consequently, as was the case for the younger adults, the older listeners showed no significant difference in transcription scores between the true and false sentences in the exact word match and in the content word match.

However, in the verification task, the listeners had to process the meaning of the sentence to determine whether it was true or false. It has been suggested that besides age-related differences in peripheral and central auditory processing abilities, older listeners tend to use a more cautious (or less risky) decision criteria than do younger adults in speech perception tasks or in daily communicative situations (Gordon-Salant, 1986; Marshall, 1981; Yanz & Anderson, 1984). Namely, the older listeners are more inclined to demand greater clarity of the spoken messages than are younger ones before providing a response; they are less inclined to respond to spoken messages that are uncertain or unclear (Gordon-Salant, 1986; Yanz & Anderson, 1984). Also, it has been suggested that older adults have a greater tendency than do younger adults to select an avoidance option, if available, so as to avoid risky alternatives (Botwinick, 1969; Gordon-Salant, 1986).

As already described above, regarding the screen display for the verification task using ExperimentMFC, in addition to the two buttons of “True” and “False”, an “Unknown” button was also available. The purpose of which is to discourage listeners from consistently selecting “False” whenever they are not able to determine the truth value of a statement. For the current study, there were 24 noisy and 24 clean sentences in each of the four complete lists of stimulus sentences. Of the 24 noisy speech samples, an average of 19 sentences (79%) with a range of 13 (54%) to 24 (100%) were selected as “Unknown” by the elderly listeners. In contrast, of the 24 clean sentences, the older adults chose the “Unknown” button for an average of 3 sentences (13%) with a range of 0 (0%) (i.e., the button was not pressed) to 9 (38%) statements. For the younger adults, the number of noisy statements considered as “Unknown” ranged from 3 (13%) to 14 sentences (58%) with an average of 7 sentences (29%), while the clean statements averaged to less than one sentence (l.7%) with a range from 0 (0%) to 3 utterances (13%).

It can readily be seen that the elderly English listeners selected the “Unknown” button for the sentences masked with multibabble much more frequently than did the younger adults in the verification task. Therefore, the discrepancy in response patterns between the transcription and verification tasks for the elderly listeners appears to be due in part to the fact that when presented with the noisy sentences, the older adults were inclined to use a more conservative criterion in determining the truth value of the statements than were the younger English listeners.

As in previous L2 speech studies involving nonnative speakers of English (Anderson-Hsieh & Koehler, 1988; Burda et al., 2003; Derwing & Munro, 1997;

Derwing et al., 1998; Li, 2000; Mahendra et al., 1999; Munro, 1995, 1998; Munro & Derwing, 1994, 1995a, 1995b, 1998), the English spoken by the native Hong Kong Cantonese speakers here was perceived to be significantly less intelligible than that of the native English speakers in terms of intelligibility. In each of the four sentence conditions (i.e., Clr-N, Clr+N, Con-N, and Con+N), the Cantonese speakers' sentences were less correctly transcribed than those of the native productions according to both of the two scoring methods. For the exact word match, it was found that overall, the mean score for the Cantonese speakers was 73% (exact word match), while the mean score for English speakers was 77%. Similarly, the content-word matching score for the Cantonese speakers (71%) was less than the English speakers' score (79%). For the verification task, as was the case for the two transcription tasks, sentences produced by the Cantonese speakers (63%) were correctly verified less frequently than the speech samples produced by the English speakers (73%) across all the sentence conditions by the two groups of listeners.

Consistent with the findings reported in earlier studies (Bradlow & Bent, 2002; Caissie et al., 2005; Helfer, 1998; Krause & Braida, 2002; Payton et al., 1994; Picheny et al., 1985, 1989; Schum, 1996; Smiljanic & Bradlow, 2005), it was found that clearly spoken sentences were significantly more intelligible than statements spoken in a conversational style (pooled across the two groups of speakers, the two groups of listeners, and the two listening conditions). Scores for clear speech were 79% and those for conversational speech were 71%, identical in the two transcription tasks (EWM and CWM). For the verification task, an intelligibility difference of 9 percentage points was found between clear (72%) and conversational speech (63%). Moreover, it should be mentioned that the results obtained in the present experiment confirmed the findings of previous studies associated with the size of the clear speech advantage for native-produced clear and conversational speech for English listeners. An examination of the mean transcription scores between clear and conversational speech spoken by the native English speakers for the two groups of English listeners in noisy conditions revealed an intelligibility benefit of 17 percentage points in both the exact word match and content word match. As in previous studies, the data obtained in the present study further illustrated that the clear speech effect is robust across speakers, listeners, and listening conditions.

Furthermore, while the native English listeners derived a substantial perceptual advantage to listening to the clear speech produced by the native English speakers, no significant clear speech effect was exhibited by the nonnative speakers of English. For the exact word match, it was found that, pooled across the listener groups and the listening conditions, English speakers' clear sentences were more intelligible than their conversational speech by 13 percentage points, while the intelligibility difference between clear and conversational speech spoken by the Cantonese speakers of English was only 3 percentage points. For the content word match, a similar pattern of results was observed. The native English speakers elicited a greater clear speech effect (11 percentage points) than did the nonnative English speakers (4 percentage points). In view of the findings, it seems that a clear speaking style for nonnative

English speakers is not to be an effective speech perception enhancement strategy for native English listeners compared to the clear speech productions of native English speakers.

As expected, overall, sentences presented without noise were better perceived than those presented with the 12-talker babble in the transcription and verification tasks. For both the exact-word and content-word matching, sentences presented in the conditions of Clr-N (97%, EWM; 97%, CWM) and Con-N (91%, EWM; 92%, CWM) were more correctly transcribed than were sentences presented in the Clr+N (61%, EWM; 61%, CWM) and Con+N (51%, EWM; 51%, CWM) conditions. A similar pattern of results was also observed for the verification task. The Clean sentences (95%, Clr-N; 88%, Con-N) were correctly verified more often than the sentences presented with the masking noise (49%, Clr+N; 39%, Con+N). The findings demonstrated that the additive noise did degrade the intelligibility of both Conversational and Clear speech.

In addition, the masking noise used for the current experiment had a more deleterious effect on sentences spoken by the Cantonese speakers of English than on those produced by the native English speakers. For the content word match, the mean percent correct transcription score for the English speakers' sentences had a drop of about 35% from the Clean to Noisy conditions, whereas that of the Cantonese speakers' utterances was decreased by almost 47%. For the verification task, it was found that the Cantonese statements exhibited a drop in scores by 60% from the Clean to Noisy conditions, while the native-produced sentences decreased from 93% in the Clean condition to 52% in the Noisy

Condition (i.e., a decrease in score of 41%). A similar pattern, though marginally non-significant, was also observed for the data on the exact word match. For the foreign-accented speech, there was a decrease in transcription score of 41% from the Clean to Noisy condition. The corresponding figure for the native-produced sentences was 35%. The above results provide further evidence that the effect of masking noise on the intelligibility of foreign-accented English is greater than that on the sentences spoken by native English speakers, as in previous studies that examined intelligibility of foreign-accented English for native English listeners (Li, 2000; Munro, 1998).

In agreement with the findings of previous studies (Burda et al., 2003; CHABA, 1988; Cheesman, 1997; Crandell et al., 1991; Gordon-Salant, 1986; Pichora-Fuller et al., 1995; Tun, 1998), overall, the older listeners here performed more poorly than the younger adults in the transcription and verification tasks. This age-related difference in speech perception ability was even greater when the speech samples (pooled across the speakers and the speaking styles) were presented with the 12-talker babble. For the exact word match, the younger adults obtained a score of 99% in the Clean condition and 78% in the Noisy listening condition. For the elderly listeners, in contrast, the score decreased from 90% in the Clean condition to 34% in the Noisy condition. For the content word match, the older listeners showed a decrease in mean transcription scores of 65% (90%, Clean; 35%, Noisy), whereas there was only a drop in scores of 22% in score for the younger adults (99%, Clean; 77%, Noisy). As in the transcription task, a decrease in verification scores of 60% (i.e., from 85% in the Clean condition to 20% in the Noisy condition) was found for the older adults. For the younger adults, however, the verification score decreased from 98% in the Clean sentences to 68% in the Noisy sentences (i.e., a decrease in score of 33% only).

As discussed above, sentences spoken in a clear speaking mode were found to be more intelligible than speech produced in a conversational manner. Also, the younger listeners outperformed the older adults in perceiving the stimulus sentences, presented with or without the multibabble, spoken by both the Cantonese speakers and native English speakers. Interestingly, for the verification task, the clear speech perceptual effect was beneficial to the two groups of listeners to a different extent and in different listening conditions. It was found that when presented with the noisy sentences, the younger listeners obtained a verification score of 62% for the Conversational sentences and 74% for the Clear sentences (an increase of 12%), while the elderly listeners obtained an increase in score of only 6% (17%, Conversational; 23%, Clear). However, in the Clean condition, the verification score for the elderly listeners increased by 12% (79%, Conversational; 91%, Clear). For the younger listeners, the verification scores for the Conversational and Clear sentences were 96% and 100%, respectively, showing an increase of 4% only. It was obvious that the older adults derived greater clear speech perceptual advantage in quiet conditions than in noisy conditions. However, the clear speech effect was beneficial to the younger listeners more when the sentences were masked with background noise than when the utterances were presented without any masking noise.

Overall, it was found that in this perception experiment, there were no significant differences in transcription scores, as measured in the exact word and content word matches, and verification scores between the true and false sentences for the younger English listeners. Although the older English listeners exhibited no significant differences in transcription scores (EWM and CWM), they showed significantly lower scores for the false sentences than for the true sentences in the verification task.

Sentences produced by the Cantonese speakers of English were less intelligible than those spoken by the native English speakers in each of the two tasks for assessing speech intelligibility - transcription and verification. Also, sentences masked with the 12-talker multibabble received poorer scores than did the speech samples presented without masking noise. As in previous studies, overall, sentences produced in a clear speaking style were better perceived than those spoken in a conversational manner. Nonetheless, only the clear speech produced by the native English speakers was significantly more intelligible than the conversational speech. There was no significant difference between the two types of speaking styles as spoken by the Cantonese speakers of English. In addition, the findings revealed that the elderly listeners scored much lower than their younger counterparts in the exact word match, content word match, as well as in the verification task, and that the magnitude of difference was greater when the sentences were presented in noisy conditions than when the speech samples were presented without the multibabble noise.

Table 1. Participant characteristics for the younger English listeners.

Younger Listeners	Sex	Age	Highest Education	Overall Health	Foreign Accent commonly heard	Frequency
1	M	20	Undergraduate Student	Good	Chinese, Dutch, Punjabi	Very Often
2	F		Undergraduate Student	Very Good	Asian	Very Often
3	M		Undergraduate Student	Very Good	British, Chinese Indian	Not Very Often
4	M		Undergraduate Student	Very Good	Chinese, Korean	Very Often
5	F		Undergraduate Student	Good	Hungarian	Very Often
6	F		Undergraduate Student	Very Good	Chinese, French, Japanese, Korean	Every Day
7	F		Undergraduate Student	Very Good	Chinese, Japanese	Often
8	F		Undergraduate Student	Very Good	French, Chinese, Swedish, Scottish	Very Often
9	F		Bachelor	Very Good	Chinese, Japanese	Every Day
10	M		Undergraduate Student	Very Good	American, Scottish	Not Very Often
11	F		Bachelor	Very Good	Chinese, Indian	Very Often
12	F		Undergraduate Student	Very Good	Chinese, European	Often

Note: The listeners rated their overall health condition on a 5-point scale from Very Good, Good, Fair, Poor to Very Poor, and the frequency of interacting with speakers with foreign accents in English from Every Day, Very Often, Often, to Not Very Often.

Table 2. Participant characteristics for the older English listeners.

Older Listeners	Sex	Age	Highest Education	Overall Health	Foreign Accent commonly heard	Frequency
1	F	72	College	Good	Chinese, Indian, Japanese	Every Day
2	F	75	Bachelor	Very Good	Chinese, Indian	Every Day
3	F	68	University Level	Good	Asian, European	Very Often
4	F	69	Bachelor	Good	Chinese, Italian, German	Often
5	F	65	Bachelor	Very Good	Chinese, Korean Spanish, Vietnamese	Every Day
6	M	80	University Level	Good	Chinese, Scottish	Every Day
7	F	71	High School	Good	British, Czech, Croatian	Very Often
8	F	75	University Level	Very Good	French, Chinese, European, Iranian	Very Often
9	F	73	Master	Good	Latino, Italian, German, Russian	Often
10	F	71	Bachelor	Good	Hungarian	Every Day
11	F	78	College	Very Good	Chinese, Spanish	Not Very Often
12	F	79	High School	Very Good	Asian, European, Indian, First Nation	Very Often

Note: The listeners rated their overall health condition on a 5-point scale from Very Good, Good, Fair, Poor to Very Poor, and the frequency of interacting with speakers with foreign accents in English from Every Day, Very Often, Often, to Not Very Often.

Table 3. Mean pure-tone air-conduction thresholds (dB HL) from 250 Hz to 8000 Hz for the younger and older English-speaking listeners. Standard deviations are in parentheses.

	Younger Listeners		Older Listeners	
Frequency (Hz)	Right	Left	Right	Left
250	8.8 (6.4)	5.4 (8.6)	25.8 (8.2)	20.4 (9.6)
500	9.2 (5.1)	7.5 (4.0)	24.6 (6.2)	21.7 (9.8)
1000	2.5 (8.4)	-2.1 (8.1)	20.0 (9.0)	16.7 (9.6)
2000	0.4 (9.4)	2.1 (11.0)	22.5 (7.5)	22.1 (7.2)
4000	-2.5 (7.5)	-2.1 (8.4)	31.7 (10.3)	31.3 (9.3)
8000	-2.5 (7.5)	-2.1 (8.6)	42.5 (12.9)	42.9 (13.2)

Table 4. The means (M), standard deviations (SD), and standard errors (SE) in the exact-word matching (EWM) scores from the older (Old) and younger (Yng) listeners for sentences produced by the two groups of speakers, Cantonese and English, in the two speaking styles, Clear and Conversational under the two listening conditions, Clean and Noisy.

		Cantonese Speakers				English Speakers			
		Clear		Conversational		Clear		Conversational	
		Noisy	Clean	Noisy	Clean	Noisy	Clean	Noisy	Clean
Old	M	31.11	92.24	29.73	86.65	46.63	96.69	28.28	83.07
	SD	19.46	7.84	21.73	16.15	19.91	4.78	22.24	17.41
	SE	5.62	2.26	6.27	4.66	5.75	1.38	6.42	5.03
Yng	M	76.20	99.32	71.97	97.99	89.77	100.00	73.05	97.92
	SD.	14.15	1.26	13.46	3.61	10.19	0.00	15.15	3.46
	SE	4.09	0.36	3.89	1.04	2.94	0.00	4.37	1.00

Table 5. The means (M), standard deviations (SD), and standard errors (SE) in the content-word matching (CWM) scores from the older (Old) and younger (Yng) listeners for sentences produced by the two groups of speakers, Cantonese and English, in the two speaking styles, Clear and Conversational under the two listening conditions, Clean and Noisy.

		Cantonese Speakers				English Speakers			
		Clear		Conversational		Clear		Conversational	
		Noisy	Clean	Noisy	Clean	Noisy	Clean	Noisy	Clean
Old	M	30.93	90.53	27.52	83.56	49.54	97.34	32.29	87.62
	SD	17.94	9.75	20.93	18.68	21.13	4.29	21.91	16.01
	SE	5.18	2.81	6.04	5.39	6.10	1.24	6.33	4.62
Yng	M	71.64	99.07	67.85	97.69	91.44	100.00	75.93	99.31
	SD.	14.58	2.16	14.09	4.41	9.40	0.00	16.39	1.62
	SE	4.21	0.62	4.07	1.27	2.71	0.00	4.73	0.47

Table 6. The means (M), standard deviations (SD), and standard errors (SE) in the verification scores from the older (Old) and younger (Yng) listeners for sentences produced by the two groups of speakers, Cantonese and English, in the two speaking styles, Clear and Conversational under the two listening conditions, Clean and Noisy.

		Cantonese Speakers				English Speakers			
		Clear		Conversational		Clear		Conversational	
		Noisy	Clean	Noisy	Clean	Noisy	Clean	Noisy	Clean
Old	M	13.89	86.11	11.11	77.78	31.94	95.83	22.22	80.56
	SD	13.91	13.91	16.41	26.91	21.86	7.54	19.25	17.16
	SE	4.02	4.02	4.74	7.77	6.31	2.18	5.56	4.95
Yng	M	62.50	100.00	55.56	95.83	86.11	100.00	68.06	95.83
	SD.	14.43	0.00	23.92	7.54	11.96	0.00	21.86	10.36
	SE	4.17	0.00	6.91	2.18	3.45	0.00	6.31	2.99

Figure 5. Percent correct transcription (exact word match) scores for the True and False sentences for the older listeners (Old) and the younger listeners (Yng). Error bars indicate ±standard error.

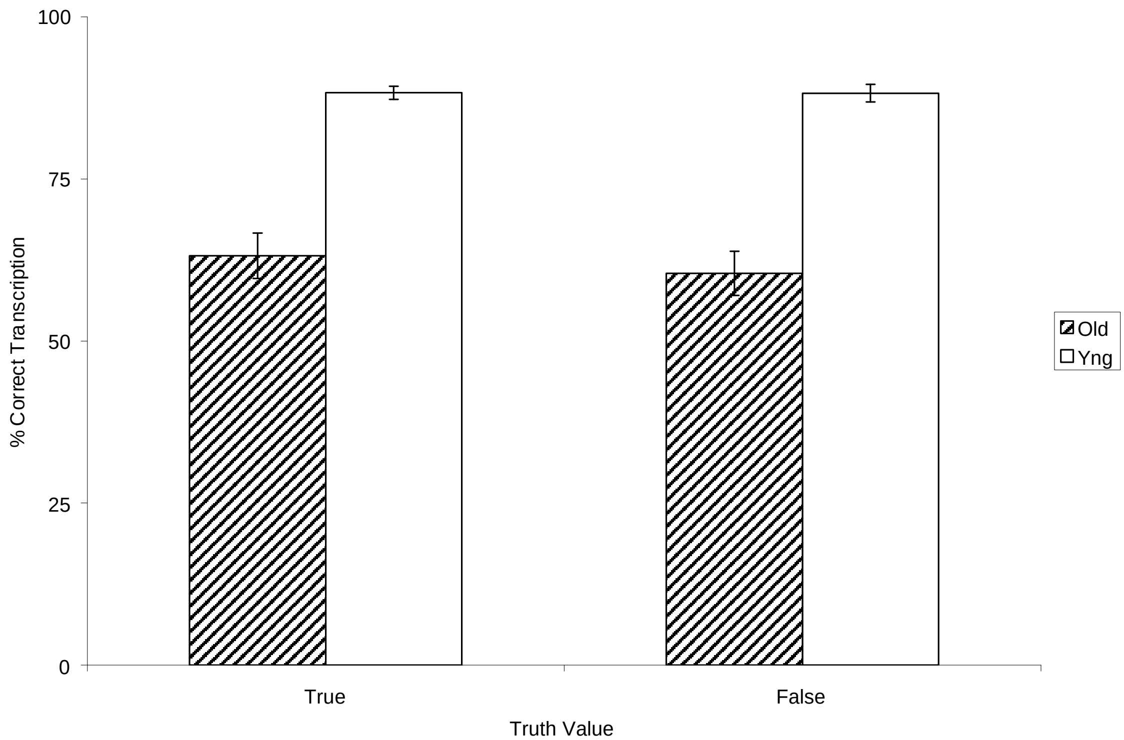


Figure 6. Percent correct transcription (content word match) scores for the True and False sentences for the older listeners (Old) and the younger listeners (Yng). Error bars indicate ± standard error.

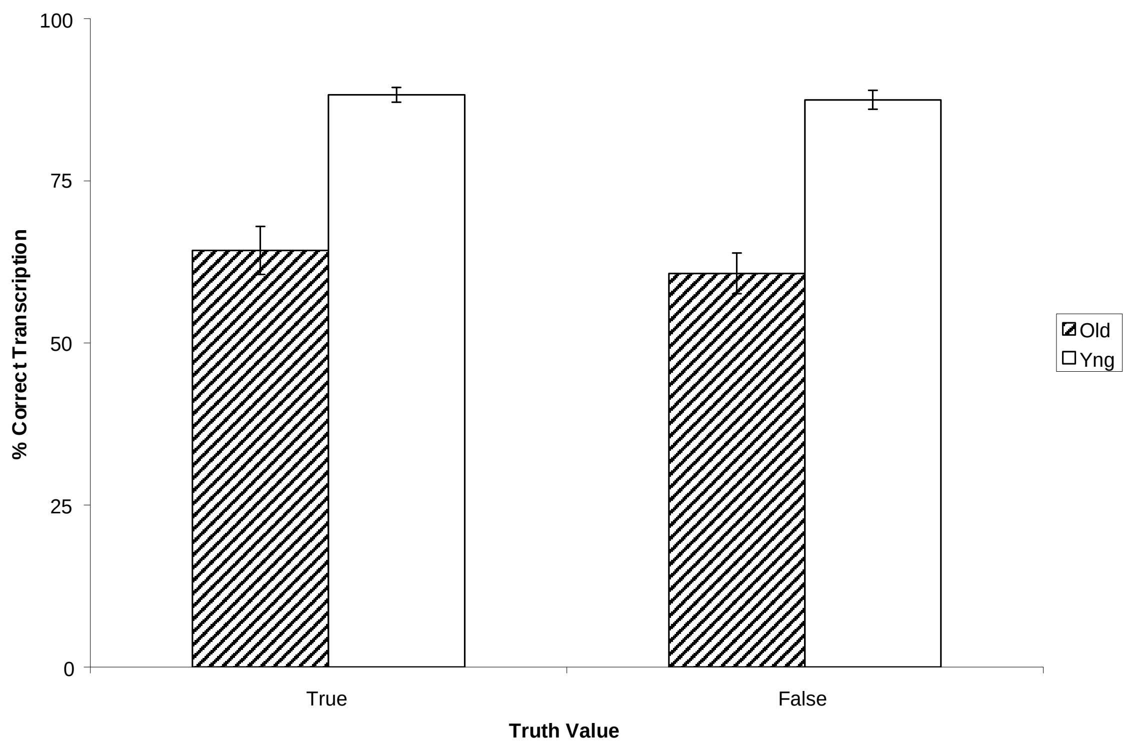


Figure 7. Percent correct verification scores for the True and False sentences for the older listeners (Old) and the younger listeners (Yng). Error bars indicate ± standard error.

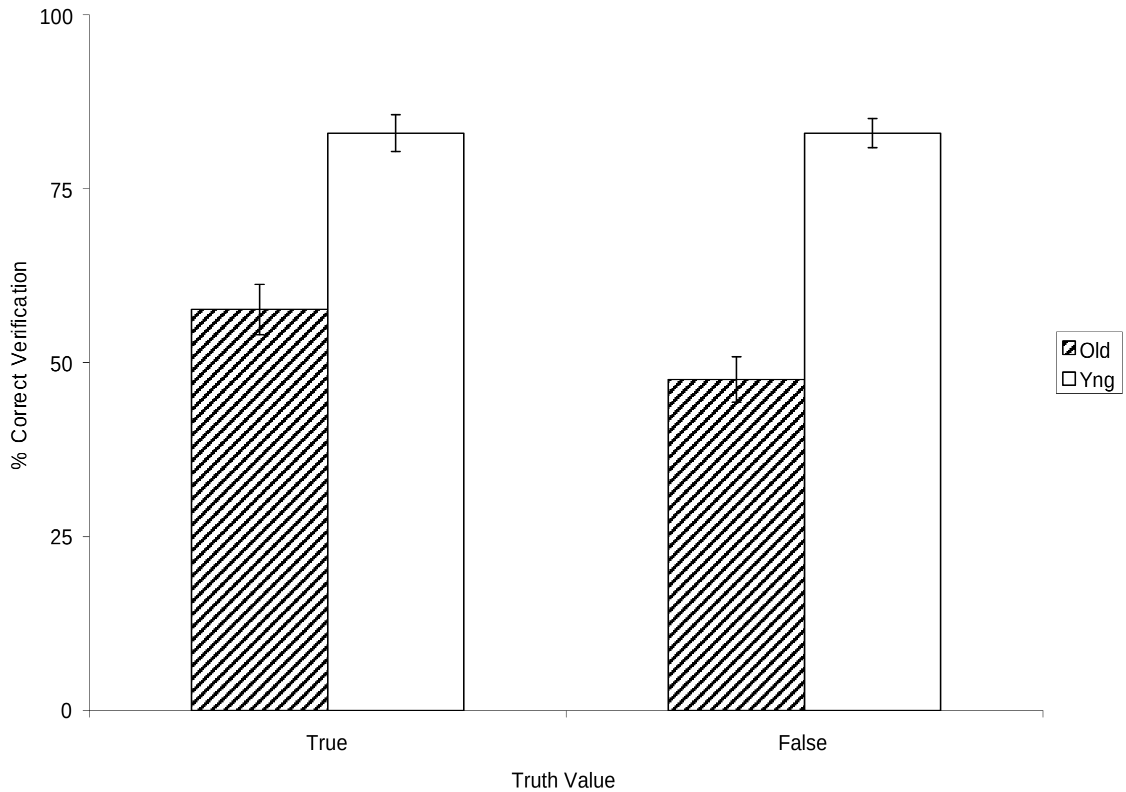


Figure 8. Percent correct transcription (exact word match) scores obtained by the older listeners (Old) and the younger listeners (Yng) for the sentences spoken by the Cantonese speakers (Can Spkrs) and the English speakers (Eng Spkrs) in each of the four sentence conditions. Error bars indicate ± standard error.

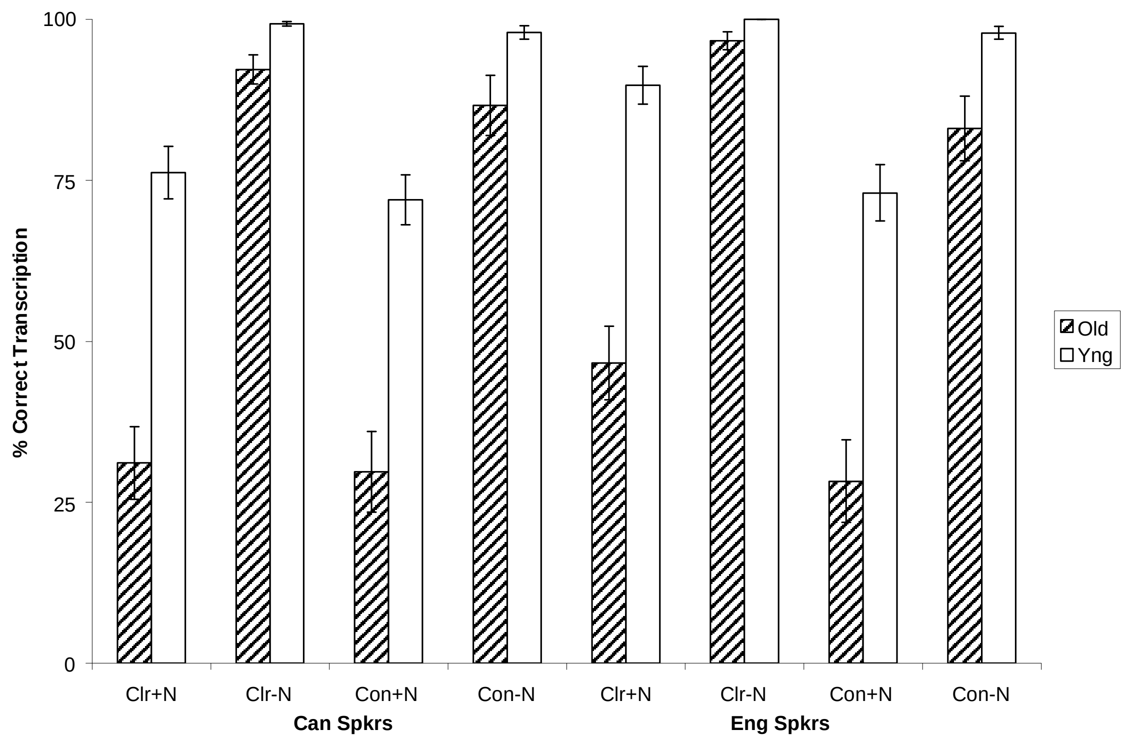


Figure 9. Percent correct transcription (exact word match) scores obtained by the older listeners (Old) and the younger listeners (Yng) in each of the two listening conditions. Error bars indicate ± standard error.

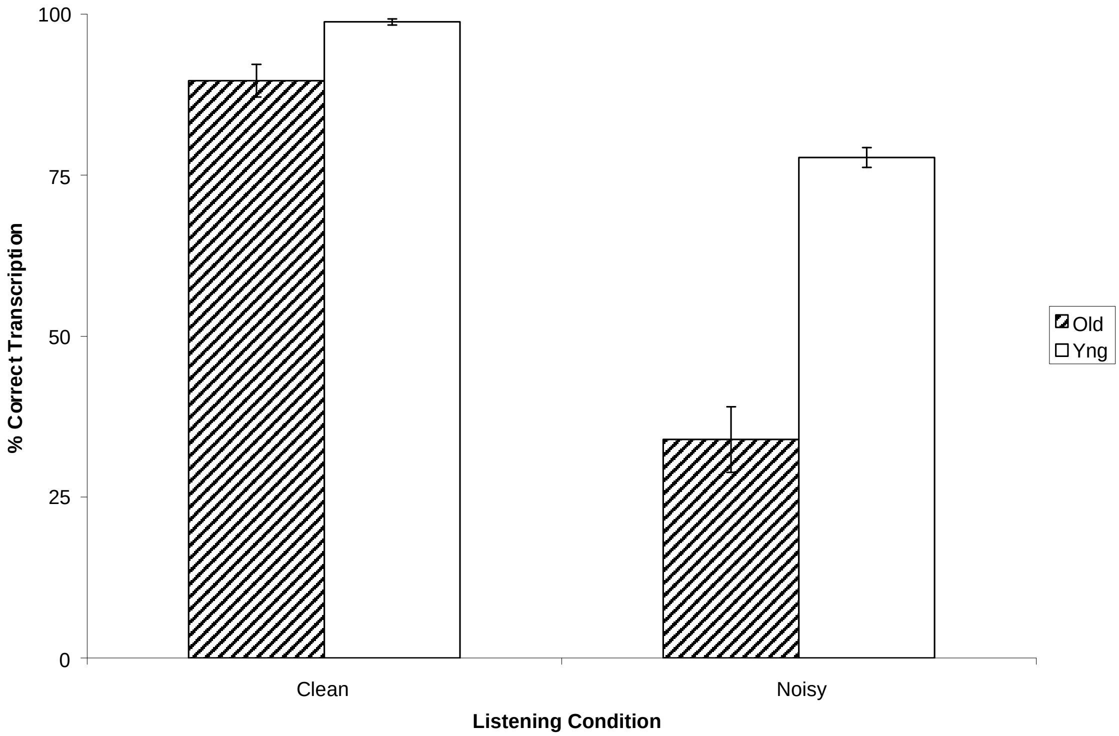


Figure 10. Percent correct transcription (exact word match) scores for the sentences spoken by the Cantonese speakers (Can Spkrs) and the English speakers (Eng Spkrs) in each of the two speaking styles. Error bars indicate ± standard error.

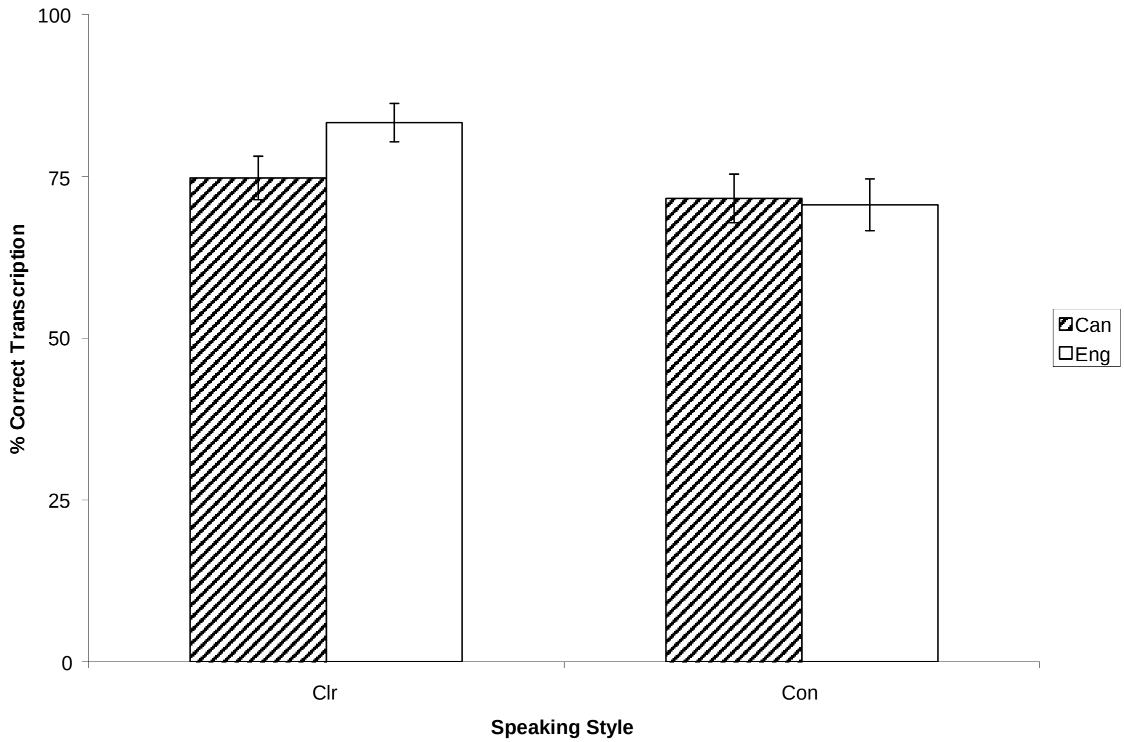


Figure 11. Percent correct transcription (content word match) scores obtained by the older listeners (Old) and the younger listeners (Yng) for the sentences spoken by the Cantonese speakers (Can Spkrs) and the English speakers (Eng Spkrs) in each of the four sentence conditions. Error bars indicate ± standard error.

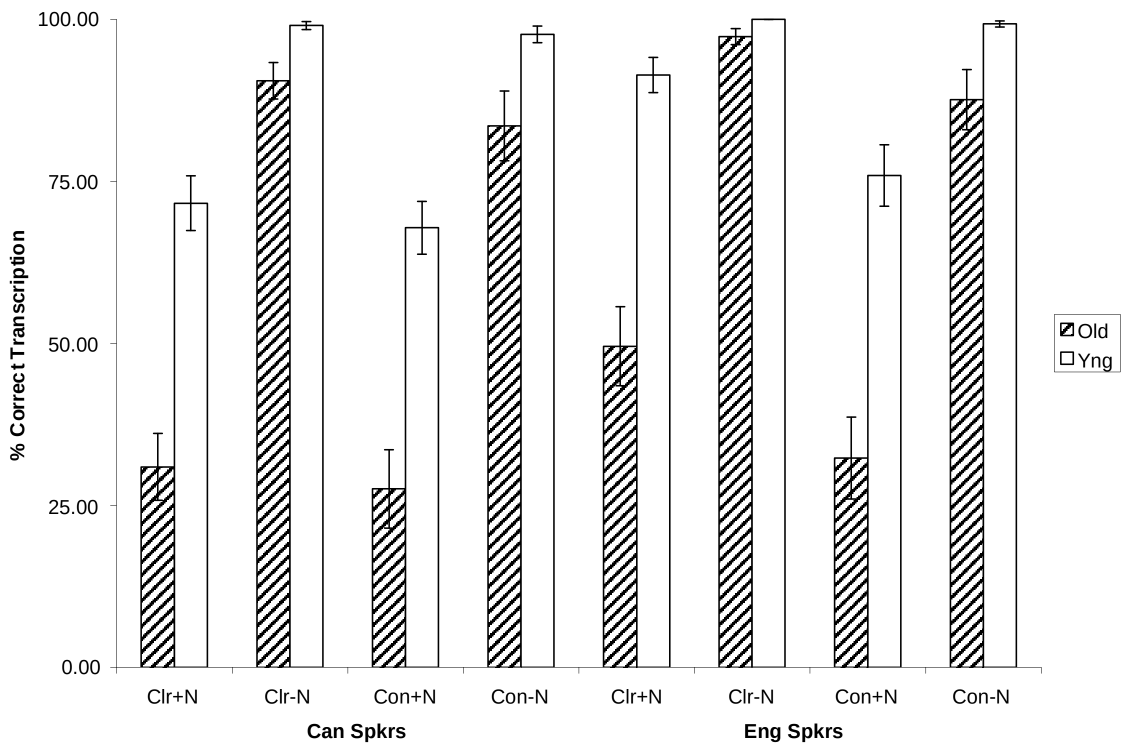


Figure 12. Percent correct transcription (content word match) scores obtained by the older listeners (Old) and the younger listeners (Yng) in each of the two listening conditions. Error bars indicate ± standard error.

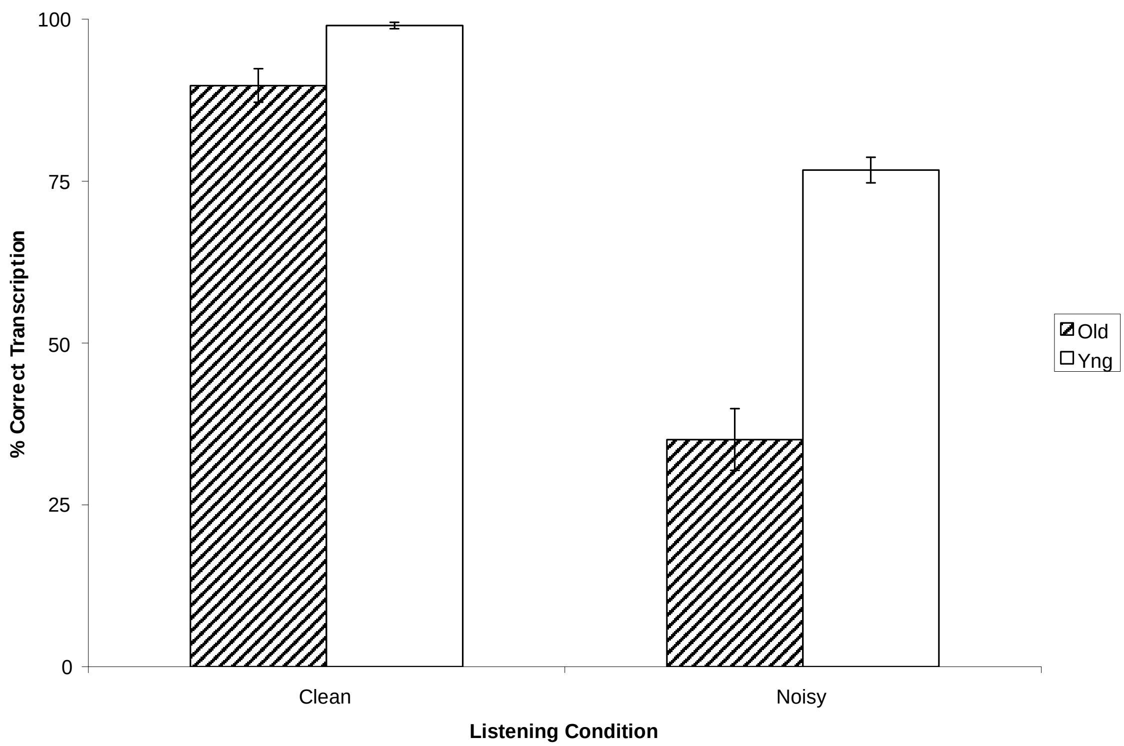


Figure 13. Percent correct transcription (content word match) scores for the sentences spoken by the Cantonese speakers (Can Spkrs) and the English speakers (Eng Spkrs) in each of the two speaking styles. Error bars indicate ± standard error.

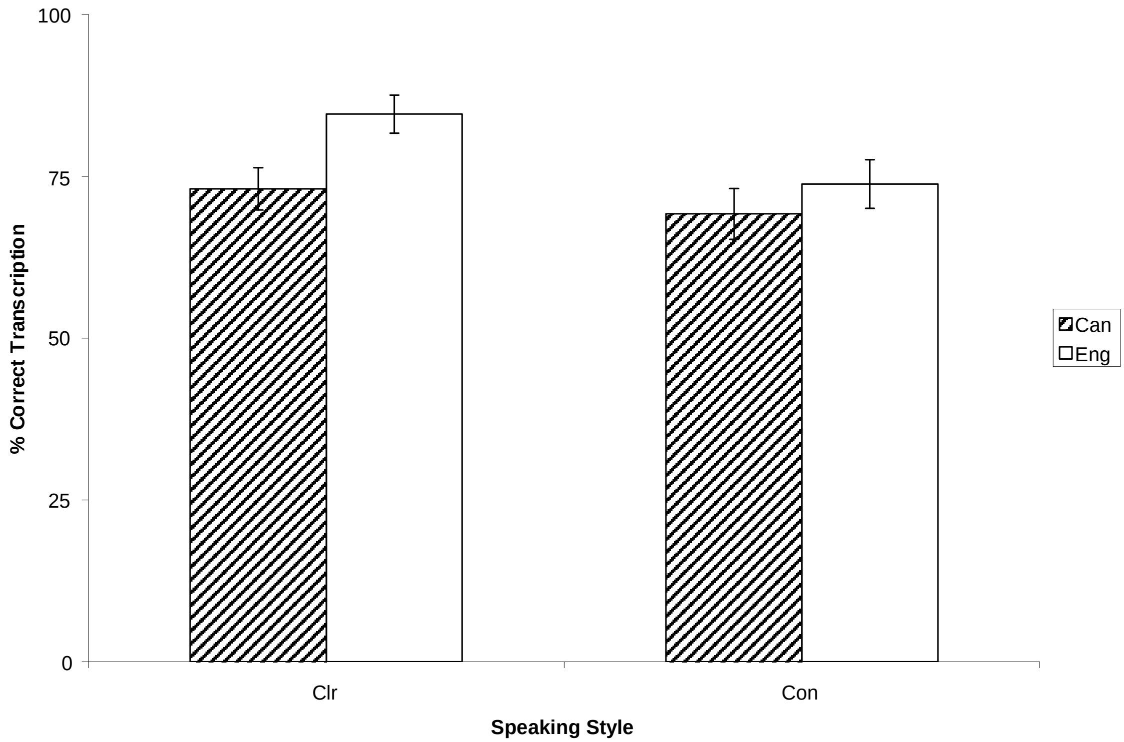


Figure 14. Percent correct transcription (content word match) scores for the sentences spoken by the Cantonese speakers (Can Spkrs) and the English speakers (Eng Spkrs) in each of the two listening conditions. Error bars indicate ± standard error.

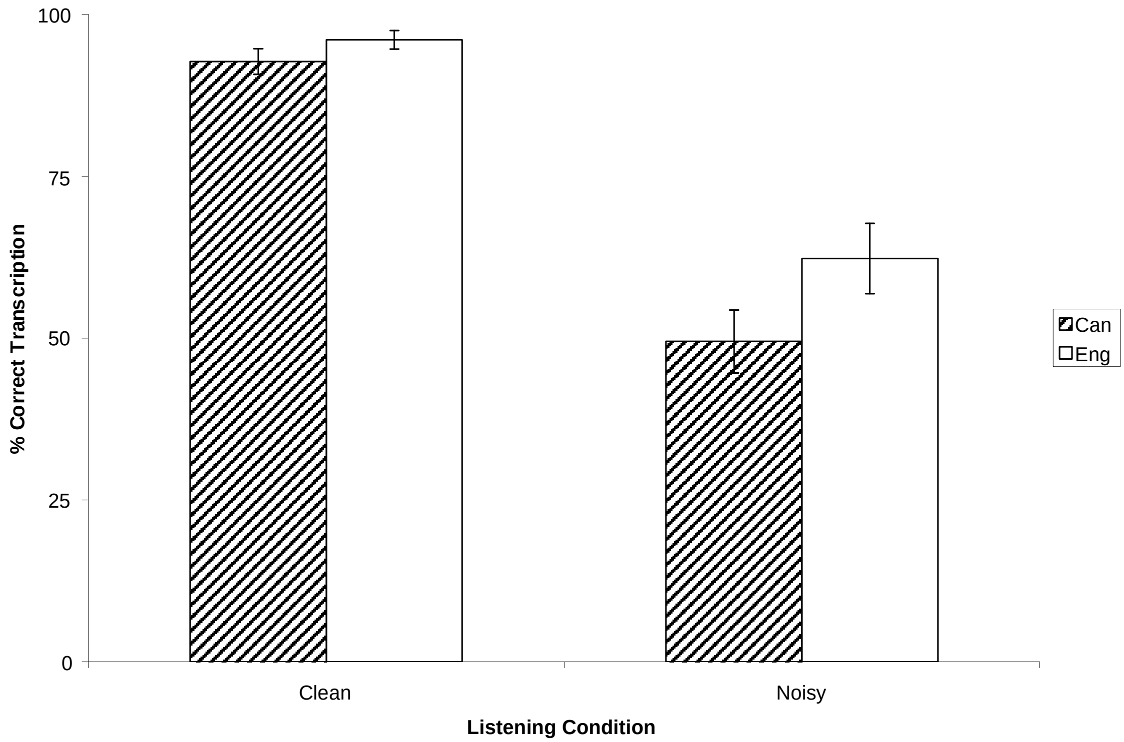


Figure 15. Percent correct verification scores obtained by the older listeners (Old) and the younger listeners (Yng) for the sentences spoken by the Cantonese speakers (Can Spkrs) and the English speakers (Eng Spkrs) in each of the four sentence conditions. Error bars indicate ± standard error.

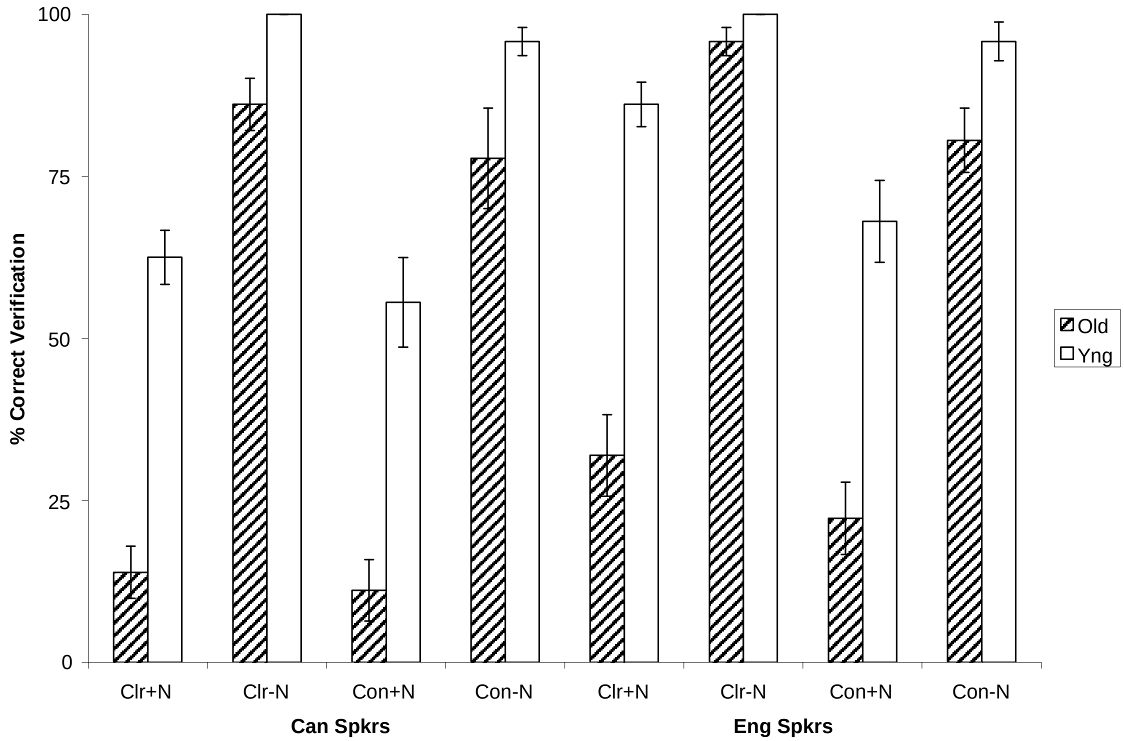


Figure 16. Percent correct verification scores obtained by the older listeners (Old) and the younger listeners (Yng) in each of the two listening conditions. Error bars indicate ± standard error.

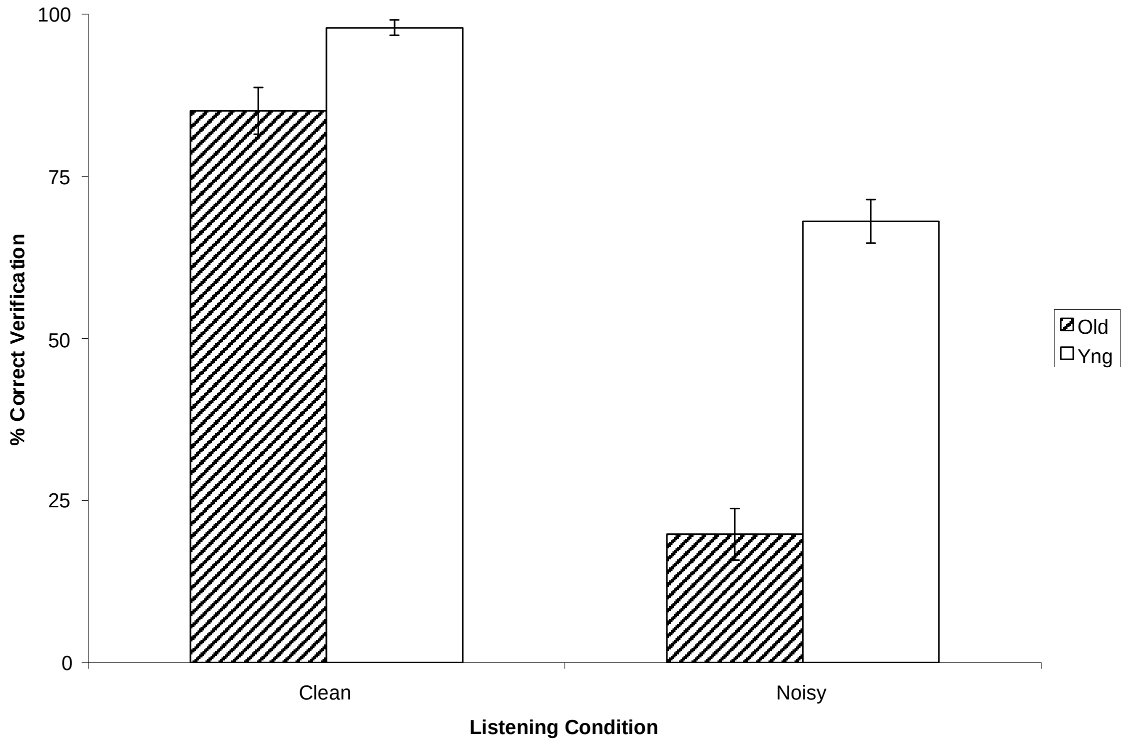


Figure 17. Percent correct verification scores for the sentences spoken by the Cantonese speakers (Can Spkrs) and the English speakers (Eng Spkrs) in each of the two listening conditions. Error bars indicate ± standard error.

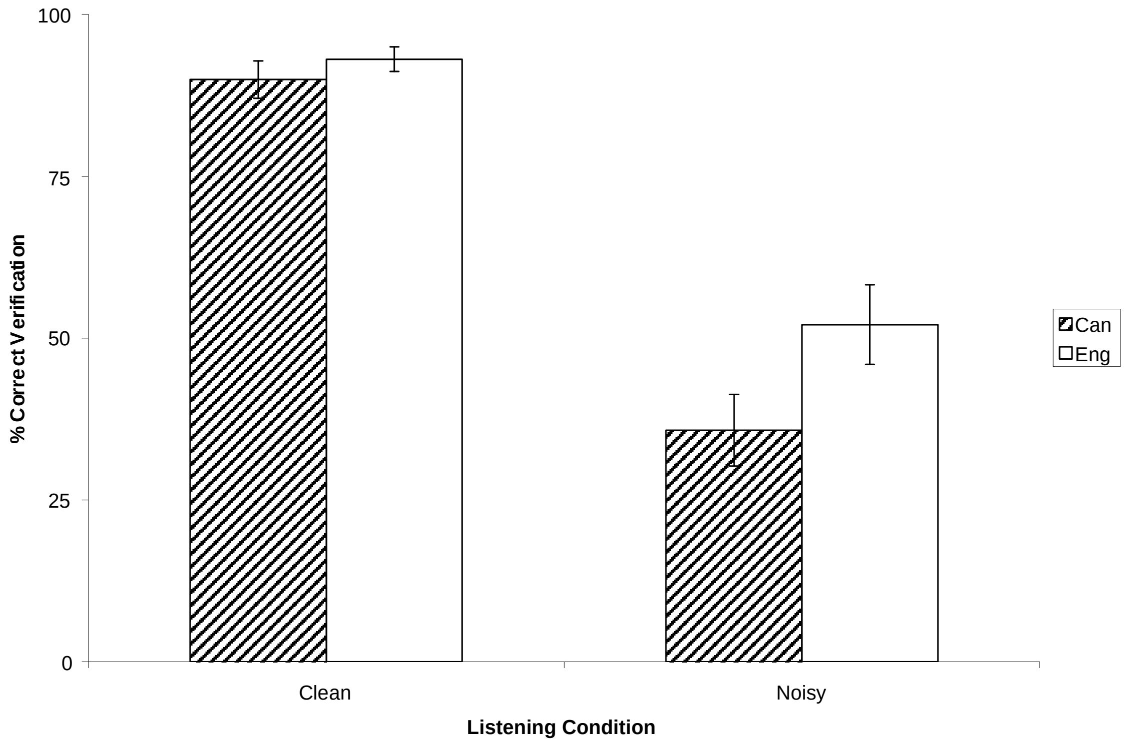
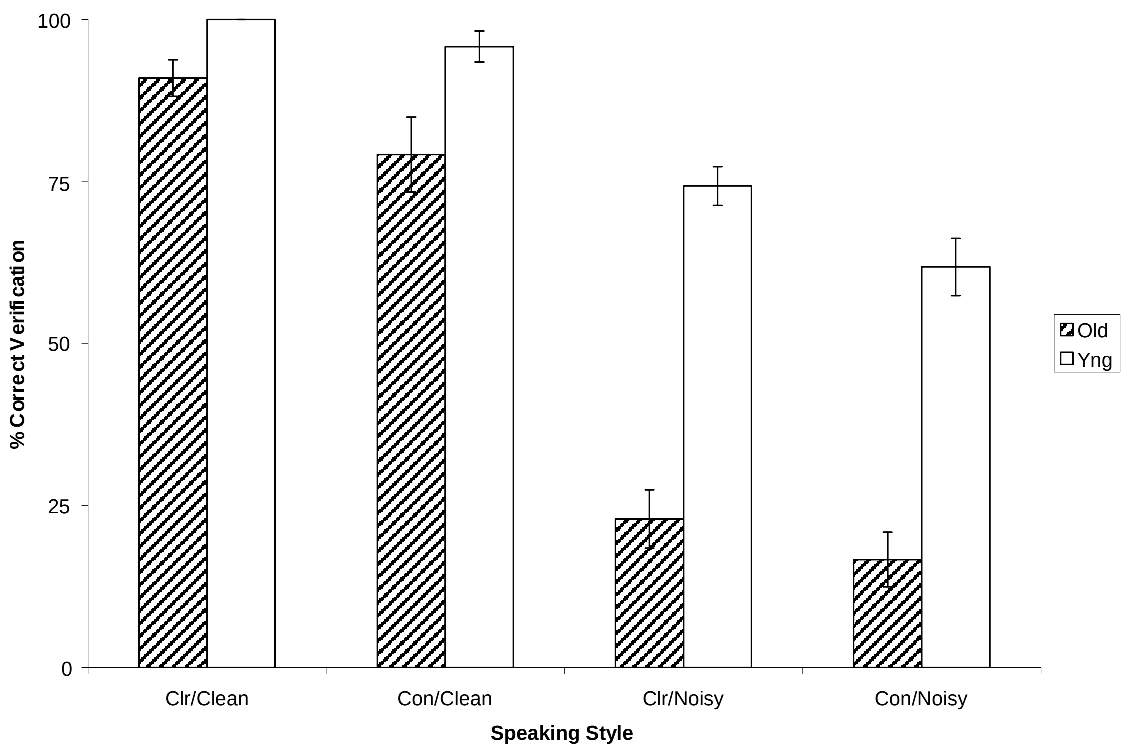


Figure 18. Percent correct verification scores obtained by the older listeners (Old) and the younger listeners (Yng) for sentences spoken in each of the two speaking styles in the Clean and Noisy conditions. Error bars indicate ± standard error.



CHAPTER 4: DISCUSSION AND CONCLUSIONS

Despite the extensive literature on clear speech over the past decades, relatively little is known about the effects of this careful-speaking style on the production and perception of foreign-accented English. Moreover, while there has been substantial research on the perception of foreign-accented speech by younger English listeners, few studies have examined the ability of older English-speaking adults to listen to English spoken by nonnative speakers. The goals of the present study were twofold. First, an attempt was made to examine whether nonnative speakers of a language would employ the same strategies as used by native speakers in producing clear speech. To this end, acoustic characteristics of English sentences spoken clearly and conversationally by nonnative speakers of English were examined and compared to those produced by native English speakers. The second goal was to investigate whether there was any clear speech effect on leading to an enhancement of the intelligibility of foreign-accented English for younger and older English-speaking listeners.

This research represents the first attempt to report any changes in speaking rate, articulation rate, total pause time, and sentential fundamental frequency values in simple, short English declarative sentences spoken clearly and conversationally by nonnative speakers of English. In addition, the current study explores intelligibility differences between foreign-accented clear and conversational speech presented in noise-free and noisy conditions for younger and older English-speaking listeners using standard procedures that have been commonly employed in second language speech studies.

In the production task, recordings were made of Cantonese speakers of English and a comparison group of native English speakers producing a list of simple, short English sentences, once in a conversational speaking style and once in a clear speech mode. Four different sentences produced in each of the speaking styles (clear vs. conversational) by each of the speakers were randomly selected for acoustic analyses and for a subsequent perceptual experiment.

Results of the production study revealed that, as was the case for the native English speakers, the Cantonese speakers produced the sentences with slower speaking and articulation rates in a clear speaking style than in a conversational manner. In addition, the total pause time was longer and the fundamental frequency was higher in clear speech than in conversational speech. The findings illustrated that upon being given a simple instruction to speak as clearly as possible, the nonnative English speakers were able to employ speaking strategies comparable to those used by native speakers of English in producing clear speech.

However, several differences in the acoustic parameters were noted between the speech produced by the Cantonese speakers and the sentences produced by the native English speakers. First, the Cantonese speakers spoke significantly slower than did the native English speakers, not only in clear speech, but also in the conversational speech mode. This finding was in agreement with that of previous studies in that nonnative speakers of English typically speak slower than native English speakers. In addition, it was noteworthy that the Cantonese speakers lengthened the total pause time in clear sentences to a greater extent than the native English speakers did. The reason for this significantly longer pause time in Cantonese speakers' clear speech is not fully understood. However, it was found that the Cantonese speakers' total pause time was also longer than that of the native English speakers in conversational speech. It is possible that when they were explicitly told to speak as clearly as possible, the nonnative speakers might have intentionally adopted a strategy of increasing the total pause time much more than did the English speakers.

From the acoustic analyses, it can readily be seen that Cantonese speakers of English exhibited significant differences in acoustic characteristics between clear and conversational speech. Nonetheless, it is important to examine whether the conversational-to-clear speech transformations would enhance their speech intelligibility for native English-speaking listeners. In the perception study, the selected utterances were duplicated and masked with 12-talker babble at a predetermined, fixed speech-to-babble ratio, and presented in addition to noise-free stimuli to two groups of English-speaking listeners: younger and older adults. The listeners assessed the intelligibility of the clear and conversational speech productions by transcribing the sentences in standard orthography and verifying their truth value.

As in previous studies, Cantonese-accented English was found to be less well perceived than native-produced English for both younger and older English listeners. It was found that the speech of the Cantonese speakers was less intelligible than the native productions regardless of the speaking styles (i.e., clear and conversational) or the listening conditions (i.e., clean and noisy). As expected, the findings of the present research show that, in general, sentences spoken by the two groups of speakers presented in clean conditions received transcription and verification scores greater than those presented in the background of multibabble noise. Also, it was not surprising to find that the older listeners performed more poorly than did the younger adults in transcribing and verifying the sentences spoken by the two groups of speakers in both speaking styles. The performance of the older listeners was significantly worse when the sentences were presented in noisy conditions. In addition, it was found that overall, sentences spoken clearly were more intelligible than those produced in a conversational manner.

As mentioned before, both younger and older English listeners derived a significant clear speech benefit from the native English speakers, but not from the Cantonese speakers of English. A plausible reason for the lack of clear speech advantage elicited by the Cantonese speakers might be the extent of their deviations from the native-produced clear speech productions. As already discussed, Cantonese speakers of English employed the same strategies as the ones used by the native English speakers in producing the stimulus sentences in a clear speaking style. Namely, they slowed down the speaking rate, reduced the articulation rate, lengthened all the pauses, and increased the speaking fundamental frequency in clear speech. Nevertheless, differences existed between the native-produced speech and foreign-accented sentences. Compared to the English talkers, the Cantonese speakers spoke slower in both clear and conversational speech. In addition, they increased their total pause time to a greater extent than did the English speakers in clear speech productions. These deviations from the patterns of native-produced clear speech might have an undesirable effect on listeners in that they may have limited the intelligibility advantage of foreign-accented clear speech for the native English listeners. Though it was not statistically significant, there was a tendency for Cantonese-accented clear speech to be more intelligible than conversational speech for the two groups of English listeners in clean and noisy listening conditions (see Figures 3-4, 3-7, and 3-11). Of course, other characteristics of foreign-accented English may also be at work, such as the Cantonese speakers' productions of consonants and vowels, prosody, and voice quality, that may contribute to reduced speech understanding in the older and younger English listeners. As a result, a clear speaking style seems not to be as effective an intelligibility enhancement strategy for the Cantonese speakers of English as for the native English speakers when their clear speech productions were to be comprehended by native English listeners.

There have been anecdotal claims that older English-speaking listeners find foreign-accented English harder to understand than do younger listeners. However, to the best of the author's knowledge, there has been very little published data to substantiate or refute these anecdotal claims. As in Burda et al. (2003), the statistical analyses for the present study revealed that there were no significant interaction effects between the two groups of listeners (i.e., younger and older listeners) and the two groups of speakers (i.e., Cantonese and English talkers) in both transcription and verification. In other words, the older listeners did not find Cantonese-accented English significantly less intelligible as compared to native-produced English than did the younger listeners. A possible reason may be that there are more and more individuals whose first languages are not English living in multicultural societies such as the United States or Canada. Therefore, older English-speaking adults have more opportunity to interact with these nonnative English speakers in different settings. It is possible that older adults may be able to perceptually adapt to foreign-accented speech, like younger English-speaking listeners (Bradlow & Bent, 2008). As can be seen in Table 3-1, of the 12 younger listeners, two reported hearing Chinese-accented English “Every Day”, while four indicated “Very Often” and another two reported “Often”. Table 3-2 shows that four of the 12 older listeners indicated hearing English spoken by Chinese speakers on a daily basis. In addition, one of the older listeners selected “Very Often” and another reported often hearing Chinese-accented English.

It was found that the multibabble noise had a more deleterious effect on the intelligibility of conversational and clear speech produced by the Cantonese speakers than on the intelligibility of sentences spoken by native English speakers. This is similar to findings of previous research that the addition of masking noise to sentences was found to have a stronger effect on verification and transcription scores for nonnative speakers of English (Li, 2000; Munro, 1998), providing further evidence that nonnative English is more difficult to understand in adverse listening conditions than in quiet conditions.

In the present study, it was found that overall, the speech perception performance of the older listeners was poorer than that of their younger counterparts. Specifically, the older English listeners were more susceptible to the masking noise than were the younger adults in transcribing and verifying the stimulus sentences. This finding is in agreement with those of previous studies that elderly listeners experience greater difficulty understanding spoken language than do younger listeners, especially in the presence of background noise. As already mentioned in Chapter 1, the age-related decline in speech understanding could be accounted for by several possible explanations, as suggested by previous researchers (CHABA, 1988; Crandell, et al., 1991; Jerger et al., 1989; Schneider et al., 2002; Weinstein, 2002). First of all, as noted before, the hearing thresholds for the older listeners on average were poorer than those of the younger listeners, most notably in the high frequencies (see Table 3-3). The elevation of hearing thresholds attenuates the sound energy to a level that falls below the audible region of the individual, thus causing difficulty in speech recognition. Also, speech recognition may be impaired by distortions due to age-related changes in the cochlea, thereby resulting in poorer frequency resolution, temporal resolution, and/or intensity resolution. Second, speech recognition deficits may also be caused by age-related changes in the central auditory systems. The dysfunction in the auditory pathways of the brainstem or part of the auditory cortex may lead to poorer phonemic discrimination or deficits in making use of speech redundancy. Finally, as briefly pointed out in Chapter 1, performance in speech recognition may also be affected by age-related changes in global cognitive abilities such as attention, memory, information processing and retrieval.

All these age-related changes adversely influence the communication functions of older adults, and the effect is more deleterious in noisy environments. It has been suggested that pure tone sensitivity and performance in speech recognition in quiet are not predictive enough to describe older adults' declining ability to understand spoken language in adverse listening conditions (CHABA, 1988; Crandell et al., 1991; Jerger et al., 1989). Heinrich and Schneider (2001) attempted to propose a perceptual and cognitive model to explain the decline in speech recognition performance of older adults in noisy conditions. Speech signals have to be perceived and encoded before they can be recalled. The authors proposed that perception and cognition share a common pool of processing resources. However, some resources will be compromised because of the presence of factors such as background noise and/or aging. Therefore, fewer resources will be available for encoding and less information will be recalled. Although this theoretical framework seems to offer a reasonable explanation, other factors (e.g., central auditory processing ability) may also be at work (Jerger et al., 1989) and no single factor can explain the speech decrements of older adults (CHABA, 1989). The present design did not address this issue. Further research is needed to assess the relative contributions of auditive, central, and cognitive domains to the older adults' progressively declining speech understanding problems.

Interestingly, it was found that whereas younger listeners benefited from clear speech more in noisy conditions than in quiet conditions in verifying the truth value of the sentences, the older adults derived a greater clear speech advantage in the opposite situations (i.e., more clear speech benefit in quiet than in noisy environments). At first glance, it appears that the present finding is somewhat inconsistent with those of previous related studies, in which clear speech is more intelligible than utterances spoken in a conversational style in noisy conditions not only for younger listeners, but also for older adults. Also, it has been reported that younger English listeners find L2 speech produced in a noisy background to be more intelligible than that spoken in a conversational manner when the stimulus sentences are presented with masking noise, while no significant difference in intelligibility was found between the two types of speech in quiet situations (Li, 2000). The discrepancy seems to be associated with the nature of the task involved (i.e., verification) again. To the best of the author's knowledge, all the previous studies that have examined intelligibility of clear speech ask listeners either to write out or to repeat aloud what they heard. None, if any, has requested listeners to verify the truth value of the sentence stimulus. In the sentence transcription task of the current study, the listeners simply wrote out as many words as they could in response to each of stimulus statements. In the verification task, however, the listeners had to process the meaning of the sentence in order to determine whether it was true or false. Also, as discussed before, reduced speech perception ability of elderly listeners may be due partly to deficits in cognitive functions as a result of normal aging processes. In addition, as noted by Kalikow & Stevens (1977), babble is more likely to interfere with speech understanding than other non-speech noise (e.g., white noise), because false speech cues inherent in this type of masker will increase the attentional load on listeners. Therefore, it is not unreasonable to suggest that the multitalker babble noise used in the present study exacerbates the sentence processing or attentional difficulties of the older listeners, despite the fact that the sentences were spoken in a clear speaking style. As a consequence, unlike the younger listeners who benefited from the clear speech advantage more in noisy conditions than in the clean condition, the older adults performed better in verifying the sentences spoken clearly in quiet conditions.

The findings of the present study are likely to be of interest to medical professionals or other health care providers who frequently work with older adults. Older adults are a fast-growing segment of the Canadian population (Minister of Public Works and Government Services Canada, 2002).In 2001, one in eight Canadians was aged 65 years old or above; however, it is anticipated that one Canadian in five will have reached 65 years by 2026. As mentioned before, we have large numbers of immigrants in our society whose first languages are not English working with older adults in their professions (e.g., medical doctors, nurses, etc.). Given this increasing cultural diversity in the health care industry, as suggested by Burda et al. (2003) and Mahendra et al. (1999), it is important for employers and the health care providers themselves to be mindful of the effects of their foreign accents on communication with English-speaking older clients. More importantly, they should make efforts to find techniques to facilitate effective communication with older adults. For instance, nonnative speakers may employ “elderspeak”, a special speech register that uses shorter utterances with fewer clauses, simplified syntactic structures, a restricted vocabulary, more sentence fragments, and fewer long words (no more than three syllables), a slower speech rate, as well as longer pauses within utterances (Kemper, Ferrell, Harden, Finter-Urczyk, & Billington, 1998; Kemper, Othick, Warren, Gubarchuk, & Gerhing, 1996; Kemper, Vandeputte, Rice, Cheung, & Gubarchuk, 1995). Kemper and her colleagues (1995, 1996) have shown that English-speaking older adults benefit from this speech adjustment strategy in following complicated instructions given by younger English-speaking adults in referential communication tasks.

Moreover, the findings of this study have important implications for second language teachers who help ESL students improve their speech intelligibility. Individuals often communicate with one another in a background of noise and/or reverberation. Also, it has been demonstrated that foreign-accented English is more difficult to understand under non-optimal listening conditions. Although the Cantonese speakers in the present study were found to adopt the same strategies as those used by the English speakers in going from conversational to clear speech, both the younger and older English-speaking adults did not derive a significant intelligibility benefit from the clear speech spoken by the Cantonese speakers. As already suggested, a clear speaking style seems not to be an effective speech intelligibility enhancement strategy for nonnative speakers of English. As a result, ESL teachers should find means to improve speech intelligibility of nonnative English speakers, other than simply instructing them to speak clearly. For instance, speech training programs may be implemented in the classroom that aim to improve the intelligibility of vowels and consonants, and to modify prosody, global speaking habits, and voice quality of nonnative speakers in their second language.

4.1. Limitations and Future Directions

To the best of the author's knowledge, this research is the first of its kind not only to record nonnative clear speech samples, but also to present both foreign-accented clear and conversational speech in quiet and noisy conditions to younger and older English-speaking listeners for evaluations of intelligibility through transcription and verification. However, some limitations of the present study should be identified. First of all, Van Summers, Pisoni, Bernacki, Pedlow, & Stokes (1988) suggest that the effects of masking noise seem to be greater in speech tasks involving interaction or communication than in those with no external feedback from a communication partner. In this experiment, as in previous research, after hearing simple instructions, individual speaker-participants were requested first to speak in a conversation-like manner similar to the way they talked in daily situations, then to utter the sentences as clearly as possible. It seems that so as to make the recording conditions more realistic when compared with those used in previous studies, spontaneous speech or even real communication, rather than a simple sentence-reading task, need to be explored. An investigation of clear speech produced in these conditions may deepen our understanding of the acoustic characteristics and intelligibility benefit of clear speech relative to conversational speech.

In addition, only one type of masking noise, 12-talker multibabble, with a fixed speech-to-babble ratio was used in the current research. Future studies of the intelligibility of clear speech produced by nonnative English speakers for older and younger English listeners may be conducted using other kinds of noise (e.g., traffic noise) at varying speech-to-noise ratios, or in other degraded listening conditions (e.g., reverberation and/or noisy conditions, or telephone speech), the findings of which may contribute a better understanding of the effect of real-world situations on the perception of nonnative-produced clear speech.

In the present study, only one group of L2 speakers (Cantonese speakers of English from Hong Kong) has been considered. As a result, the findings of this research cannot be generalized too far. The listeners in this study may have benefited from familiarity with the particular accent used, as the nonnative speakers all come from the same L1 background. So that the effect of clear speech on nonnative English speakers can be more fully evaluated, research with L2 speakers of other native languages needs to be carried out.

Last but not least, as pointed out by Schum (1996), no strong correlations have been found between any acoustic measures and improvement in clear speech intelligibility. He suggested that the clear speech effect is probably due to a complex interaction of intensity levels, and spectral and durational dimensions of utterances. For the present study, only four global characteristics of clear speech spoken by nonnative English speakers were examined: speaking rate, articulation rate, total pause time, and fundamental frequency values. For future research, it may be worthwhile to look at other characteristics of foreign-accented clear speech, such as intensity levels, formant centre frequencies (F1 and F2), durations and amplitudes of individual consonants and vowels, among others, as measured in earlier studies of native-produced clear speech.

APPENDICES

Appendix 1

Background Questionnaire – Nonnative English Speakers

Participant code: ___________ **Date:** __________

1. Gender (Circle one) Male Female

2. Date of birth _____/_____/_____ (DD/MM/YY)

3. Place of Birth (city, province/state, country) ___________________________

4. How long have you remained in that place (Q.3. above)? ____________________

5. List all other places where you have lived for more than 6 months:

Where	When

6. What is your mother's native language? ____________________

7. What is your father's native language? ____________________

8. What is your first language? ____________________

9a. When you were growing up, did you speak ONLY that language (Q8. above) at home?

(Circle one) Yes No

9b. If NO, please list other language(s) or dialect(s) that you used at home.

	How proficient are you? (Check the appropriate box)			
Language/Dialect	very	moderately	slightly	not at all

10. What is the highest level of school you have completed? _____________

11. At what age did you begin studying English in school? _____________

12. Were any of your teachers in your home country native speakers of English? How many? (Circle one for each category that applies)

College	all	most	half	a few	none
High school	all	most	half	a few	none
Elementary school	all	most	half	a few	none

13. When did you arrive in Canada? _____/_____/_____ (DD/MM/YY)

14. For how many years (total) did you study English before coming to Canada?

____

15. Have you ever been away from Canada for more than 6 months since you arrived? Where and for how long?

____

16. Have you ever taken any ESL classes in Canada? If so, for how long?

____

17. What other language(s) have you studied in school or university?

	How proficient are you? (Check the appropriate box)			
Language	very	moderately	slightly	not at all

18. Have you ever taken a special course to improve your pronunciation? If so, how long (in weeks) was it?

____

19. What Linguistics courses have you taken at college or at university?

____

20a. Do you smoke? (Circle one) Yes No

20b. If YES, how many cigarettes do/did you smoke on a typical day?

____

20c. If you have quit smoking, when?

____

21a. Have you ever had any experience in communicating with a hearing-impaired person?

(Circle one) Yes No
If YES,

21b. How frequently do/did you communicate with him/her?

(Circle one) every day very often often not very often

21c. Have you received any training in communicative strategies for speaking to hearing-impaired individuals?

(Circle one) Yes No

21d. Could you briefly describe the strategies that you have learned?

Appendix 2

Background Questionnaire – Native English Speakers

Participant code: ____________ **Date:** ___________

1. Gender (Circle one) Male Female

2. Date of birth _____/_____/_____ (DD/MM/YY)

3. Place of Birth (city, province, country) __________________________

4. How long did (have) you remain (remained) in that place (Q.3. above)?_____________________

5. List all other places where you have lived for more than 6 months. (You may continue on the back of this page for additional space)

Where	When

6. What is your mother's native language? _____________________

7. What is your father's native language? _____________________

8. What is your first language? _____________________

9a. When you were growing up, did you speak ONLY that language (Q8. above) at home?

(Circle one) Yes No

9b. If NO, please list other language(s) or dialect(s) that you used at home.

	How proficient are you? (Check the appropriate box)			
Language/Dialect	very	moderately	slightly	not at all

10. What is the highest level of school you have completed? ______________

11. What other language(s) have you studied in school or university?

	How proficient are you? (Check the appropriate box)			
Language	very	moderately	slightly	not at all

12. How often do you regularly interact with people who have a second language accent?

(Circle one) every day very often often not very often

13. What accents do you commonly hear in your study, daily work, and social life?

(a)	(b)
(c)	(d)

14a. Do you smoke? (Circle one) Yes No

14b. If YES, how many cigarettes do/did you smoke on a typical day?

____

14c. If you have quit smoking, when?

____

15a. Have you ever had any experience in communicating with a hearing-impaired person?

(Circle one) Yes No

If YES,

15b. How frequently do/did you communicate with him/her?

(Circle one) every day very often often not very often

15c. Have you received any training in communicative strategies for speaking to hearing-impaired individuals?

Circle one Yes No

15d. Could you briefly describe the strategies that you have learned?

____

Appendix 3

(A) List of True (1-24) sentences with the numbers of words.

Number	Sentence	Number of Words
1	You can *take pictures* with a *camera*	7
2	*Bread* is *made* with *flour*	5
3	An *engine* is a *part* of a *ship*	8
4	A *tiger* is *bigger* than a *cat*	7
5	You can *tell time* with a *watch*	7
6	*India* is in *Asia*	4
7	*People* can *ride camels* in the *desert*	7
8	A *pigeon* is a *kind* of *bird*	7
9	You can *borrow* a *book* from a *library*	8
10	*Water* and *sunlight* are *essential* to *flowers*	7
11	*Seven* is an *odd number*	5
12	*Christmas* is in *December*	4
13	*Elephants* are *big animals*	4
14	*Hot* and *cold* are *opposites*	5
15	*Exercise* is *good* for your *health*	6
16	*Japan* is a *wealthy country*	5
17	*Ships travel* on the *water*	5
18	Some *people keep dogs* as *pets*	6
19	*Young children* can be *very noisy*	6
20	Some *roses have* a *beautiful smell*	6
21	*Hungry cats like* to *chase mice*	6
22	*Italy* is a *country* in *Europe*	6
23	*Red* and *green* are *colors*	5
24	*Gold* is a *valuable metal*	5

(B) List of False (25-48) sentences with the numbers of words.

Number	Sentence	Number of Words
25	*California* is in *Russia*	4
26	*Christmas* is in *September*	4
27	Most *cats like* to *read magazines*	6
28	In *summer* the *sun* is *blue*	6
29	A *spider* is *bigger* than a *cat*	7
30	Some *chickens live* on the *moon*	6
31	*Butterflies need batteries* to *fly*	5
32	You can *buy vegetables* at the *bank*	7
33	It is *good* to *have stones* for *breakfast*	7
34	All *scientists have three brains*	5
35	*People brush* their *teeth* with a *telephone*	7
36	You can *tell time* with a *kettle*	7
37	*Gasoline* is an *excellent drink*	5
38	The *sun always sets* in the *north*	7
39	The *inside* of an *egg* is *blue*	7
40	*August* is a *winter month*	5
41	It *always snows* in *July*	5
42	Most *people wear hats* on their *feet*	7
43	The *stars come* out in the *day*	7
44	*Wednesday* is the *first day* of the *week*	8
45	All *men* can *have babies*	5
46	All *dogs have fifteen legs*	5
47	*People eat* through their *noses*	5
48	A *monkey* is a *kind* of *bird*	7

Appendix 4

Record Sheet (T/F: List A)

Participant's Code:________________________________ Today's Date: ________________

Style	Sequence
Conversational	1st
Clear	2nd

==

On the No., mark √ (for acceptable utterance), or ***O*** *(for unacceptable utterance to be repeated at the end of each list)*

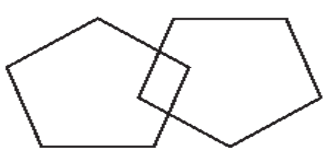
List A 1		**List A 4**	
13.	Elephants are big animals.	33.	It's good to have stones for breakfast.
23.	Red and green are colors.	21.	Hungry cats like to chase mice.
15.	Exercise is good for your health.	9.	You can borrow a book from a library.
43.	The stars come out in the day.	22.	Italy is a country in Europe.
16.	Japan is a wealthy country.	7.	People can ride camels in the desert.
13.	Elephants are big animals.	33.	It's good to have stones for breakfast.
18.	Some people keep dogs as pets.	17.	Ships travel on the water.
1.	You can take pictures with a camera.	40.	August is a winter month.
28.	In summer the sun is blue.	3.	An engine is a part of a ship.
16.	Japan is a wealthy country.	7.	People can ride camels in the desert.
List A 2		**List A 5**	
14.	Hot and cold are opposites.	44.	Wednesday is the first day of the week.
39.	The inside of an egg is blue.	45.	All men can have babies.
2.	Bread is made with flour.	10.	Water and sunlight are essential to flowers.
8.	A pigeon is a kind of bird.	27.	Most cats like to read magazines.
5.	You can tell time with a watch.	24.	Gold is a valuable metal.
14.	Hot and cold are opposites.	44.	Wednesday is the first day of the week.
29.	A spider is bigger than a cat.	35.	People brush their teeth with a telephone.
41.	It always snows in July.	6.	India is in Asia.
30.	Some chickens live on the moon.	36.	You can tell time with a kettle.
5.	You can tell time with a watch.	24.	Gold is a valuable metal.
List A 3		**List A 6**	
19.	Young children can be very noisy.	46.	All dogs have fifteen legs.
47.	People eat through their noses.	38.	The sun always sets in the north.
42.	Most people wear hats on their feet.	34.	All scientists have three brains.
4.	A tiger is bigger than a cat.	26.	Christmas is in September.
31.	Butterflies need batteries to fly.	32.	You can buy vegetables at the bank.
19.	Young children can be very noisy.	46.	All dogs have fifteen legs.
12.	Christmas is in December.	25.	California is in Russia.
48.	A monkey is a kind of bird.	37.	Gasoline is an excellent drink.
11.	Seven is an odd number.	20.	Some roses have a beautiful smell.
31.	Butterflies need batteries to fly.	32.	You can buy vegetables at the bank

Appendix 5

Mini-Mental State Examination (MMSE)

Participant Code:_________________________ **Date:**_______________

Activity	**Score**
ORIENTATION	
1. Ask: What is the (year) (season) (month) (date) (day)?	/5
2. Ask: Where are we? (country) (province) (city) (place) (room).	/5
MEMORY REGISTRATION	
3. Name three unrelated objects clearly and slowly. Ask the subject to repeat all three and remember the three objects.	/3
ATTENTION AND CONCENTRATION	
4. Ask the subject to spell "world" backwards.	/5
RECALL	
5. Ask the subject to recall the three objects from item 3 above.	/3
LANGUAGE	
6. Show the subject two familiar objects (e.g., a pen, a watch) and ask him/her to name them.	/2
7. Ask the subject to repeat a sentence after you: "No ifs, ands or buts".	/1
8. Ask the subject to follow a three-stage command: "Please take this paper in your right hand, fold it in half and put it on the chair".	/3
9. Ask the subject to read and obey a written instruction: "Close your eyes".	/1
10. Ask the subject to write a simple sentence. The sentence must contain a subject and a verb, and should make sense.	/1
11**.** Ask the subject to copy a picture of intersecting pentagons.	/1



Total score: /30

Source: Folstein, M., Folstein, S., & McHugh, P. (1975). Mini-Mental State: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12,* 189-198.

Appendix 6

Background Questionnaire – Native English Listener

Participant code: ___________ Date: __________

1. Gender (Circle one) Male Female

2. Date of birth _____/_____/_____ (DD/MM/YY)

3. Place of Birth (city, province, country) _________________________________

4. How long did (have) you remain (remained) in that place (Q.3. above)? _____________

5. List all other places where you have lived for more than 6 months. (You may continue on the back of this page for additional space)

Where	When

6. What is your mother's native language? ____________________

7. What is your father's native language? ____________________

8. What is your first language? ____________________

9a. When you were growing up, did you speak ONLY that language (Q8. above) at home?

(Circle one) Yes No

9b. If NO, please list other language(s) or dialect(s) that you used at home. (You may continue on the back of this page for additional space)

	How proficient are you? (Check the appropriate box)			
Language/Dialect	very	moderately	slightly	not at all

10a. What is the highest level of school you have completed?

____

10b. How many years of formal education did you have?

1. Elementary ( ) 2. High School ( )
3. College ( ) 4. University or above ( )
5. Others ( )

11. What other language(s) have you studied in school or university? (You may continue on the back of this page for additional space)

	How proficient are you? (Check the appropriate box)			
Language	very	moderately	slightly	not at all

12. How often do you regularly interact with people who have a second language accent?

(Circle one) every day very often often not very often

13. What accents do you commonly hear in your study, daily work, and social life?

(a)	(b)
(c)	(d)

14a. What is your occupation (if retired, former one)? ____________________________

14b. Have you ever been exposed to loud noise because of your occupation? Yes No

14c. If Yes, please briefly describe.____
____

15a. Have you ever had any ear trouble (e.g., ear infections, ringing in ears)? Yes No

15b. If Yes, please specify the problems and when.
____

16a. Have you ever had any close relatives who have had hearing loss? Yes No

16b. If Yes, please briefly describe.____
____

17a. Do you have any chronic medical problems (e.g. arthritis)? Yes No

17b. If Yes, please specify ____
____

18. How would you rate your overall health condition?

(Circle one) very good good fair poor very poor

Appendix 7

Transcription Record (Set ______)

Participant Code__________________ **Date________________**

Procedures:

(1) You are going to listen to **48** statements through the computer. Each statement is presented only once. After the presentation of each statement, please try as much as you can to write it out **clearly** in standard English spelling in the space provided below. **<u>If you miss any word(s) in the sentence, please draw a dash line</u>.**

(2) After writing down the statement, use the mouse to click on the computer screen one of the three buttons, "**True**", "**False**", or "**Unknown**" (in case you are uncertain of the truth value of the statement or you cannot clearly hear the sentence). PLEASE DO NOT CLICK THE BUTTON UNTIL YOU HAVE WRITTEN DOWN THE STATEMENT.

(3) There is no limitation on time for step (1) and (2). Once you have clicked the button on the screen, the next statement will be presented to you in a short moment.

==

1.____

____

2.____

____

3.____

____

4.____

____

Turn to the next page before you press the button

5.____

____

6.____

____

7.____

____

8.____

____

9.____

____

10.____

____

11.____

____

12.____

____

13.____

____

Turn to the next page before you press the button

14.

15

16.

17

18.

19.

20.

21.

22.

Turn to the next page before you press the button

23.____

____

24.____

____

25.____

____

26.____

____

27.____

____

28.____

____

29.____

____

30.____

____

31.____

____

Turn to the next page before you press the button

32. ____

____

33. ____

____

34. ____

____

35. ____

____

36. ____

____

37. ____

____

38. ____

____

39. ____

____

40. ____

____

Turn to the next page before you press the button

41.____

____

42.____

____

43.____

____

44.____

____

45.____

____

46.____

____

47.____

____

48.____

____

The End.

Appendix 8

Practice Sentences

(A) True sentences:

You can start a fire with a match.

Most teenagers like rock and roll.

December has thirty-one days.

Grass is green in color.

(B) False sentences:

You can start a fire with a watch.

March has thirty-eight days.

You can buy beer at church.

People play football with a violin.

REFERENCES

American Speech-Language-Hearing Association (ASHA) (1989). Guidelines for the identification of hearing impairment /handicap in adult/elderly persons. *American Speech-Language-Hearing Association*, *31*, 59-63.

Anderson-Hsieh, J. & Koehler, K. (1988). The effect of foreign accent and speaking rate on native speaker comprehension. *Language Learning, 38(4),* 561-613.

Ash, R. & Higton, B. (1990). *A classical illustrated edition*: Aesop's Fables. San Francisco: Chronicle Books.

Botwinick, J. (1969). Disinclination to venture response versus cautiousness in responding: Age differences. *Journal of Genetic Psychology, 115*, 55-62

Bradlow, A. & Bent, T. (2002). The clear speech effect for non-native listeners. *Journal of the Acoustical Society of America, 112(1)*, 272-284.

Bradlow, A. & Bent, T. (2008). Perceptual adaptation to non-native speech. *Cognition, 106*, 706-729.

Burda, A., Scherz, J., Hageman, C., & Edwards, H. (2003). Age and understanding speakers with Spanish or Taiwanese accents. *Perceptual Motor and Skills, 97*, 11-20.

Caissie, R., Campbell, M., Frenette, W., Scott, L., Howell, I., & Roy, A. (2005). Clear speech for adults with a hearing loss: Does intervention with communication partners make a difference? *Journal of the American Academy of Audiology, 16, 157-171.*

CHABA (Committee on Hearing, Bioacoustics, and Biomechanics). (1988). Speech understanding and aging. *Journal of Acoustical Society of America, 83*, 859-895.

Cheesman, M. (1997). Speech perception by elderly listeners: basic knowledge and implications for audiology. *Journal of Speech-Language Pathology and Audiology*, *21(2)*, 104-110.

Cooper, W., Eady, S., & Mueller, P. (1985). Acoustics aspects of contrastive stress in question-answer contexts. *Journal of Speech-Language Pathology and Audiology*, *77(6)*, 2142-2156.

Coughlin, M., Kewley-Port, D., & Humes, L. (1998). The relation between identification and discrimination of vowels in young and elderly listeners. *Journal of Acoustical Society of America, 104(6),* 3597-3607.

Crandell, C., Henoch, M., & Dunkerson, K. (1991). A review of speech perception and aging: some implications for aural rehabilitation. *Journal of the Academy of Rehabilitative Audiology*, *24*, 121-132.

Derwing, T. & Munro, M. (1997). Accent, intelligibility and comprehensibility: Evidence from four L1s. *Studies in Second Language Acquisition, 19*, 1-16.

Derwing, T., Munro, M., & Wiebe, G. (1998). Evidence in favor of a broad framework for pronunciation instruction. *Language Learning, 48(3)*, 393-410.

Feeney, P. & Hallowell, B. (2000). Practice and list effects on the synthetic sentence identification test in young and elderly listeners. *Journal of Speech, Language, and Hearing Research, 43*, 1160-1167.

Ferguson, S. H. (2004). Talker differences in clear and conversational speech: Vowel intelligibility for normal-hearing listeners. *Journal of Acoustical Society of America, 116(4),* 2365-2373.

Ferguson, S. & Kewley-Port, D. (2002). Vowel intelligibility in clear and conversational speech for normal-hearing and hearing-impaired listeners. *Journal of the Acoustical Society of America, 112(1)*, 259-271.

Fitzgibbons, P. & Gordon-Salant, S. (1994). Age effects on measures of auditory duration discrimination. *Journal of Speech and Hearing Research, 37*, 662-670.

Fitzgibbons, P. & Gordon-Salant, S. (2004). Age effects on discrimination of timing in auditory sequences. *Journal of the Acoustical Society of America, 116(2)*, 1126-1134.

Folstein, M., Folstein, S., & McHugh, P. (1975). Mini-mental state: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*:189-198.

Fry, D. (1968). Prosodic phenomena. In B. Malmberg (Ed.), *Manual of phonetics* (pp. 365-410). Amsterdam: North-Holland Publishing Company.

Fry, D. (1992). *The physics of speech*. Cambridge, UK: Cambridge University Press.

Fulvio, T. (1989). *Aesop's Fables*. New York: Barron's Educational Services.

Gordon-Salant, S. (1986). Effects of aging on response criteria in speech-recognition tasks. *Journal of Speech and Hearing Research, 29*, 155-162.

Gordon-Salant, S. & Fitzgibbons, P. (1993). Temporal factors and speech recognition performance in young and elderly listeners. *Journal of Speech and Hearing Research, 36*, 1276-1285.

Gordon-Salant, S. & Fitzgibbons, P. (2001). Sources of age-related recognition difficulty for time-compressed speech. *Journal of Speech, Language, and Hearing Research, 44*, 709-719.

Guion, S. Flege, J., Liu, S., & Yeni-Komshian, G. (2000). Age of learning effects on the duration of sentences produced in a second language. *Applied Psycholinguistics, 21(2),* 205-228.

Halling, D. & Humes, L. (2000). Factors affecting the recognition of reverberant speech by elderly listeners. *Journal of Speech, Language, and Hearing Research, 43,* 414-431.

He, S. (1987). Several aspects in the comparison between Chinese and English in the teaching of English phonology. *Foreign Languages, 52,* 70-73.

Heinrich, A. & Schneider, B. (2001). *Effects of age and auditory degradation on memory.* The 17th Annual Meeting of the International Society for Psychophysics. Retrieved from www.uni-leipzip.de.

Helfer, K. (1998). Auditory and auditory-visual recognition of clear and conversational speech by older adults. *Journal of the American Academy of Audiology, 9,* 234-242.

Jerger, J. & Chmiel, R. (1997). Factor analytic structure of auditory impairment in elderly persons. *Journal of the American Academy of Audiology, 8(9),* 269-276.

Jerger, J., Jerger, S., Oliver, T., & Pirozzolo, F. (1989). Speech understanding in the elderly. *Ear and Hearing, 10(2)*, 79-89.

Kalikow, D. & Stevens, K. (1977). Development of a test of speech intelligibility in noise using sentence materials with controlled word predictability. *Journal of the Acoustical Society of America, 61(5),* 1337-1349.

Kehoe, M., Stoel-Gammon, C., & Buder, E. (1995). Acoustic correlates of stress in young children's speech. *Journal of Speech and Hearing Research, 38,* 338-350.

Kemper, S., Vandeputte, D., Rice, K., Cheung, H., & Gubarchuk, J. (1995). Speech adjustments to aging during a referential communication task. *Journal of Language and Social Psychology, 14(1-2)*, 40-59.

Kemper, S., Othick, M., Warren, J., Gubarchuk, J., &. Gerhing, H. (1996). Facilitating older adults' performance on a referential communication task through speech accommodation. *Aging, Neuropsychology, and Cognition, 3(1)*, 37-55.

Kemper, S., Ferrell, P., Harden, T., Finter-Urczyk, A, J., &. Billington, C. (1998). Use of elderspeak by young and older adults to impaired and unimpaired listeners. *Aging, Neuropsychology, and Cognition, 5(1)*, 43-55.

Kemper, S., Herman, R., & Lian, C. (2003). Age differences in sentence production. *Journal of Gerontology. 58B(5)*, 260-268.

Krause, J. & Braida, L. (2002). Investigating alternative forms of clear speech: The effects of speaking rate and speaking mode on intelligibility. *Journal of the Acoustical Society of America, 112(5)*, 2165-2172.

Krause, J. & Braida, L. (2004). Acoustic properties of naturally produced clear speech at normal speaking rates. *Journal of the Acoustical Society of America, 115(1)*, 362-378.

Ladefoged, P. (1993). *A course in Phonetics*. Fort Worth, TX: Harcourt Brace Jovanovich, Inc.

Lane, H. (1963). Foreign accent and speech distortion. *Journal of the Acoustical Society of America, 35(4)*, 451-453.

Leder, S. & Spitzer, J. (1993). Speaking fundamental frequency, intensity, and rate of adventitiously profoundly hearing-impaired adult women. *Journal of the Acoustical Society of America, 93(4)*, 2146-2151.

Li, C.-N. (2000). *The role of the Lombard reflex in the production and perception of Cantonese-accented English.* Unpublished Master Thesis, Simon Fraser University.

Loren, C., Colcord, R., & Rastatter, M. (1986). Effects of auditory masking by white noise on variability of fundamental frequency during highly similar productions of spontaneous speech. *Perceptual and Motor Skills, 63*, 1203-1206.

Mahendra, N., Bayles,K., & Tomoeda, C. (1999). Effect of an unfamiliar accent on the repetition ability of normal elders and individuals with Alzheimers's Disease. *Journal of Medical Speech-Language Pathology, 7(3),* 223-230.

Marshall, L. (1981). Auditory processing in adult listeners. *Journal of Speech and Hearing Disorders, 46,* 226-240.

Minister of Public Works and Government Services Canada. (2002). *Canada's Aging Population*. Retrieved from http://www.hc-sc.gc.ca/seniors-aines.

McGuire, L., Morian, A., Codding, R., & Smyer, M. (2000). Older adults' memory for medical information: Influence of elderspeak and note taking. *International Journal of Rehabilitation and Health, 5(2),* 117-128.

Munro, M. (1995). Nonsegmental factors in foreign accent. *Studies in Second Language Acquisition, 17*, 17-34.

Munro, M. (1998). The effects of noise on the intelligibility of foreign-accented speech. *Studies in Second Language Acquisition, 20, 139-154.*

Munro, M. & Derwing, T. (1994). Evaluations of foreign accent in extemporaneous and read material. *Language Testing, 11*, 253-266.

Munro, M. & Derwing, T. (1995a). Foreign accent, comprehensibility and intelligibility in the speech of second language learners. *Language Learning, 45(1)*, 73-97.

Munro, M. & Derwing, T. (1995b). Processing time, accent, and comprehensibility in the perception of native and foreign-accented speech. *Language and Speech, 38(3)*, 289-306.

Munro, M. & Derwing, T. (1998). The effects of speaking rate on listeners evaluations of native and foreign-accented speech. *Language Learning, 48(2)*, 159-182.

Palmer. F. (1981). *Semantics*. Cambridge, UK: Cambridge University Press.

Payton, K., Uchanski, R., & Braida, L. (1994). Intelligibility of conversational and clear speech in noise and reverberation for listeners with normal and impaired hearing. *Journal of the Acoustical Society of America, 95(3), 1581-1592.*

Phillips, S., Gordon-Salant, S., Fitzgibbons, P., & Yeni-Komshian, G. (2000). Frequency and temporal resolution in elderly listeners with good and poor word recognition. *Journal of Speech, Language, and Hearing Research, 43*, 217-228.

Picheny, M., Durlach, N., & Braida, L. (1985). Speaking clearly for the hard of hearing I: Intelligibility differences between clear and conversational speech. *Journal of Speech and Hearing Research, 28*, 96-103.

Picheny, M., Durlach, N., & Braida, L. (1986). Speaking clearly for the hard of hearing II: Acoustic characteristics of clear and conversational speech. *Journal of Speech and Hearing Research, 29*, 434-446.

Picheny, M., Durlach, N., & Braida, L. (1989). Speaking clearly for the hard of hearing III: An attempt to determine the contribution of speaking rate to differences in intelligibility between clear and conversational speech. *Journal of Speech and Hearing Research, 32*, 600-603.

Pichora-Fuller, K. (1997). Language comprehension in older listeners. *Journal of Speech-Language Pathology and Audiology*, *21(2),* 125-142.

Pichora-Fuller, K., Schneider, B., & Daneman, M. (1995). How young and old adults listen to and remember speech in noise. *Journal of Acoustical Society of America*, *97(1)*, 593-608.

Pisoni, D. & Dedina, M. (1986). Comprehensibility of digitally encoded natural speech using a sentence verification task (SVT): A first report. *Research on speech perception (No. 12).* Bloomington, IN: Indiana University.

Quach, W. (1998). *Linguistic equivalence of the sentence format of the Test of Children's speech*. Unpublished MSLP thesis. University of Alberta.

Rivers, C. & Rastatter, M. (1985). The effects of multitalker and masker noise on fundamental frequency variability during spontaneous speech for children and adults. *Journal of Auditory Research, 25*, 37-45.

Roach, P. (1982). On the distinction between stress-timed and syllable-timed languages. In D. Crystal (Ed.), *Linguistics and controversies* (pp. 682-688). London: Edward Arnold.

Sakiey, M. & Fry, E. (1979). *3000 instant words*. Highland Park, NJ: Dreier Educational Systems.

Schneider, B., Daneman, M., & Pichora-Fuller, K. (2002). Listening in aging adults: From discourse comprehension to psychoacoustics. *Canadian Journal of Experimental Psychology, 56(3),* 139-152.

Schum, D. (1996). Intelligibility of clear and conversation speech of young and elderly talkers. *Journal of the American Academy of Audiology, 7(3),* 212-218.

Shadden, B. (1988). Interpersonal communication patterns and strategies in the elderly. In B. Shadden (Ed.), *Communication behavior and aging: a sourcebook for clinician.* (pp. 182-196). Baltimore, MD: Williams & Wilkins597-604.

Smiljanic, R. & Bradlow, A. (2005). Production and perception of clear speech in Croatian and English. *Journal of the Acoustical Society of America, 118 (3)*,1677-1688.

Tun, P. (1998). Fast noisy speech: Age differences in processing rapid speech with background noise. *Psychology and Aging, 13(3),* 424-434.

Tun, P., Kane, G., & Wingfield, A. (2002). Distraction by competing speech in young and older adult listeners. *Psychology and Aging, 17(3),* 453-467.

Uchanski, R. (2005). Clear Speech. In D. B. Pisoni & R. E. Remez (Eds.), *The handbook of speech perception* (pp. 207-235). Malden, MA: Blackwell Publishing Limited.

Uchanski, R., Choi, S., Braida, L., Reed, C., & Durlach, N. (1996). Speaking clearly for the hard of hearing IV: Further Studies of the role of speaking rate. *Journal of Speech and Hearing Research, 39*, 494-509.

Van Rooij, J. & Plomp, R. (1991). Auditive and cognitive factors in speech perception by elderly listeners. *Acta Oto-Laryngologica, 476,* 177-181.

Van Summers, W., Pisoni, D., Bernacki, R., Pedlow, R., & Stokes, M. (1988). Effects of noise on speech production: acoustic and perceptual analyses. *Journal of the Acoustical Society of America, 84(3)*, 917-928.

Weinstein, B. (2002). Hearing loss in the elderly: A new look at an old problems. In J. Katz (Ed.), *Handbook of clinical audiology* (pp. 207-235). Baltimore, MD: Lippincott Williams & Wilkins.

Yamazawa, H. & Hollien, H. (1992). Speaking fundamental frequency of Japanese women. *Phonetica, 49,* 128-140.

Yanz, J. & Anderson, S. (1984). Comparison of speech perception skills in young and old listeners. *Ear and Hearing, 5(3),* 134-137.