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Recognition of Accented English With Advancing Age

by

Elizabeth Galletta

**A dissertation submitted to the Graduate Faculty in Speech and Hearing Sciences in
partial fulfillment of the requirements for the degree of Doctor of Philosophy
The City University of New York**

2003

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This manuscript has been read and accepted for the Graduate Faculty in Speech and Hearing Sciences in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract**RECOGNITION OF ACCENTED ENGLISH WITH ADVANCING AGE**

by

Elizabeth Galletta**Advisor: Loraine K. Obler, Ph.D.**

At least 10.4 percent of the current U.S. population is foreign-born (U.S. Census Bureau, 2001). Of those who immigrated after puberty, many are likely to speak accented English (Patkowski, 1990). Although listeners of every age complain about difficulty understanding accented English (AE), only two studies to date have explored the ability to understand AE as it relates to normal aging (Burda, 2000; Shah, Schmidt, Goral, and Obler, submitted). While Burda reports that older adults have difficulty repeating AE sentences compared to younger adults, Shah et al. report older adults do not have significantly more difficulty understanding accented speech than younger adults. In view of research suggesting older adults have disproportionate difficulty, relative to younger adults, recognizing distorted speech compared to standard speech (e.g. Bergman, 1980; Gordon-Salant and Fitzgibbons, 1995) one might predict that older adults would have even more difficulty with recognition of AE than recognition of Standard American English (SAE).

Forty-four participants completed this study. Ages ranged from 20 – 81 years. Correlations of confidence ratings with performance and age were computed. Findings indicate older adults have more difficulty than younger adults in ability to repeat words and sentences in AE, but the data distribution did not permit determining whether the

poorer performance of participants over age 70 was disproportionately more problematic than in SAE. Lastly, older adults did not demonstrate less confidence than younger adults in their ability to recognize accented speech. Correlations between confidence in ability to recognize accented-contextual speech and performance on contextual sentences suggest that older adults can be realistic judges of their ability to recognize sentences with contextual cues.

DEDICATION

This dissertation is dedicated to my three young children: Francesco Galletta Scioscia, Anthony Galletta Scioscia, and Sebastien Galletta Scioscia, in the hope that each one of them believes in himself and is not discouraged by the challenges one encounters along the way to reaching a goal. It is also dedicated to my husband, Charlie Scioscia, who believed in me and helped make it possible for me to achieve this goal.

ACKNOWLEDGEMENTS

This research was supported, in part, by N.I.H. EARDA Grant number 6-42041-3945, to Mercy College. I want to thank Steve Daniel, Principal Investigator, for encouraging me to apply for this funding. Funding for the project helped me in many ways. In particular, funds were available to hire a graphics consultant. I want to thank Eileen Westler, who patiently worked with me on the figures and tables for this project. I also thank Priya Persaud who worked on this grant as a research assistant.

So many people at Mercy College and the CUNY Graduate Center helped me to see this project to its completion.

From Mercy College, I want to thank my friends and colleagues in the Department of Communication Disorders who helped me in a variety of ways. These include: Pat Rowan, Kerry Ann Smith, Christine Rivera, Meg Nachman, Denise Di Cristofaro, Leslie Dowling, and Gloria Schlisselberg. Several of these individuals helped me pilot the procedures and sat in the audiological booth much longer than they had planned. I also want to thank the many people from the Division of Health Professions who volunteered to participate in this study, especially Joan Paternoster who announced the study at a Division meeting and encouraged several people to participate. I thank my colleague and friend, Helen Buhler, who willingly helped me with the recordings and served as one of my Standard American English speakers. Throughout this process she has given me much verbal support and helped keep me thinking positively. Toward the end of data collection, Joe Trzasko read my draft, made comments, and helped me with

the statistical analyses. I am grateful to him for his time and effort on my behalf. Finally, I am indebted to Joan Kosta, my Program Director, colleague, mentor, and friend. Joan's constant support throughout this process enabled me to complete this project. Joan gave me the latitude I needed to work on my dissertation whenever I had the chance. I never could imagine a Director could be as generous and supportive as Joan Kosta, and without her constant encouragement this project would not have been completed.

From the CUNY Graduate Center, Ph.D. Program in Speech and Hearing Sciences, I want to thank faculty, staff, fellow students and alumni, especially: Loretta Walker, Linda Ashour, Gary Chant, Barbara Schmidt, Pam Mathews, Erika Levy, Pui-san Wong, Julia Wang, King Chung, Barbara O'Connor, Eddie Yeung, Anita Haravon, Matt Bakke, and David Rindskopf. Several years ago I worked for Harry Levitt when I was a master's student at Hunter College. Harry supported me when I was searching for the right CFY and allowed me to work on research in his lab while I interviewed for audiology positions. He helped me make the transition from student to professional and I thank him wholeheartedly. During those early years at CUNY, I became friends with Orna Eran. Her support and friendship over the years have helped me tremendously. My other dear friend from my more recent years at CUNY is Mira Goral. I continue to benefit from Mira's intellect and ability to think through a project logically. I feel so fortunate to have worked on research projects with Mira in the Neurolinguistics Lab at CUNY and I am grateful to her for always being able to schedule our meetings around my family commitments.

Finally I want to thank the members of my committee: Marty Gitterman, Arlene Neuman, and my chair, Loraine K. Obler. Marty has always enthusiastically supported

my interests and I appreciate his gentle spirit. He carefully helped me prepare for my second examination as well as this dissertation project. I thank Arlene Neuman for her patience and insightful comments, particularly regarding the statistical analyses. Several years ago when I worked for Harry Levitt, I also worked in Arlene's lab. More than ten years had transpired when I asked her to be on my committee, although working with her now has felt similar to the years past when I worked in her lab. Lastly, I want to thank the chair of my committee: Loraine K. Obler. I have learned so much from Loraine over the years that I cannot begin to state the degree to which she has helped me grow as a thinker, researcher, teacher. I often comment on my students' papers using similar phrases to those Loraine has written on my papers. As I write in Loraine's voice I think to myself how fortunate I have been to have had Loraine as my mentor. I appreciate her careful consideration of all the factors that come into play when doing research and also her open and direct style when addressing students and people in general.

I also thank Dan Kempler who was the outside reader for this paper.

I want to acknowledge the people from the many facets of my life who have encouraged me along the way. Many people from Grace Church in Hastings-on-Hudson volunteered to be my participants. I especially thank my friends Amy Boaz, Andrea Deutsch, and JoAnne Levine. I also want to thank the women in the mother's group I joined after the birth of my third child: Suzanne McIntyre, Jackie Sasloff, Nancy Angiello, Eva Wicht, Raine Gifford, Lisa Foderaro, Lori Walsh, and Gita Brix. These women balance their careers and motherhood so beautifully. I feel fortunate to have had this network of support.

I thank my parents John and Betty Galletta, who as educators taught me the value of education early on in my life. My parents have always supported my endeavors and I am grateful for their continued support of me. I thank my mother-in-law, Mary Scioscia, and my sister-in-law, Virginia Vazirani, who so often read to my children at night while I was at my office working on my dissertation. I thank my dear friend Eileen Ryan, who not only encourages me and supports me, but loves my children and supports them as much as she supports me.

Also, I thank Flavia Alves Pinto, the beautiful international student who lives in my home. Flavia provides an abundance of love and child-care to my children. Without her help and willingness to pitch-in with everything that occurs in my home, completion of this project would have been impossible.

Finally, I thank my beloved husband Charlie Scioiscia and my three children: Francesco Galletta Scioscia, Anthony Galletta Scioscia, and Sebastien Galletta Scioscia. They are the true blessings in my life.

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CHAPTER 1: INTRODUCTION

I. Overview

At least 28.4 million people in the United States today were born in countries other than the U.S. This represents 10.4 percent of the total U.S. population (U.S. Census Bureau, 2001). Of those who immigrated after puberty, many are likely to speak English with an accent (Patkowski, 1990). Although listeners of every age complain about difficulty understanding accented English (AE), only two studies to date have explored the ability to understand AE as it relates to normal aging (Burda, 2000; Shah, Schmidt, Goral, and Obler, submitted). Both of these studies suggest that older adults have difficulty repeating sentences compared to younger adults. While Burda reported older adults have significant difficulty compared to younger adults with accented English sentences, Shah et al. did not report a similar finding when they looked at accented English sentences alone. In Shah et al., an age difference was not significant when looking at accented English alone. In view of research suggesting older adults have disproportionate difficulty recognizing distorted speech (e.g. Bergman, 1980; Gordon-Salant and Fitzgibbons, 1995) one might predict that older adults would have more difficulty with recognition of AE than recognition of Standard American English (SAE) compared to younger adults. It is surprising, then, in the only two studies to date, older adults did not evidence such disproportionate difficulty relative to younger adults in repeating AE sentences compared to SAE sentences. However, there are several methodological problems with the only studies to date that have examined older adults' ability to recognize accented English.

We attempted to control for precisely the methodological problems that were ignored in the two previous studies: hearing and cognitive factors. It is useful to think of these hearing and cognitive factors in light of theories that distinguish hypotheses posed to explain the speech-recognition-ability problem in aging.

II. The Peripheral and Cognitive Hypotheses

The peripheral and cognitive hypotheses are two explanations that have been posed for the speech-recognition difficulties noted among the elderly population. These hypotheses are not described as a hierarchy in terms of processing load required, however, there is a hierarchy in terms of structure, with peripheral hearing loss at the level of the cochlea and cognitive processes at the level of the cortex. The peripheral hypothesis attributes the difficulty with speech-recognition ability (how well an individual identifies words at a particular threshold level) in the elderly to peripheral hearing loss. Supporters of this hypothesis report that *presbycusis* (hearing loss in the elderly), demonstrated by elevated pure-tone thresholds and an age-related decline in speech-recognition ability, is at least partially correlated with age-related decline in high-frequency hearing (Bergman, 1980; Cokely and Humes, 1992; Helfer, 1992; Helfer and Wilbur, 1990; Humes and Christopherson, 1991; Humes and Roberts, 1990; Humes et al., 1994; Jerger, Jerger, Oliver, and Pirozzolo, 1989; Jerger, Jerger, and Pirozzolo, 1991; VanRooij and Plomp, 1990).

While the peripheral hypothesis considers the relationship between degree of hearing loss and speech-recognition ability among the elderly, the cognitive hypothesis examines the connection between cognitive decline and speech-recognition ability.

Cognitive abilities that decline with age include memory and attention (Lindfield, K.C., 1997). More specifically, age-related decline has been observed in episodic memory, working memory, and sustained attention. Given that these cognitive constraints on language processing are well-documented in the elderly, it is likely that these abilities would affect speech-recognition ability as well (Wingfield, 2000). For example, processing speech presented at various rates has been shown to have an effect on speech understanding. It has been found that both rapid speech and speech presented at a reduced rate are difficult for people to understand. Difficulty with speech presented at a fast rate has been attributed to difficulty integrating information presented rapidly (Cohen, 1979) while difficulty with speech presented at a reduced rate is thought to reflect the degree to which working memory is impaired (Small, J.A., Andersen, E.S., & Kempler, D., 1997). Thus, elderly adults may have more difficulty than young adults with speech presented at a slower rate given that working memory decreases with aging.

It seems logical, then, to assume that cognition plays a substantial role in the decline in speech-recognition ability among the elderly. Although the cognitive hypothesis as the sole explanation for the speech-recognition problem among the elderly is not widely supported in the literature, there is some support for a combined cognitive and peripheral explanation when considering the speech-recognition problem among the elderly. Given that it is known that hearing and cognition decline with aging, a combined contribution of these factors to ability to recognize speech is a realistic expectation. Furthermore, separating the exact contribution of each may be challenging due to the interrelatedness of decreased hearing and cognition with advancing age.

In fact, two research teams report that the problem with speech recognition among the elderly is due to a combination of peripheral hearing loss and cognitive decline (Jerger et al., 1989; Jerger et al., 1991; Van Rooij and Plomp 1990). Additional researchers consider the contribution of cognitive decline to the speech-recognition problem in the elderly (Obler, Fein, Nicholas, and Albert, 1991; Jerger, Jerger, and Pirizzolo, 1991). Obler et al. (1991) specifically evaluated the relationship between sentence comprehension and cognitive skills such as speed of processing, working memory, and sustained attention. They administered a short battery of neuropsychological tasks to 66 participants ages 30-39 years, 50-59 years, 60-69 years and 70-79 years. Neuropsychological tasks in their test battery included the Stroop Test (Stroop, 1935), the Continuous Performance Test (CPT) (based on Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956), Digit Span from the Wechsler Adult Intelligence Scale – Revised (WAIS-R), which includes Digits Forward and Digits Backward (Wechsler, 1981), and the California Verbal Learning Test (CVLT) (Trial 1 and Trial 5). These neuropsychological tasks were correlated with performance on a sentence-comprehension task. There was a significant correlation between comprehension scores and speed of processing (Stroop times) and comprehension and capacity for sustained attention (the CPT, Digits Forward) with no correlation between comprehension and measures involving complex cognitive processes such as mental control and learning (CVLT Trial 1, CVLT Trial 5, and Digits Backward). An examination of age differences on neuropsychological tests indicated significant differences for the timed portions of the Stroop Test. There were no significant age differences for the other neuropsychological measures.

Using a test-battery that included hearing measurement, Jerger, Jerger, and Pirizzolo (1991) conducted a study that involved adults as well. This research group did a correlational analysis of speech-audiometric scores, hearing loss, age, and cognitive ability. Speech-audiometric measures included phonemically balanced (PB) word lists, the Synthetic Sentence Identification test (SSI), the Speech Perception in Noise (SPIN) test, and the Dichotic Sentence Identification (DSI) test. The neuropsychological measures included the Wechsler Adult Intelligence Scale – Revised (WAIS-R) (eleven subtests of intellectual function: arithmetic, vocabulary, picture arrangement, picture completion, information, digit span, similarities, comprehension, block design, object assembly, and digit symbol), the Wechsler Memory Scale (WMS) (three subtests: passages, visual reproduction, paired-associate learning), the Boston Naming Test (BNT) (a test of visual confrontation naming), the Spatial Orientation Memory Test (SOM) (a test of memory for designs), and the Buschke Selective Reminding Test (BSRT) (a clinical test of long-term memory). They reported that degree of hearing loss had the strongest relationship to speech recognition scores, with degree of hearing loss predicting most of the variance in all of the speech measures. The cognitive variables minimally affected the variance. Correlations for individual cognitive variables were not reported.

Based on these findings, one might conclude that there is variability with respect to research results' reports of the contribution of peripheral hearing loss and cognition when examining the speech-recognition problem among the elderly. The extent to which specific hearing and cognitive components may contribute to the decline in speech-recognition ability in the elderly is unknown since Obler et al. did not measure hearing and Jerger et al. did not report which specific cognitive abilities appeared to be related to

speech-recognition ability. It is quite possible that the differing reports in the literature with respect to the relative contribution of hearing and cognition to ability to recognize speech may be a product of the inherent difficulty separating the two components.

III. Assessment of Hearing and Cognition

Before detailing what AE is and the two studies that addressed recognition of AE in the elderly, a discussion of how hearing and cognition are evaluated is necessary since in actuality these each should contribute to ability to recognize AE. As part of a complete hearing assessment, an audiological evaluation includes speech-recognition-ability testing. For this assessment, prerecorded materials are presented. These materials are recordings which are typically made in a sound-treated room. Recording levels are controlled, and enunciation is usually quite clear. The actual testing of listeners is completed under headphones in a sound-treated room, which is an environment that is protected from the degradation that occurs in the real world. Therefore, this type of speech is not typical of the real world. Furthermore, in a traditional audiological assessment the speech is presented in quiet at suprathreshold levels meant to allow for maximum performance.

The materials traditionally used for assessment of speech-recognition ability include single-syllable words. In addition, other materials used for specific purposes include nonsense syllables, sentences, and connected discourse. In some instances distorted-speech materials (such as time-compressed speech) have been used in assessment. Since speech becomes distorted in natural listening conditions due to environmental factors, testing using distorted speech is aimed at trying to capture closer

to real-life listening conditions. It is clear that the type of materials used for assessment may affect the conclusions drawn by researchers. Perhaps the nonsense syllables and single-word materials do not tap the level of processing that is required to cause breakdown above the peripheral level. Sentence- and paragraph-level materials that are designed to examine the use of context in the ability to recognize speech are more likely to reflect breakdown above the peripheral level.

Recorded materials more typical of the real world would include reverberant speech, speech in noise, and accented speech. An audiological assessment that includes words and sentences typical of speech in the real world (such as accented speech) as well as Standard American English (SAE) speech would provide comparisons within subjects on a variety of materials.

The Revised Speech Perception in Noise Test (Revised SPIN) is an audiological test that includes components similar to speech in the real world. The Revised SPIN Test is a sentence-level test that differentiates the role of context in the ability to recognize speech. Listeners are presented with sentences within background noise that consists of speech babble. There are eight lists of sentences that each include “high-predictability” and “low-predictability” sentences (25 high- and 25 low-predictability sentences on each list). For the high-predictability sentences, the last word of each sentence is contextually related to the rest of the sentence (e.g. *The watchdog gave a warning growl*) while for the low-predictability sentences the last word of each sentence is not contextually related to the sentence (e.g. *I had not thought about the growl*). Although in its clinical application the Revised SPIN Test was not designed to assess cognition, the test sentences provide an opportunity to consider the role of attention and working memory in speech-recognition

ability. The repetition of high- and low-predictability sentences provides two different experiences. Repetition of low-predictability sentences presumably requires a certain degree of attention and working memory since there are no semantic cues to aid the listener in processing the sentences. Repetition of low-predictability sentences will not provide the opportunity for participants to integrate semantic information from the sentence in the same manner that is reflected in the repetition of high-predictability sentences. Reduced low-predictability sentence scores, compared to scores on the high-predictability sentences, are generally reported. If the elderly have reduced attention their performance on high-predictability sentences may also be lower than that of the younger adults, and the difference between high and low-predictability sentence performance might also be reduced for the elderly.

It is relevant to consider the proportion of low-predictability items correct as a function of proportion of high-predictability items correct as described by Bilger (no date) in the Manual for the Clinical Use of the Revised SPIN Test. Bilger reported proportions based on participants (ages 19-69 years) with sensorineural hearing loss (losses ranged from borderline normal in the low frequencies to a profound hearing loss in the high frequencies). Bilger noted that for the clinical use of the Revised SPIN recordings, performance on final words in high-predictability sentences is always better than performance on final words in low-predictability sentences. As performance on final words in high-predictability sentences increases, performance on final words in low-predictability sentences increases for the majority of individuals. However, at maximum performance on final words in high-predictability sentences (90 percent or greater) few participants with hearing loss have similar performance (90 percent or greater) for the

final words in low-predictability sentences. For the majority of Bilger's participants, performance on final words in high-predictability sentences is far better than performance on final words in low-predictability sentences. For example, according to Bilger, at approximately 40 percent correct for the final words in low-predictability sentences, performance for the final words in high-predictability sentences is 80 to 90 percent correct. This indicates a proportion of .44 to .50 when comparing final words in low-predictability sentences to final words in high-predictability sentences. Our study will inform us whether performance on accented speech yields similar or different patterns of performance.

An assessment of cognition can involve a variety of tasks. These include measures that reflect cognitive skills such as attention and working memory. These skills are addressed on intelligence tests. For example, Digit Span, a subtest of the Wechsler Adult Intelligence Scale-Revised (Wechsler, 1981), includes two tasks: Digits Forward and Digits Backward. Digits Forward is a task that involves the repetition of a sequence of numbers presented by an examiner. The more numbers an individual is able to repeat, the more numbers the individual is then presented with (up to a maximum of nine digits). Digits Forward is described as a reflection of attention and working memory. Digits Backward is a task in which individuals are required to repeat numbers 'backwards' such that when the examiner presents "9-1-5" the individual is required to repeat the numbers 'backwards' as "5-1-9." In the same format as Digits Forward, the more numbers the individual is able to repeat in the correct sequence, the more numbers the individual is presented with (up to a maximum of eight digits). Another measure of cognition is the Continuous Performance Test (CPT), originally described by Rosvold et al., 1956). The

CPT has been reported to be the most popular measure of sustained attention and vigilance used clinically (Riccio, Waldrop, Reynolds, and Lowe, 2001). It is a test of attention that requires individuals to pay attention to a specific item and indicate to the examiner each time the specific item is presented. There are several variations of the original CPT (Rosvold et al, 1956) that are used today. Some are visual tasks, some are auditory tasks, and some are a combination of visual and auditory tasks. Obler, Fein, Nicholas, and Albert (1991) used Rosvold et al.'s model for the CPT and designed a format for the CPT meant to capture a range of performance. The form of the CPT used by Oblor et al. involved attending to the presentation of a list of numbers. Participants listened to the recitation of a list of numbers for about ten minutes and indicated every time three odd numbers were spoken in succession. This form of the CPT was replicated in this dissertation project.

IV. Accented Speech

In this section accented speech will be defined and research in the area of AE will be described. When evaluating the degree to which speech is accented, speech intelligibility is a factor that is considered. Intelligibility has been defined in the AE literature as “the extent to which the native speaker understands the intended message” (Munro and Derwing, 1995a).

The Miriam-Webster dictionary definition of “accent” ignores the notion of “foreign accent”. Rather the definition includes the following:

a distinctive manner of pronouncing: as a: an individual's distinctive or characteristic inflection, tone, or choice of words – b: a way of speaking typical

of a particular group of people and especially of the natives or residents of a region (<http://www.m-w.com/cgi-bin/dictionary>).

Combining these definitions of accent could suggest that it is both the specific characteristics of speech (such as rate, prosody, and segmental substitutions and distortions) and the native language of the speaker that make the speech sound accented to the native-speaking listener. Accented speech could actually be thought of as degraded speech since there is some degree of distortion present in accented speech that has rate, prosody, and segmental variations from unaccented speech. Extending the Merriam Webster definition, accented English could be defined as English spoken with distinctive or characteristic inflection, tone, or choice of words by a particular group of people who are natives of a region other than a region in which English is the native language. So, for example, Spanish Accented English would be English spoken with a distinctive inflection, tone, and choice of words, by people who are natives of a region in which Spanish is the native language.

Of course discourse characteristics in addition to the distortion present in accented speech could also affect the degree to which accented speech is judged intelligible. For example, Tyler (1992) completed a study where native English listeners were presented with two identical lecture topics, one composed by a native English speaker and one composed by a nonnative English speaker. Each lecture was delivered by a native English speaker. However the lecture composed by the nonnative English speaker was judged as less intelligible. Differences in discourse style (such as narrative discourse versus procedural discourse) were described as having an effect on listeners' understanding of the lecture composed by the nonnative English speaker.

The accented speech used in this project is referred to as accented English (AE) and the nonnative English speakers in this study were born in a country other than the United States or other English-speaking countries. Accented English (AE), as described for this study, differs from what we describe as Standard American English (SAE) at both the segmental and the suprasegmental levels. At the segmental level, there are vowel and consonantal substitutions and deviations from the standard variety and at the suprasegmental level, there are rate, prosody, and intonation differences from SAE. Since the speakers for this dissertation project recited lists of words and lists of sentences, discourse factors are thought not to have had an effect on degree of accentedness.

Several studies in the education literature employ AE. Among these studies, different measures (such as intelligibility, comprehension, comprehensibility, and degree of foreign accent) of AE were implemented. Intelligibility was defined above by Munro and Derwing as the 'extent to which the native speaker understands the message'. Intelligibility has been described by several researchers including Anderson, 1993; Derwing & Munro, 1997; Fayer & Krasinski, 1987; Munro & Derwing, 1995a; Munro & Derwing, 1995b; and Schairer, 1992. It has been judged by the use of rating scales, repetition tasks, and word-for-word transcription. For example, Derwing and Munro (1997) measured intelligibility by having participants transcribe a passage spoken by nonnative speakers of English. They had, 26 native English-speaking participants (ages 18- 48 years) transcribe passages spoken by four nonnative-English speakers (native Polish, Spanish, Chinese, and Spanish speakers). Based on these transcriptions, intelligibility of AE in this study was judged to be good. The authors concluded that

although accented speech may display some highly salient characteristics, these features do not necessarily interfere with intelligibility.

The specific characteristics of accent and the effects of accented speech on intelligibility appear to vary. A recent study (van Wijngaarden, Steeneken, & Houtgast, 2002) attempted to quantify the effects of nonnative talker on speech intelligibility. In this study, the effect of foreign accent on speech intelligibility was investigated taking into account various factors that included language background, age of second-language (L2) acquisition, and experience with the target language. It was reported that a talker's L2 experience and his or her own opinion of his or her L2 proficiency were good predictors of speech intelligibility.

The term *comprehension*, defined by Schmid and Yeni-Komshian (1999) as word recognition and Goral et al. (2000) as the ability to understand the content of a passage, is used less in the AE literature than the term *intelligibility*. "Comprehension" was evaluated by Schmid and Yeni-Komshian (1999) using a task called the listening for mispronunciations task (LM). In this study, 48 listeners (ages not provided, however all participants were undergraduate students enrolled in introductory-level classes at a university) were presented with previously tape-recorded sentences spoken by eight speakers (four native English speakers, two native Spanish speakers, and two native Tamil speakers) and indicated when a sentence contained a mispronounced word. "Comprehension" of mispronounced words (as it was defined by the authors to consist of the identification of a mispronounced word) was found to be significantly more difficult in AE compared to SAE. This is not surprising, especially since it appears that any word with a phonemic substitution could have been counted as a mispronounced word.

The term *comprehensibility*, defined as perception of intelligibility by Derwing & Munro (1997), is referred to in other works by these authors (Munro & Derwing, 1995a, Munro & Derwing, 1995b). In one study, for example, Munro and Derwing (1995b) measured comprehensibility by implementing a sentence-verification task. In this study, 20 native English speakers (ages 19 – 45 years) listened to AE sentences spoken by native Chinese speakers and indicated whether each sentence was true or false. Participants performed well on the task of identifying true and false statements spoken in AE.

Finally, degree of perceived foreign accent, defined based on a judgment made by native listeners (Brennan & Brennan, 1981; Derwing & Munro, 1997; Flege & Fletcher, 1992; Flege, Munro, & Mackay, 1995; Munro, 1993; Munro & Derwing, 1995a, Munro & Derwing, 1995b; Schmid & Yeni-Komshian, 1999) is considered to some degree in most work that addresses AE. For example, in Brennan and Brennan (1981) 80 young-adult participants (specific ages not reported) listened to nine native-Spanish speakers (previously recorded reading a standard 162-word English passage). Speakers represented a range of degree of accent (as judged by three linguists). Using these tape recordings, the researchers evaluated participants' perceptions of the degree of social status of each speaker. Degree of status decreased as degree of accent increased.

To our knowledge, at least two research groups have tested normal elderly participants on AE. In addition, Burda is involved in pilot research that includes participants with dementia (personal communication with Angela Burda, November 22, 2002). Research that included presumably normal elderly participants (Burda, 2000 and

Shah, Schmidt, Goral, and Obler, submitted) assessed performance of young and elderly adults on SAE and AE using a sentence-repetition task.

Burda tested three groups of participants: 24 adults ages 20-39, 24 adults ages 40-59, and 24 adults ages 60-81. Participants were tested in AE (a native Spanish speaker and a native Chinese speaker) and SAE on measures of intelligibility (defined by Burda as the ability to repeat words and sentences), and comprehensibility (defined here as the ability to answer yes-no questions after listening to auditory paragraphs). In addition, participants made ratings of accentedness in which they listened to two statements recorded by each speaker and rated degree of accent on a scale of one to seven (with one representing 'no accent' and seven representing 'very accented').

For Burda's study there were three speakers: a SAE speaker and two AE speakers: a native Spanish speaker and a native Chinese speaker. For the word-repetition task (an intelligibility task), there were three lists of words (one for each speaker) with 20 words on each list. For the sentence-repetition task (a second intelligibility task), there were three lists of sentences (again one for each speaker) with ten sentences on each list (words and sentences taken from the Assessment of Intelligibility of Dysarthric Speech, Yorkston and Beukelman, 1984). Participants were presented with recordings of each word list and recordings of each sentence list and instructed to repeat each word or sentence after it was presented. Number of words correctly repeated was tallied for each word list and each sentence list.

Burda also described two tasks of comprehensibility. For one of these, participants listened to auditory paragraphs recorded by each speaker and then answered ten yes-no questions. For the second task of comprehensibility, participants listened to the

statements recorded by each speaker and rated the degree to which these statements were comprehensible.

Results from Burda's study indicated older adults have more difficulty with accented English than younger adults and that overall the tasks were more difficult in AE compared to SAE. Shah et al. (submitted) reported that AE was more difficult than SAE but that older adults did not have more difficulty than younger adults with respect to ability to understand accented speech. In Shah et al. 13 participants ages 17 - 25 years and 14 participants ages 62 - 92 years listened to and repeated sentences in AE and SAE. There was one SAE speaker and one AE speaker (a native Croatian speaker). Sentence lists from the 'repetition' section of the Boston Diagnostic Aphasia Examination (BDAE, Goodglass and Kaplan, 1983) were recorded. These sentences include what Goodglass and Kaplan describe as high-probability sentences and low-probability sentences. Compared to the low-probability sentences, the high-probability sentences contain words that occur more frequently in the English language. In addition to these BDAE sentences, comparable sentences were also constructed by the researchers for use in this study. For each sentence presented, participants were instructed to repeat the sentence. Total number of words repeated correctly was tallied by the researchers. There was a main effect for age, meaning that elderly participants in general had more difficulty repeating the sentences compared to the younger participants. However, there was no interaction between age and accent. Older adult participants did not have significantly more difficulty than younger-adult participants repeating AE sentences compared to their ability to repeat SAE sentences. This is surprising given that older adults do have more

difficulty than younger adults with other forms of degraded speech such as speech in which temporal characteristics have been modified (Cohen, 1979).

There are methodological problems in both the Burda (2000) and Shah et al. (submitted) studies that could have affected the results. One methodological issue relates to hearing level. In both of the above-described studies, hearing was not tested. In Burda, hearing was screened at levels that included a mild hearing loss (40 decibels). Thus even though all participants passed a hearing screening, individual threshold differences among participants' hearing cannot be considered. A person could have passed the hearing screening and had a 35 dB hearing loss or a person could have passed the hearing screening and had normal hearing. In Shah et al., hearing was not tested nor was it screened. Rather a paper/pencil inventory that described degree of hearing handicap was used. Certainly, participants in Shah et al. might have had a hearing loss that they were unaware of or did not report. Since both of these studies did not control for specific degree of hearing loss, the contribution of hearing loss in ability to recognize AE cannot be determined. Indeed, hearing loss could have affected results in both studies. In both studies, there was a main effect for age. Since the elderly participants may have had a hearing loss, the main effect for age may be correlated with hearing loss in the elderly.

Another methodological issue involves cognitive status. Neither Burda nor Shah et al. screened cognition to determine that participants had normal mental status. It is presumed that both Burda and Shah et al. intended to include elderly participants who had normal cognitive function. However, since no cognitive screening was included in either study, that they did so cannot be verified. Given that the elderly performed worse

overall compared to the younger participants, it is possible that cognitive decline associated with aging affected the performance of the older participants.

A third methodological question is whether difficulty recognizing accented English is language specific. Shah et al. utilized only one AE speaker while Burda attempted to address this issue by using two AE speakers. However, Burda's design would have been strengthened if more accented English speakers were included. If at least two speakers of each type of AE were used, individual speaker-differences could be distinguished from language-specific effects.

Lastly, speech rate for the stimulus items was not controlled for in neither Burda's nor Shah et al.'s research. This is important because rate of speech affects speech intelligibility. Presumably, speech spoken rapidly is less intelligible than speak spoken at a normal speech rate. In summary, past research on the recognition of AE has not included experimental control of several variables that may be important for an understanding of whether older adults have more difficulty with AE than SAE compared to younger adults. These variables include degree of accent, type of accent, cognitive status, hearing loss, and rate of speech. In this dissertation project, we attempted to account for several of these methodological issues. In order to balance for accentedness, each speaker was rated by three raters using a nine-point scale (Appendix A). In order to attempt to account for language-specific effects, there were four AE speakers. Two of these speakers were native Chinese speakers, and two were native Portuguese speakers. Although exposure was not found to be a correlate of performance in a previous study (Goral et al., 2000) listeners completed an exposure questionnaire to determine native language and elicit information regarding degree of exposure to foreign languages and

foreign accents (Appendix B). Listeners were native speakers of English who did not speak Chinese or Portuguese and reported limited exposure to speakers with a Chinese or Portuguese accent. It should be noted that in general participants reported slightly more exposure to Chinese-accented English than Portuguese-accented English. On a scale from zero to four, average exposure to Chinese-accented English was .96 and average exposure to Portuguese accented English was .51. However, exposure to accents was not part of the exclusionary criteria for participants since exposure to accents and languages in general has not been found to affect ability to comprehend accented English (Goral et al., 2000).

All participants passed a cognitive screening (Appendix C) and underwent a complete audiological evaluation. Since hearing and cognitive decline are two prominent problems that are linked to speech-recognition ability in the elderly, they were carefully considered.

V. Research Questions

Given that there is decline in speech-recognition ability among the elderly for SAE, one might assume that there is decline in speech-recognition ability among the elderly for AE as well. However, this was not reported in one of the only two studies to date that have tested older adults' ability to understand accented speech. In order to better evaluate adults' ability to recognize AE and answer the question whether older adults have more difficulty recognizing accented speech compared to younger adults, the research questions were:

1. Does ability to recognize accented English change across the adult lifespan?
2. Is recognition of accented English disproportionately difficult compared to recognition of Standard American English across the adult lifespan?
3. Can the degree to which peripheral hearing loss and performance on neuropsychological tasks of attention and working memory correlate to ability to recognize speech be determined?
4. Do older adults demonstrate less confidence in their ability to recognize accented English compared to younger adults?

CHAPTER 2: METHOD

PARTICIPANTS

Fifty-four participants were recruited from Mercy College, the Graduate School of the City University of New York, senior centers in Westchester, and churches in Westchester. Of these participants, six served as pilot participants and four participants who did not meet selection criteria were excluded. All of the remaining participants were included in this study. All participants were native speakers of Standard American English. Participants who spoke Chinese and/or Portuguese were not included. Participant ages ranged from 20 to 81 years. All participants had at least a high-school education. Participants did not report any history of stroke, neurological problems, or learning problems (based on the Health and History Questionnaire, designed by the author for use in this study, see Appendix D). All participants had normal mental status, based on the Mini-Mental State Examination (passing score equals 24 or greater), (Folstein et al., 1975, see Appendix C).

Participants were asked whether they owned or used a hearing aid. This was part of the exclusionary criteria in that no participants who used a hearing aid were included in this study. An audiological evaluation was completed for all participants. Participants had hearing within normal limits or a mild hearing loss. Hearing was tested under headphones for all participants as part of the audiological evaluation. Thresholds between ears were symmetrical. Soundfield testing was also completed for the majority of the participants. When comparing headphone and soundfield thresholds there was no more than a 10 dB difference between the soundfield threshold and the better ear for any of the

participants. This is thought to be comparable to differences attributed to test retest reliability or the binaural summation effect. Participants with a hearing loss had a pure-tone average no poorer than 40 dB, and hearing levels generally no poorer than 50 dB at frequencies between 3000 and 4000Hz. See participant information in appendix E.

MATERIALS

Recordings

Six speakers recorded the materials: two SAE speakers, two native Chinese speakers, and two native Portuguese speakers. Potential AE speakers were recorded and then rated for degree of accentedness (see rating criteria described below) until we had the correct number of speakers for the study. Each speaker was recorded reading a list of fifty words and a list of fifty sentences.

The native languages of the AE speakers (Portuguese and Chinese) were chosen because linguists agree these languages differ markedly from English and from each other both in segmental and suprasegmental characteristics (Martin Gitterman and Loraine K. Obler, personal communication, 2001). For example, Chinese is a tone language in which distinctions are made based on pitch whereas Portuguese and English do not make similar distinctions. Moreover, syllabic structure differs in the three languages. Female speakers, ranging in age from 20-40 years old were recorded.

Rate of spoken sentences was determined post-hoc. Each sentence was timed, and then the total time was divided by the number of sentences spoken. Average speech rate for sentences spoken in Standard American English was 2.8 seconds per sentence for both Standard American English speakers. The average speech rate for sentences spoken

in Portuguese-accented English was 2.5 seconds per sentence for Portuguese-accented English speaker number one and 2.6 seconds per sentence for Portuguese-accented English speaker number two. Thus, the Portuguese-accented English sentences were more rapid than the SAE sentences. In addition, sentences spoken by one of the Chinese-accented English speakers were more rapid than the Standard American English sentences, while sentences spoken by the other Chinese-accented English speaker demonstrated a reduced rate compared to the Standard American English sentences. In most instances, speech rate is described in terms of words or syllables per minute, however since our participants were listening to speech at the sentence level, speech rate per sentence is more relevant than speech rate per minute.

Rating

Speakers were rated by three native-English-speaking monolinguals (who were not familiar with Portuguese and/or Chinese, had not lived abroad for three months or more, and were not regular speakers of another language, see Appendix F) to determine the degree of foreign accent and to balance for degree of accent among the speakers. Raters were students enrolled in a speech-language-pathology training program. Foreign-accent ratings were determined using a nine-point Likert scale, ranging from “no accent” (zero) to “heavy accent” (eight) (Schmid and Yeni-Komshian, 1999, see Foreign Accent Scale, appendix A). Inter-rater judgments for degree of foreign accent were determined. For the AE recordings, a rating of five on the foreign-accent scale was the minimum degree of foreign accent accepted. Inter-rater judgments were accepted if the mean of the ratings for each of the four speakers was within two points (e.g. mean for one AE speaker

was 5 and mean for another AE speaker was 7). If a potential speaker was rated below a 5 by any rater or inter-rater judgments were not established within two points for a particular speaker, the speaker was not used for the study. Six potential speakers were recorded. Four out of these six potential speakers were rated such that ratings met the criteria described (see AE speaker ratings for the four acceptable AE speakers, Appendix A).

AE and SAE Assessment Tasks

Assessment was aimed at providing an explanation for how hearing and cognition contribute to ability to process AE. Materials used for assessment included word lists used in traditional audiological assessment, sentence lists from the Revised Speech Perception in Noise Test (Revised SPIN Test) (Bilger, Nuetzel, Rabinowitz, & Rzeczkowski, 1984), and a short battery of neuropsychological tasks discussed below.

All speech materials were presented at 65 dB SPL. A standard presentation level was necessary in order to help determine the effect hearing had on performance. This level was chosen because it approximates the level of normal conversational speech and because it is also sufficiently loud so that even participants with hearing levels up to a 40 dB PTA were able to hear and repeat at least some of the words and sentences. Materials were presented in speech spectral noise at a S/N ratio of +5dB in order to approximate the listening environment in the real world in which noise is present (Pearsons, Bennett, & Fidell, 1977).

Audiological Assessment Word Lists

Traditional audiological testing includes assessment of pure-tone thresholds, speech-reception-threshold testing, and speech-recognition-ability testing. Speech-recognition-ability testing is completed using single-syllable-word lists. Published lists of single-syllable words used in traditional audiological assessment include phonetically-balanced word lists, (PBWLs); created at Central Institute For the Deaf by Hirsh, Davis, Silverman, Reynolds, Eldert, & Benson, 1952 as cited in Katz, 2002; and PAL word lists (Psycho-Acoustic Laboratory); created at Harvard Psycho-Acoustic Laboratory by Egan, 1948 as cited in Katz, 2002. The PAL word lists were used in this study because there was an adequate number of lists, which allowed each of the six speakers in this study to record a different list.

Each of the six speakers recorded a different 50-item PAL word list. The following labels were assigned to each recording:

Word-SAE1 (word list, Standard American English Speaker “1”)

Word-SAE2 (word list, Standard American English Speaker “2”)

Word-AE1 (word list, native Portuguese speaker number “1”)

Word-AE2 (word list, native Portuguese speaker number “2”)

Word-AE3 (word list, native Chinese speaker number “1”)

Word-AE4 (word list, native Chinese speaker number “2”)

Revised SPIN Sentences

The Revised SPIN Test includes eight lists of fifty sentences in which the last word of each sentence is a single-syllable word. Twenty-five sentences on each list are

high-predictability sentences (meaning that the last word of the sentence is easily predicted) and twenty-five sentences are low-predictability sentences (meaning that the last word of the sentence is less easily predicted). In this study, a different sentence list was recorded by each speaker. Each speaker recorded one list of 50 sentences (25 high-predictability sentences and 25 low-predictability sentences). The following labels were assigned to each recording:

S-SAE1 (sentence list, Standard American English Speaker “1”)

S-SAE2 (sentence list, Standard American English Speaker “2”)

S-AE1 (sentence list, native Portuguese speaker number “1”)

S-AE2 (sentence list, native Portuguese speaker number “2”)

S-AE3 (sentence list, native Chinese speaker number “1”)

S-AE4 (sentence list, native Chinese speaker number “2”)

Participants' Confidence Ratings

After this research project had begun and the majority of the participants had already been tested, this task was included in order to consider older participants' perception of their ability to recognize accented English. This provided confidence data for twenty of the forty-four participants who participated in the larger study. The participants who completed this task were representative of the age range across the adult lifespan, with ages ranging from 23 to 79 years (median age=51.5). Of the twenty participants who completed this task, four were age 70 years or older (see * next to participants' ages in appendix E which indicates the participants who participated in this confidence-judgment task). These participants were asked to rate their degree of

confidence regarding what they heard and repeated. Each of the participants was given 12 forms to complete these ratings as they listened to and repeated the words and sentences (six forms for the six word lists and six forms for the six sentence lists). Each item on the forms consisted of a five-point-Likert-rating scale (in percent) for each token.

Participants circled the percentage (0%, 25%, 50%, 75% or 100%) that best corresponded to the degree of confidence that each token (the word for the word lists and the last word of the sentence for the sentence lists) was heard and repeated correctly (see sample of form, Appendix G). This self-rating scale was designed to include a Likert scale with five points since most studies that have evaluated the use of Likert scales have indicated that the accuracy of the statistics calculated on such scales is not compromised as long as the scales have at least five points (Rasmussen, 1989).

Neuropsychological Tasks

Some of the neuropsychological tasks used for assessment in Obler et al. (1991) were used in this study. Most crucially, the neuropsychological tasks that reflected the cognitive skills posited to be reflected in the Revised SPIN Test were implemented. The neuropsychological tasks included were:

Continuous Performance Test (CPT) (recorded by the researcher based on Obler et al., 1991) – for sustained attention

Digits Forward (recorded by the researcher based on Wechsler, 1981) – for buffer capacity of working memory; and for attention

Digits Backward (recorded by the researcher based on Wechsler, 1981) – for executive component of working memory

Stimuli for each of these tasks were recorded by a Standard American English speaker in a sound-treated room using a digital tape recorder (a TASCAM TEAC Professional Division DA-P1 Digital Audio Tape Recorder), digitized using SoundForge, a computer program designed to digitize speech and normalize the loudness, and then copied onto a compact disk. These materials were presented to participants through a Grasen-Stadler GS26 audiometer at each participant's most comfortable listening level (MCL). Unlike the accented English materials, these materials were presented at MCL to insure participants could easily hear these stimuli and that an inability to hear the stimuli would not affect measures of cognition.

Exposure Questionnaire

Native language and degree of exposure to accents and foreign languages was determined based on responses from a questionnaire in which participants answered questions related to exposure accents and foreign languages (see Exposure Questionnaire, Appendix B). Any participant able to speak Chinese or Portuguese was excluded from the study. Degree of participants' exposure to Portuguese-accented English and Chinese-accented English is included in Appendix E.

PROCEDURE

The testing session took place in a two-room audiological testing suite. The participant sat in one room while the investigator sat on the audiometer side of the two-room suite. The investigator and participant were able to see each other through a window that connects the two rooms of the audiological suite. There was one testing

session. In the beginning of the testing session, each participant filled out the questionnaires and signed the Informed Consent. A complete audiological assessment was then administered. After this, two parts to the testing session, separated by a 15-minute break, are described. Half of the participants were first presented with materials under Part A (described below) and then Part B (described below) while half of the participants were first presented with materials under Part B and then Part A. The specific steps to the testing session included:

For All Participants at Beginning of Test Session

1. Each participant signed a consent form, authorizing consent for participation in this study (see Appendix H).
2. Each participant filled out the Exposure Questionnaire (Appendix B).
3. Each participant filled out the Health and History Questionnaire (Appendix D).
4. Each participant was administered the Mini-Mental State Examination (Folstein et al., 1975, Appendix C).
5. Each participant underwent a complete audiological assessment.

Part A (Half of the Participants completed Part A first, and then part B)

1. Each participant was presented with oral and written instructions from the examiner for repetition of words (See Appendix I).

2. Examiner administered the SAE and AE words through the audiometer at 65dBSPL (using a Latin square randomization schedule) in sound field. All materials were administered in the presence of speech noise at a +5 S/N ratio.
3. Each participant was presented with oral and written instructions from the examiner for repetition of sentences (Appendix I).
4. Examiner administered the SAE and AE sentences through the audiometer at 65dBSPL (using a Latin square randomization schedule) in sound field. All material were administered in the presence of speech noise at a +5 S/N ratio.

After this, participants took a 15-minute break. Refreshments were provided during the break.

Part B (Half of the participants completed Part B first, and then part A)

1. Each participant was presented with the neuropsychological tasks (CPT, digits forward, digits backward) at a most comfortable listening level (MCL). MCL was determined individually for each participant using the standard audiological procedure. Each neuropsychological task was presented in soundfield at MCL through the audiometer. Order of presentation of these three neuropsychological tasks adhered to Latin Square randomization.

SCORING

Words

Each testing session was audio-recorded so the investigator could go back and listen to the recording if she was unsure of a participant's response. For the lists of single words, participants were scored on-line by the examiner on number of words judged to be repeated correctly. The examiner sat opposite from the participant on the audiometer side of the two-room audiological-testing suite. The examiner and participant saw each other through a window and the examiner was able to hear the participant's responses through a monitor. As the participant repeated back each word, the examiner checked off on a list whether the word was repeated correctly. The participant was not able to see the examiner's scoring sheets.

Six audio-recordings were randomly chosen to check accuracy of scoring. A graduate speech-language pathology student listened to and scored responses from these six participants. Inter-rater judgments for scoring were good. For three out of the six participants there was 100% agreement between on-line scoring and the rater who scored the audio recordings. For three participants there were minor differences in scoring. For one word list, agreement was originally 96%. For two low-predictability sentence-lists agreement was originally 92 and 94%. When a third rater scored these lists, inter-rater judgments were in 100% agreement and reflected the on-line rater's scores. It is thought that the on-line scoring may have been somewhat easier than the scoring of the audio-recordings because of the presence of visual cues.

Sentences

Sentences were scored using the scoring designed for the Revised SPIN Test. A low-predictability sentence was scored correct when the last word in the sentence was repeated correctly. A high-predictability sentence was scored correct when the last word in the sentence was repeated correctly. In order for a word to be scored correct, it was repeated in the exact form as the word spoken (for example, *book* repeated as *books* was not scored correct). A high-predictability score and a low-predictability score were calculated for each sentence list.

Participants' Confidence Ratings

This Likert scale rating allowed participants to report how confident they were that they heard each word (for the single words) and the last word of each sentence (for the sentences), correctly. Participants circled the percent that corresponded to how confident they were that a word was heard and repeated correctly. Participants circled one of the following: 0%, 25%, 50%, 75%, or 100%. For the analyses, 0% equaled 1, 25% equaled 2, 50% equaled 3, seventy-five percent equaled 4, and 100% equaled 5.

These forms with the confidence ratings were not *scored* by the researcher. Rather, the researcher used these data to determine the average confidence judgment for words, low-predictability sentences, and high-predictability sentences.

Continuous Performance Test (CPT) (created for this study, based on Obler et al., 1991). This relatively difficult form of the task required listeners to listen to a 12-minute recording of a Standard American English speaker reciting numbers, approximately one

per second. Instructions required the listener to raise his or her hand each time three odd numbers were spoken in a row. On this recording there were 20 instances in which three odd numbers were recited in a row. Thus a maximum score equaled 20. If a participant raised his or her hand when three odd numbers were not spoken (the false-positive rate), the overall correct score was reduced by one point each time for each false positive.

Digits Forward (Wechsler, 1981). Participants listened to a prerecorded SAE speaker who instructed participants to repeat a series of numbers. Numbers were presented at a moderate rate (one number per second). The first two items required participants to repeat two numbers, the next two items required participants to repeat three numbers, up to a maximum repetition of nine numbers. The administration of items continued until a participant missed both items at a particular level (e.g. did not accurately repeat both trials of three numbers; see instructions to participants, Appendix I). A maximum score equaled 16.

Digits Backward (Wechsler, 1981). Participants listened to a prerecorded SAE speaker who instructed participants to repeat a series of numbers, backwards. The first two items required participants to repeat two numbers backwards, the next two items required participants to repeat three numbers backwards, up to a maximum repetition of eight numbers, backwards. These prerecorded numbers were presented at a moderate rate (one per second). The administration of items continued until a participant missed both

items at a particular level (e.g. did not accurately repeat backwards both trials of three numbers; see instructions to participants, Appendix I). A maximum score equaled 14.

CHAPTER 3: RESULTS

In this experiment, measures of speech recognition, cognition, and hearing were obtained on 44 participants ranging in age from 20 to 81 years. The first question asked whether accented English is more difficult to recognize than Standard American English. Secondly, we set out to determine whether recognition of accented English is disproportionately difficult compared to Standard American English across the adult lifespan. If disproportionate difficulty was found, a tertiary goal was to determine the relative contribution of age-related cognitive and hearing factors to speech-recognition performance. Finally, we also asked whether older adults have reduced confidence in their self-evaluation of ability to recognize accented English compared to young adults.

Three types of speech materials (words, high-predictability sentences, and low-predictability sentences) were recorded by six talkers whose speech was representative of Standard American English and accented English (two Standard American English talkers, two Portuguese-accented English talkers, and two Chinese-accented English talkers). Speech-recognition scores (percent correct) obtained from each participant for each of the six talkers are shown in Figures 1– 6. There appears to be large talker differences within an accent and between accents (see Figures 3 – 6 and Descriptive Statistics in Tables 1 – 8). In order to obtain an overall sense of performance on AE and SAE, each participant's score for the four accented English talkers and the two Standard American English talkers were averaged to come up with a single score for AE and SAE (see Tables 9 and 10). Figure 7 displays the average performance for accented English as a function of participant. Figure 8 displays the average performance for Standard

American English as a function of participant. The participant data are plotted as a function of age.

Recall that all speech materials were presented at conversational level (65 dB SPL) in the presence of background noise (S/N =+ 5 dB). Figures 1 and 2 demonstrate good performance for recognition of Standard American English for the majority of participants, even the oldest participants who had some degree of hearing loss. Figures 3 - 6 demonstrate performance for accented English. Visual inspection of these Figures reveals that in an environment of background noise, all participants recognize final words in sentences with contextual cues better than final words in sentences without contextual cues and better than single words.

In order to visually compare performance on AE and SAE words, and final words in low- and high-predictability sentences, the performance data are displayed in scatter plots in Figures 9, 10, and 11, respectively. These scatter-plots illustrate performance on each type of speech material for both SAE and AE as a function of age.

Since none of the independent variables (hearing thresholds, performance on cognitive tasks, and education) were representative of the normal distribution, nonparametric statistics were used to analyze the data. The scatter-plots that display these distributions across the age-span studied (Figures 12-17) display the lack of homoscedasticity among performance. Because there were ceiling scores, the difference score may not be representative of the true relationship between SAE and AE high-predictability sentences given that the SAE scores are at ceiling. Since the authors of the Revised SPIN Test report on the proportion of correct final words in low- and high-

predictability sentences, comparisons using these proportions were made in the present study as well.

Difficulty Recognizing Accented Speech

Because the non-parametric analysis of the data allows an examination of the first research question whether recognition of accented speech changes significantly with age, the Median and Chi-Square tests were used.

The data were divided into three groups according to subject age. Group 1 was comprised of participants ages 20-39 (n=14), Group 2 was comprised of participants' ages 40-59 (n=16), and Group 3 was comprised of participants' ages 60-81 (n=14). The median speech-recognition scores for words, final words in low-predictability sentences, and final words in high-predictability sentences as a function of accent and listener age appear in Figures 18, 19, and 20, respectively.

Separate analyses of Standard American English and accented English for each type of speech material were computed to determine whether speech-recognition ability differed significantly as a function of age-group. The Median Test and Chi-Square were computed for Standard American English words and final words in low-predictability sentences (see Tables 14 and 15, respectively). The Median Test was not computed for the final words in high-predictability SAE sentences due to the ceiling scores. Pairwise comparisons are reported in the tables to show the hypothesized patterns of differences among the three age-groups.

The median score for Standard American English words was significantly different among the three age-groups (chi-square = 10.48, $p \leq .01$). Pairwise comparisons

among the three groups of participants were computed and the hypothesized pattern of scores was found, with Group 3 displaying the lowest median score for SAE words (Group 1 median = 91, Group 2 median = 90, Group 3 median = 81.5, see Table 14). The median score for final words in SAE low-predictability sentences was also significantly different among the three age-groups ($\chi^2=7.22, p \leq .05$). Pairwise comparisons among the three groups of participants were computed and the hypothesized pattern of scores was found, with Group 3 displaying the lowest median score for final words in Standard American English low-predictability sentences (Group 1 median = 92, Group 2 median = 90, Group 3 median = 81.6, see Table 15).

Participant performance for Standard American English was similar to what was expected. Overall, performance on SAE was much better than performance on AE. As stated above, performance for the final words in high-predictability sentences was at ceiling, which prevented us from determining whether there is significant age-related decline in speech-recognition ability for final words in SAE high-predictability sentences.

Accented English was overall more difficult than Standard American English, yet similar patterns of performance were noted. Findings from the Median Test support the notion of an age-related difference in ability to recognize accented English words, final words in high-predictability sentences, and final words in low-predictability sentences. The median score for accented English words was significantly different among the three age-groups ($\chi^2 = 10.02, p \leq .01$). Pairwise comparisons among the three groups of participants were computed and the hypothesized pattern of scores was found, with Group 3 displaying the lowest median score for accented English words (Group 1 median = 56, Group 2 median = 53, Group 3 median = 40.5, see Table 11). The median score for

final words in accented English high-predictability sentences was significantly different among the three age-groups (chi-square = 7.85, $p \leq .05$). Pairwise comparisons among the three groups of participants were computed and the hypothesized pattern of scores was found, with Group 3 displaying the lowest median score for final words in accented English high-predictability sentences (Group 1 median = 90.5, Group 2 median = 89, Group 3 median = 74, see Table 12). The median score for final words in accented English low-predictability sentences was also significantly different among the three age-groups (chi-square = 12.7, $p \leq .01$). Pairwise comparisons among the three groups of participants were computed and the hypothesized pattern of scores was found, with Group 3 displaying the lowest median score for final words in accented English low-predictability sentences (Group 1 median = 44, Group 2 median = 44, Group 3 median = 22.5, see Table 13). The answer to the first research question is yes, accented English is indeed more difficult to recognize for older-adult participants compared to younger-adult participants.

Relationship Between Low- and High-Predictability Sentences

Bilger's normative data reflect the actual recordings of the SPIN sentences by Bilger and colleagues. It is, of course, not valid to apply Bilger's proportions to the recordings made for this study. However, it is interesting to consider whether the same pattern holds for participants' performance on the accented English recordings made for this project.

Visual inspection of Tables 9 and 10 and Figures 21 and 22 allows a comparison of each participant's performance on final words in low-predictability sentences and final

words in high-predictability Standard American English and accented English sentences. The proportions reported in these Tables reflect the relationship between recognition of final words in low- and high-predictability sentences for each participant. For SAE and AE, all participants did better on the final words in sentences with context cues than the final words in sentences without context. For the SAE sentences, the oldest participants (over age 70) have proportions less than .80 (with the exception of one participant) while the younger adult participants (age 70 and under) have proportions of .80 or greater. See plot of proportions as a function of age in Figures 23 and 24.

The same general pattern as reported by Bilger holds for the accented English recordings used in this study. All of our participants did better on the final words in sentences with context cues than those in the sentences without context. In addition, participants in our study who achieved a score of 40 to 50 percent for final words in low-predictability sentences, achieved a score for final words in high-predictability sentences of 80 percent or greater (with the exception of participant number 18), indicating similar proportions to those of Bilger's. For our participants who achieved a score for final words in low-predictability sentences of 40 – 50 percent, the proportion range between low and high-predictability performance is .40 -.50 since performance on high-predictability sentences is so much better than performance on low-predictability sentences. This proportion range is consistent across subjects.

In summary, in our study the majority of the participants between the ages of 20 and 69 achieved scores for final words in accented English low- and high-predictability sentences that indicate proportions of .40 or greater. All of our participants who had hearing loss (those over the age of 70 in our study) achieved scores for final words in

accented English low- and high-predictability sentences that indicate proportions less than .40. This suggests that there is less difference between recognition of final words in the low and the high-predictability accented English sentences for our oldest participants (compared to our younger adult participants) and that our oldest participants are less able (than the younger adult participants) to take advantage of the contextual cues present in the high-predictability accented English sentences.

Given this apparent discrepancy between our oldest participants and the younger adults in our study, we decided to evaluate our question regarding disproportionate difference for accented English compared to Standard American English using this proportion data. Because our data did not meet the required assumptions for parametric analysis, we used a nonparametric statistical procedure to consider this question, Friedman's Test, to compare the proportions of low-predictability to high-predictability sentences for participants in Groups 1, 2, and 3. For comparison of SAE across participant Groups, a significant difference was noted at the .05 level (Chi-Square = 6.14, $p \leq .05$). Post-hoc analysis using the Wilcoxon Signed Ranks Test indicated a significant difference between Group 2 and Group 3 ($p = .014$) and Group 1 and Group 3 ($p = .009$), with no significant difference between Group 1 and Group 2 ($p = .63$).

For comparison of accented English across participant groups, a significant difference was noted at the .01 level (Chi-Square = 13.0, $p = .002$). Post-hoc analysis using the Wilcoxon Signed Ranks Test indicated a significant difference between participant Group 2 and Group 3 ($p = .004$) and participant Group 1 and Group 3 ($p = .006$), with no significant difference between participants Group 1 and Group 2 ($p = .85$).

Correlations Among Hearing, Tasks of Attention and Working Memory, and Age

Pearson correlations within independent variables were computed in order to determine the relationships between each pair of variables. Pure-tone average and high frequency hearing levels were significantly negatively correlated to two of the three neuropsychological measures (Digits Backward, $p=.037$; CPT, $p=.026$). Age was significantly correlated with Digits Backward ($p=.032$), pure-tone hearing threshold ($p=.001$), and high frequency hearing threshold ($p=.001$; see neuropsychological scores in Table 16 and correlations in Table 17). Recall the previously discussed scatter-plots that reflect the data used for these correlational analyses (Figures 12-17). These scatter-plots demonstrate the skewed distributions which prevent us from correlating these independent variables with the dependent speech-recognition scores. Given the correlation between age and hearing loss and the finding that our oldest participants do worse on speech-recognition tasks than our young-adult participants, we conclude that age, hearing loss and speech-recognition ability are related. Thus, with respect to the third research question, hearing loss and aging are confounded in this study. It is clear that hearing is related to recognition of speech, however, since the majority of our oldest participants had both hearing loss and difficulty recognizing accented and unaccented speech, the exact contribution of peripheral factors to performance cannot be determined. Similarly, the contribution of cognition to reduced performance cannot be determined due to the skewed distributions for the cognitive variables.

Although the contribution of hearing and cognitive factors to performance cannot be determined, it is interesting to consider the hearing level and cognitive performance of

our three elderly participants whose ability to recognize accented speech appears better than the rest of the oldest participants. Participant 42, 41, and 49 (ages 70, 77, and 79, respectively) recognize accented English similarly to our younger adult participants (see scores in Table 10). One of these participants (number 42) has markedly better hearing than the other participants over the age of 70 (see PTA and HFHL in Appendix E) while for the other two it was not. Performance on the cognitive tasks among these three participants is variable (see Table 16) and thus cannot explain exceptionally good performance on accented English speech.

Confidence Ratings

The final research question asked whether older adults are disproportionately less confident about their ability to recognize accented English compared to their confidence in ability to recognize Standard American English. In order to answer this question, participants' average self-report of confidence (based on participants' Likert-Scale ratings of their confidence in recognition of words alone and final words in sentences, see rating form in Appendix G) was computed for recognition of Standard American English and accented English words, high-predictability sentences, and low-predictability sentences. Data were analyzed for the subset of twenty participants who were administered this task (see data in Table 18). The participants who participated in this analysis were representative of participants in the age-group studied (see participants with an * in Appendix E). Figures 25-28 illustrate the scatter plots for these confidence self-report ratings. The only Figure that demonstrates reduced confidence across the age-span studied is Figure 25 that includes Confidence Self-Report for Standard American

English Words. The scale on the y-axis is 1-5 (1 equals 0 percent confident, 2 equals 25% confident, 3 equals 50% confident, 4 equals 75% confident, 5 equals 100% confident).

Visual inspection of Figure 25 demonstrates the slightly reduced confidence in the elderly participants. However, the significant negative correlation between age and Standard American English confidence rating for words ($r = -.55, p < .05$) better illustrates this relationship. No other confidence-rating correlations even approached significance (see Table 19: Correlations Between Age and Confidence).

In order to consider the real-world effect of the relationship between older adults' performance and their confidence in ability to recognize accented speech, correlations between performance and confidence were computed for the four elderly participants who participated in the confidence-rating tasks (participant numbers 39, 41, 42, and 49). Correlations were computed for words and final words in high and low-predictability sentences for one Standard American English speaker, one Portuguese-accented English speaker, and one Chinese-accented English speaker. Statistically significant correlations are reported in Table 20. Significant correlations between performance on final words in accented high-predictability sentences and confidence for three of the four participants (participants 41, 42, 49) are reported, suggesting that three of the older adults who completed the task are realistic judges of their ability to recognize accented speech.

CHAPTER 4: DISCUSSION

In this project we investigated the recognition of accented English in adults with advancing age. It is well-known that speech-recognition ability declines with aging. The effect of accent on speech-recognition ability, however, has been evaluated by few researchers. In fact, there is a contradiction in the only two studies to date that have evaluated older adults' ability to recognize accented speech. Burda (2000) reported that there is a decline in ability to recognize accented speech across the adult lifespan while Shah et al. (submitted) reported their older adults do not have significantly more difficulty than younger adults when considering ability to recognize accented English. Our study further evaluates this question.

Summary of Findings

1. Recognition of accented English declines in older relative to younger adults.
2. Disproportionate difficulty in recognition of accented English compared to recognition of Standard American English for older relative to younger adults could not be tested due to the distribution of the data.
3. Peripheral hearing loss is integrally related to the ability to recognize accented speech. Due to interactions among age and hearing loss and the skewed distributions for the hearing and neuropsychological measures, the exact contribution of peripheral and cognitive factors was not determined.
4. Older adults do not demonstrate less confidence in their ability to recognize accented English compared to younger adults. Confidence in ability to recognize contextual speech correlates to actual ability to recognize accented contextual speech in three of the four participants tested.

Difficulty Recognizing Accented English

This research clearly indicates that older adults have more difficulty than younger adults in ability to recognize accented speech. Across the age-span studied, the oldest participants (Group 3) demonstrate poorer performance in tasks that include recognition of accented English single words, and recognition of final words in accented English sentences with and without contextual cues. Interestingly, there is not a steady decline in ability across the adult lifespan. Figures 3 – 7 display that Group 3 includes participants ages 60 – 81 and that it is after the age of 70 years that participants have increased difficulty with recognition of accented English. This finding supports previous findings with respect to participants' performance on recognition of accented English across the adult lifespan (Burda, 2000). It should be noted that a similar pattern of performance holds for Standard American English, with the oldest participants demonstrating a decline in speech-recognition ability for SAE.

Relationship Between Performance on Low- and High-Predictability Sentences

Prior studies had failed to show an interaction between age and recognition of accented speech. For this project we chose materials we thought might be more sensitive to this interaction. We included an assessment of ability to recognize accented English words and sentences. The sentences we chose for our recordings included sentences with and without contextual cues that would facilitate the recognition of the final words. An interaction between age and accent for the contextual sentences was predicted. We expected that the younger participants may be able to take advantage of the context cues provided by the high-predictability sentences in a manner that the elderly participants

may not be able to do. Our analysis that compared AE proportions (performance for final words in low-predictability sentences compared to final words in high-predictability sentences) to SAE proportions indicated significance for both AE and SAE. The method of analysis did not permit testing for an interaction.

Given what is known about changes in language in the elderly, a disproportionate difference in ability to recognize accented English would not surprise us. As reported in the comprehension and aging literature, several researchers note reduced comprehension skills in the elderly (Cohen, 1979; Obler et al., 1991; Obler, Nicholas, Albert, & Woodward, 1985; Norman, Kemper, Kynette, Cheung, & Anagnopoulos, 1991; Stine-Morrow, Ryan, and Leonard, 2000). For example, according to Norman et al., as length of utterance and syntactic complexity of utterances increases, healthy elderly listeners demonstrate reduced understanding of sentences.

The analysis of the relationship between low and high-predictability-sentence recognition (proportion data) suggests interesting interpretations of our findings. It is noteworthy that when listening to accented English sentences with and without contextual cues, our participants between the ages of 20 and 59 perform similar to Bilger's participants who had a hearing loss. Given that while listening to accented English the young-adult participants performed similarly to those with a hearing loss in Bilger's study, one can imagine the additional effect accented English has on individuals who also have a hearing loss. The accented English is likely to cause an additional decrement in performance in elderly hearing-impaired individuals.

Recall that in our study only the participants aged 70 and older had some degree of hearing loss. Bilger's proportions were reflective of participants across the age-span

studied who had sensorineural hearing loss. Visual inspection of the accented English scores in our study indicates similar proportions to Bilger's. However, this similar pattern of proportions is noted for different populations: Bilger's hearing-impaired participants and our normal-hearing participants.

Moreover, we might consider the reciprocal effect of Standard American English speech on non-native English speakers. If recognition of accented English is difficult for elderly native English speakers, then recognition of Standard American English by non-native English speakers may be comparable. Bergman (1980) reported that elderly non-native speakers have more difficulty than elderly native speakers understanding time-altered speech. In a study that considered the speech-recognition ability of non-native speakers of English, Mayo, Florentine, and Buus (1997) studied the effect of age of acquisition of English on ability to recognize Standard American English. They reported that early bilinguals were more able to take advantage of contextual cues in SAE sentences than were late bilinguals. It would be interesting to consider age as well as L2 acquisition in non-native English speakers' ability to recognize Standard American English.

Other Factors That Contribute to Recognition of Accented English

If older adults have disproportionate difficulty with accented English contextual sentences, then the question arises as to why these individuals may appear to take less advantage of the contextual cues when listening to accented speech. Disproportionate

difficulty for recognition of final words in high-predictability sentences would be especially interesting given that we know that older adults with and without presbycusis are able to take advantage of contextual cues (Pichora-Fuller, Schneider, & Daneman, 1995; Wingfield, Aberdeen, & Stine, 1991; Wingfield, Alexander, & Cavigelli 1994). Perhaps the natural distortion of the speech that occurs when speech is accented is interpreted unconsciously as “noise” for elderly individuals. This “noise” may act as a natural distraction and/or additional obstacle, which possibly would not allow elderly people the opportunity to take advantage of the contextual cues present in the accented speech. Unfortunately, because our participants in the oldest age-group also had hearing loss, it is not possible to determine the underlying cause for the inability to use context.

The younger participants in the present study exhibited poorer speech-recognition performance on the accented speech-in-noise than they did for the SAE speech-in-noise. In fact, for these participants, performance on the final words in low predictability and high-predictability-sentences was similar to the performance reported by Bilger for persons with hearing loss. This finding suggests that in normal hearing listeners, accent has an effect similar in magnitude to that imposed by peripheral hearing loss. The additional decrement in performance in the older participants may be due to either the effect of hearing loss, or to cognitive difficulties. Because these two factors are confounded in the present study, we cannot separate out their possible contributions.

Education is another possible factor that may contribute to elderly participants' difficulty with accented speech. In our study, the number of years of college education in Appendix E suggests many of the oldest participants had less education than the younger participants. However, the correlation between age and education is not significant ($r = -$

.03, $p=.83$, see Table 17) most likely because the distribution comparing age and education is skewed (see scatter plot, Figure 17) with less education noted for the youngest and oldest participants, and more years of college education for the middle-aged participants. Of course, a study that included participants across the age-span studied with similar range of educational level at all ages would better provide us with the ability to evaluate the relationship between education and ability to recognize accented speech.

Hearing and Aging

It is well known that hearing acuity declines with aging. Many researchers report that the difficulty recognizing speech that is noted in the elderly is due to *presbycusis*, the peripheral hearing loss that is commonly present in elderly people (e.g. Bergman, 1980; Bergman et al., 1976; Helfer, 1992; Helfer and Wilbur, 1990; Wingfield, 2000). Recall that Table 17 shows the significant positive correlations between age and pure-tone average as well as age and high frequency hearing level ($r=.59$, $.73$, respectively with $p<.01$ for both correlations). So as age increased among participants in this study, pure-tone average and high frequency hearing level also increased. This is consistent with what is generally thought to be the relationship between age and hearing across the adult lifespan. From this perspective, then, the current findings of reduced speech-recognition ability for AE and SAE as participants age clearly support previous research noting a relationship between hearing ability and recognition of speech across the adult lifespan.

Hearing loss and aging, however, are confounded in this study as in most research that includes elderly participants. By this, we mean that the individual effects of each factor on ability to recognize speech cannot be determined. Some may assume that age is

related to the reduced ability to recognize speech while others may assume that it is the hearing loss that is associated with aging that negatively affects ability to recognize speech. In the two prior studies that evaluated the ability to recognize accented speech, hearing acuity was not tested. Burda only screened hearing and Shah et al. used a paper-pencil screening questionnaire. While we tested hearing acuity in this study, we were unable to separate out the effects of hearing loss on ability to recognize accented speech since none of our younger participants had any hearing loss. The abundant support for the peripheral hypothesis when considering the reduced ability to recognize speech (e.g. Bergman, 1980; Bergman et al., 1976; Helfer, 1992; Helfer and Wilbur, 1990; Wingfield, 2000) is neither supported nor refuted by this research project since hearing and aging are confounded in this study. Future research needs to include participants with and without hearing loss at every age-interval studied in order to tease out the actual effects of hearing.

It is interesting to consider the hearing levels for the three participants in the oldest group whose speech-recognition performance appears better than that of the other elderly participants. Surprisingly, only one of these participants demonstrates hearing similar to the younger participants, indicating that even with a mild to moderate hearing loss, recognition of speech was good for two of these three elderly participants. Although, overall hearing loss was associated with decreased performance on tasks, hearing loss alone cannot explain performance. Thus one can conclude hearing loss contributes to poorer performance in the elderly on the speech recognition tasks but is not the sole determinant.

Nor do unusual high levels of education or exposure to accents explain the performance for these participants. The next obvious question is whether these elderly participants who recognized accented speech performed exceptionally well on the neuropsychological tasks. Surprisingly, the answer is no. Two of the three elderly participants who more easily recognized accented speech had hearing loss and did not demonstrate exceptionally good cognitive skills based on the neuropsychological measures.

Cognition, Aging, and Ability to Recognize Speech

Although both hearing and cognition decline across the adult lifespan, there is minimal support for a cognitive explanation when considering the decline in ability to recognize speech across the adult lifespan. In part, lack of support for the cognitive hypothesis may be due to the limited number of studies that consider the relationship between cognition and ability to recognize speech. One study that did evaluate the contribution of cognition in ability to recognize speech (Jerger et al., 1991) indicated minimal support for the cognitive hypothesis. That study used regression to correlate cognitive skills to performance, however since they did not report which specific cognitive skills were related to performance, it is not clear which aspects of cognition may be most important for speech-recognition ability. Were the distributions not skewed, this relationship could have been determined using regression analyses that included the three neuropsychological measures we chose for this study (the Continuous Performance Test, Digits Forward, and Digits Backward). Although we cannot determine the relationship between cognition, aging, and the ability to recognize speech, simple

correlations among the cognitive variables do allow us some understanding of the relationship between cognition and aging.

The Continuous Performance Test, described as a test of sustained attention, can also be thought of as a vigilance task. The literature is mixed on age differences for vigilance tasks (Rogers, 2000). Some studies report age differences on performance on attention tasks, while others do not. The exposure time of the stimulus might affect performance. If the exposure time of the target is too short, elderly participants may miss the target and not respond. This may appear to be an age-related difference in attention when it is not. Thus, the lack of a correlation between age and CPT in this project is not surprising. This task of sustained attention was included in this study because previous research by Obler et al. (1991) found it to be a sensitive measure that correlated to performance on a syntactic comprehension task. In addition, it was thought that attention was necessary for repetition of the high- and low-predictability sentences used in this study. Other cognitive tests might be included in future research on the cognitive hypothesis.

A relationship between age and Digits Forward, thought to reflect buffer capacity for working memory and attention, was also not significant. It is not surprising that these two neuropsychological measures that involve attention do not correlate with age, since attention does not decline with aging. The third neuropsychological measure we used, Digits Backward, did demonstrate a significant correlation with age.

The correlation between age and Digits Backward can be interpreted to mean that as age increased, working memory decreased. This is consistent with what is reported in the literature in that it is known that working memory decreases as individuals age (Park,

2000; Craik, 2000). This negative correlation between age and Digits Backward reflects elderly participants' reduced performance on a task that represents the executive component of working memory.

Relationship Between Age and Confidence in Ability to Recognize Accented English

Because previous studies suggested no disproportionate difference in older adults' difficulties with recognition of accented English relative to younger adults and because Obler (personal communication, 2002) speculated older adults are more cautious than younger adults, we included the Participants' Confidence Rating Task to evaluate whether there were subtle differences in participants' interpretation of their performance. As noted in Figure 23 and Table 19, only one measure reflected reduced confidence across the age-range studied. Moreover, that was not on AE but rather participants reported reduced confidence in ability to recognize Standard American English words across the age-span studied. No other confidence measures demonstrated reduced performance across the age ranges, suggesting that overall, older adults are not disproportionately less confident than younger adults about their ability to recognize accented speech. Thus, lack of confidence in ability to recognize accented English cannot be an explanation as to the general lack of disproportionate difficulty for recognition of accented English between young and older adults.

Real-world effect of older individuals' ability to recognize accented speech relative to their confidence in ability to recognize accented speech can be considered. Correlations between confidence and performance on final-words in high-predictability sentences indicate that for three of the four oldest participants who completed the

confidence-rating task, confidence in ability to recognize contextual accented English correlated to performance. This suggests that older adults are accurately judging their ability to recognize contextual speech. The converse would have implications for comprehension of conversational discourse in that a lack of a correlation between confidence in ability to recognize accented contextual speech and performance may negatively affect conversational interactions. While based on a small number of participants, this finding is consistent with older adults accurately judging their ability.

Conclusions

The major finding from our study is that older adults do indeed have more difficulty than younger adults in recognizing accented English. Our findings are in agreement with the findings reported by Burda (2000). The Median Test allowed us to look at participants across three age-groups (young, middle-aged, and elderly). Indeed, the findings support the notion of an age-related difference in ability to recognize accented speech. In our study, older adults had more difficulty recognizing accented English than did younger adults.

In addition, we addressed the question of whether older adults have disproportionate difficulty recognizing accented English (compared to younger adults). It was concluded that while older adults may have disproportionate difficulty recognizing accented English, the factors that contribute to this difficulty cannot be determined. Finally, with regard to confidence in ability to recognize accented English, older adults did not demonstrate less confidence than younger adults in their ability to recognize accented English.

Accented English can be thought of as naturally altered speech. The elderly have been shown to have more difficulty with altered speech materials that require more working memory than with speech that has not been altered (e.g. the elderly have demonstrated poorer performance for speech recognition when speech was presented at a slower speed, thus requiring more working memory for processing as in Small et al., 1997). In addition, recognition of speech in noise is difficult for the elderly (Tun, 1998). So the natural changes that occur in accented speech could be comparable to altered speech or speech in noise.

Findings from this project, then, could have broad implications for an understanding of speech-recognition ability in the aged. Our findings in part support the original work in the area of accented speech by Burda (2000). Her previous research indicated that the elderly had more difficulty than young adults with understanding accented speech. The present study corroborates those findings and allows a method of quantifying the decrement in performance in comparison to that which would be expected with hearing loss. In conclusion, while the question regarding disproportionate difficulty in recognition of accented English compared to Standard American English has not been accurately tested in any of the research that evaluates recognition of accented English, the question regarding recognition of accented speech with advancing age has been answered. Older adults have more difficulty understanding accented speech than do younger adults. Their ability to recognize meaningful sentences spoken with accented speech is seriously impaired.

This finding has serious implications when one considers that according to Lentini (2000), the majority of healthcare workers in this country are nonnative English speakers. Thus, it can be assumed that some, if not many of the staff in nursing homes are people who speak English with an accent different from that of many of their clients. In an era in which the number of elderly people in the population is increasing, and society is placing increased value on the aged, we may want to consider the effect nonnative English speech has on elderly individuals who make up much of the nursing home population. Healthcare facilities are provided with an opportunity to better facilitate communication between residents and nonnative-English-speaking staff by the inclusion of accent reduction as part of the training for healthcare workers who speak English with

an accent. In addition, training nonnative speakers to provide alternative forms of information, thus increasing the redundancy of the message, is likely to benefit the listeners' understanding of the message.

Moreover, in many cities in the United States today, there are people from other countries speaking English to communicate with native English speakers. Thus, accented English is spoken widely in restaurants, shopping malls, airports, and a variety of communities. Findings from this study indicate that the ability to recognize accented English speech, by all individuals (not only the elderly), is reduced compared to the ability to recognize Standard American English speech. Given this, all individuals may be at some disadvantage for understanding accented speech. Certainly, the redundancy of the message and contextual referents in every day communication may offset this difficulty. Strategies including repetition and paraphrasing may enhance the redundancy of everyday simple communication and thus offset the difficulty native English speakers have with recognition of accented English speech.

Limitations of this Study/Future Research

Although we attempted to address methodological problems noted in the previous research involving recognition of accented English, there are methodological problems with this research. One methodological problem or limitation to this research is the number of accented English speakers. We used more than one talker for each type of accented English with the intention of getting a better representation of accented English. More accented English speakers, representing several different accents would provide for findings that can better discern whether difficulty with accented English is a general

phenomenon or accent specific. We attempted to address this by including the four accented English speakers, however several more speakers are needed to fully address this question. It was our hypothesis that difficulty with accented English is a general phenomenon and not accent-specific, although the findings from this research do not support this. The participants' performance from this research suggested that the Portuguese-accented English was more difficult to understand than the Chinese-accented English. These differences among talkers may be due to talker-specific variables we did not consider when choosing our speakers. Consideration of these variables, along with including more talkers, would have been beneficial.

For example, post-hoc analyses of the speakers' rate of speech revealed some interesting findings that may relate to differences among participants' performance for different talkers. Rate of speech for accented English sentences was compared to rate of speech for Standard American English sentences. Some of the accented English sentences were rapid, and some were slow, when compared to the Standard American English sentences. We know that rate of speech affects speech-recognition ability (Cohen, 1979; Small et al., 1997) and so speech rate may have had a negative effect on participants' ability to recognize accented English. Certainly, speech rate should be controlled in future studies.

In addition to rate of speech, other variables related to the talkers may have had an effect on participants' performance. Speakers' proficiency in English was not measured. An assessment of English proficiency may rule out some articulatory substitutions that were possibly more related to English proficiency than accent. A phonemic error analysis of the speech produced by each speaker would provide us with useful information.

Moreover, Van Wijngaarden et al. (2002) describe the importance of quantifying the intelligibility of speech in noise for nonnative talkers. Although we did employ criteria for accentedness ratings in this study (see Appendix A), a more thorough assessment of degree of accent of our speakers may have indicated speakers were not balanced for degree of accentedness. Furthermore, had the speakers had stronger accents, one might find different results (personal communication with Martin Gitterman, 2003). In addition, more attention to the intelligibility of the accented English speakers and talker-specific variables such as L2 acquisition is thought to provide a more accurate representation of participants' ability to recognize accented English (cf. Mayo et al., 1997).

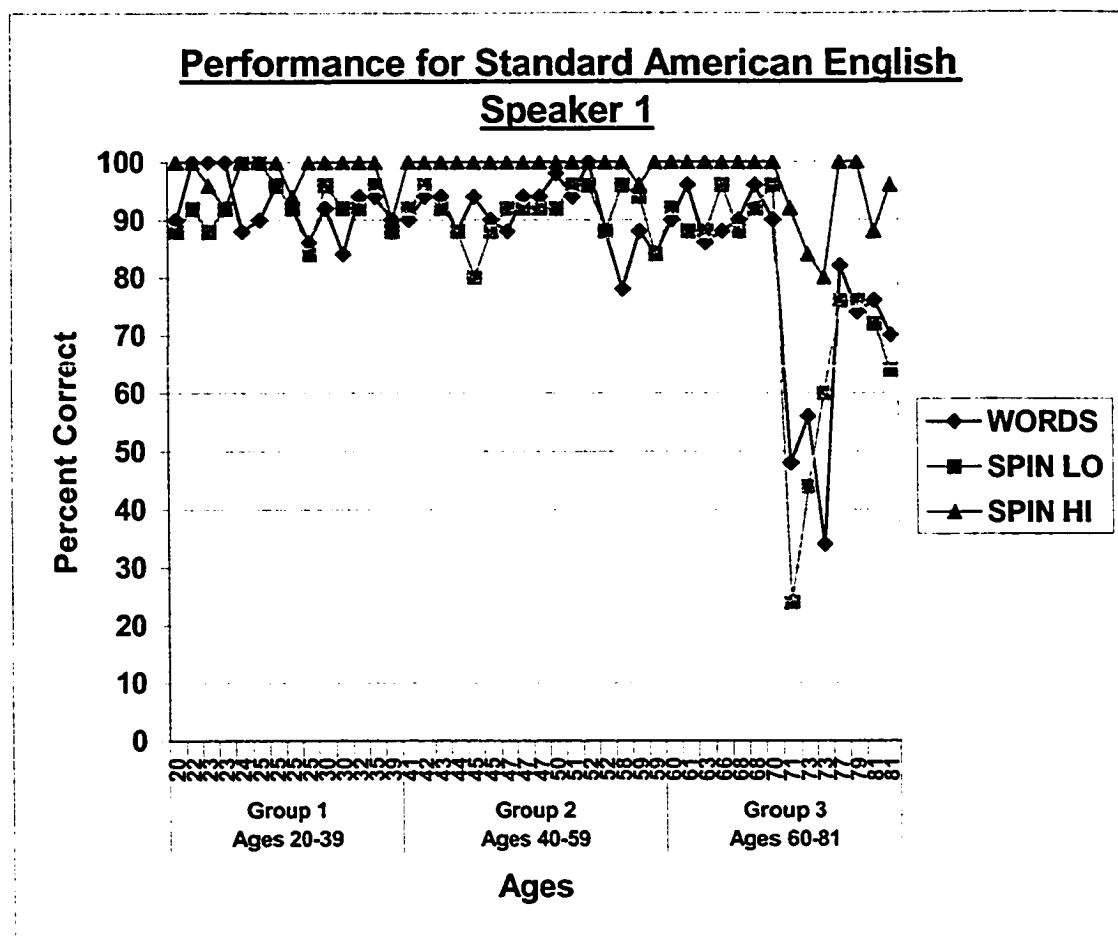
An additional limitation to this study relates to the variability of hearing among participants. Difficulty recruiting young-adult participants with hearing configurations similar to those of the older adults is understandable. However, future studies could include young-adult participants with simulated hearing loss to better attempt to determine the degree to which hearing contributes to difficulty in recognizing accented English.

In addition, to address the problematic effect of ceiling and floor performance, future research could vary the signal-to-noise ratio such that these effects are ruled out (personal communication with Arlene Neuman, 2003).

Although this study importantly supports the finding of an accented English effect for the elderly as reported by Burda, all of the original questions posed were not answered. Future research in the area of accented speech, taking the above-stated limitations into account, will better answer the original questions. It is expected that the

continued exploration of recognition of accented speech will provide stimulating opportunities for future research.

Figure 1

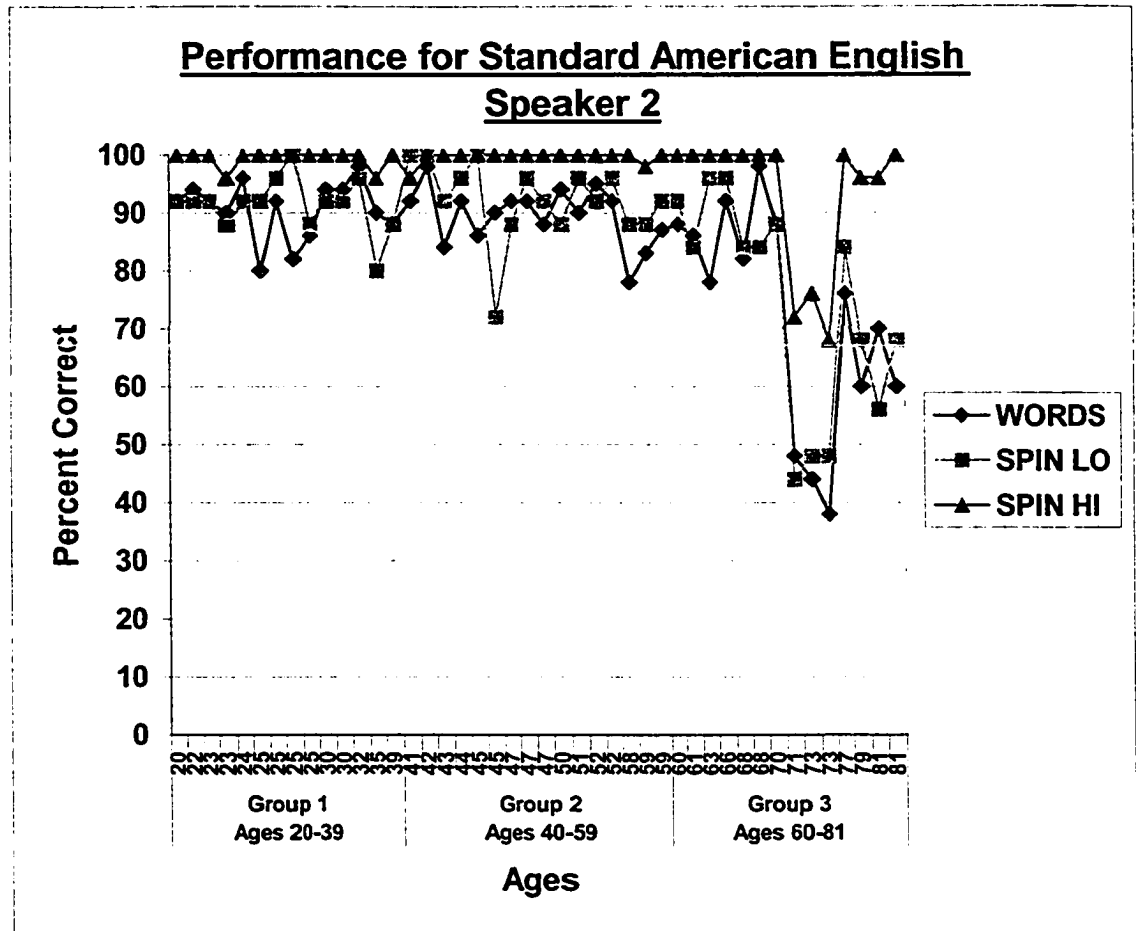


WORDS=speech-recognition performance for words

SPIN LO=speech-recognition performance for final words in low-predictability sentences

SPIN HI= speech-recognition performance for final words in high-predictability sentences

Figure 2

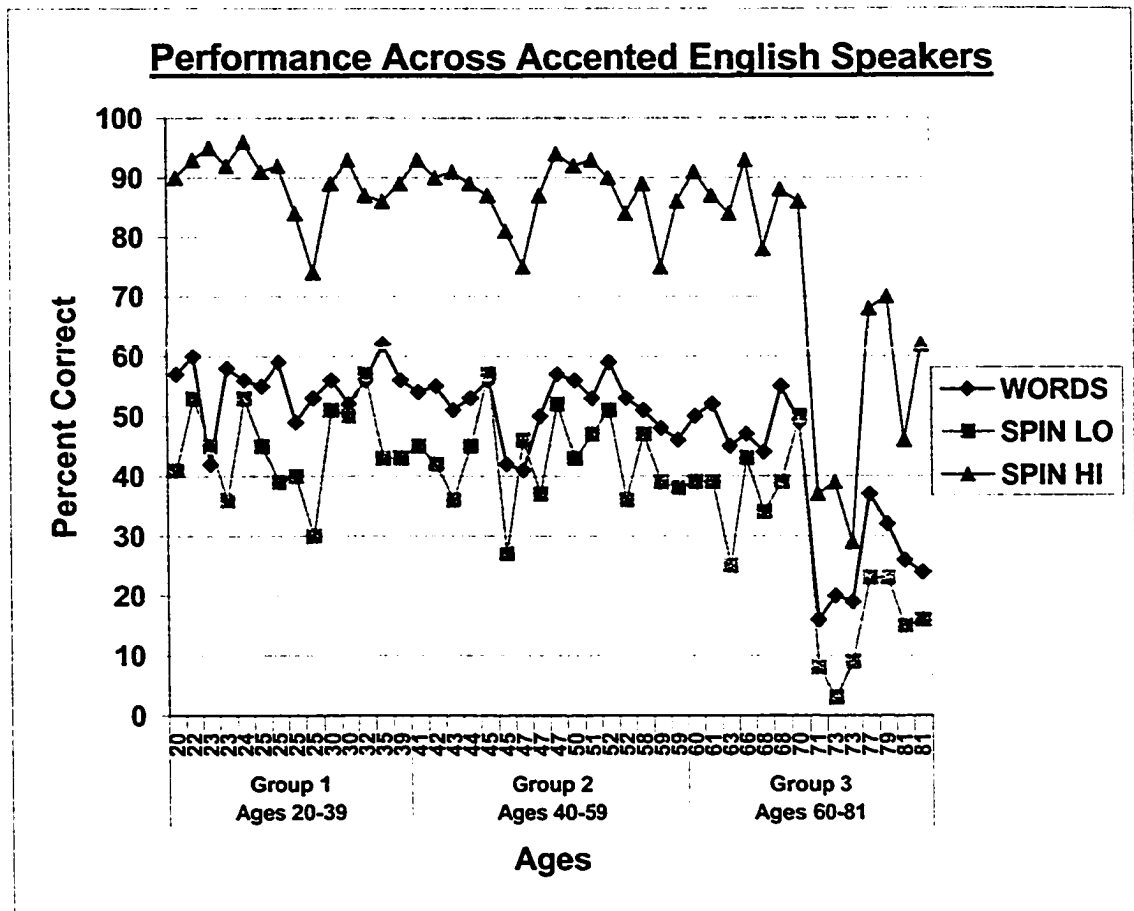


WORDS=speech-recognition performance for words

SPIN LO=speech-recognition performance for final words in low-predictability sentences

SPIN HI= speech-recognition performance for final words in high-predictability sentences

Figure 7

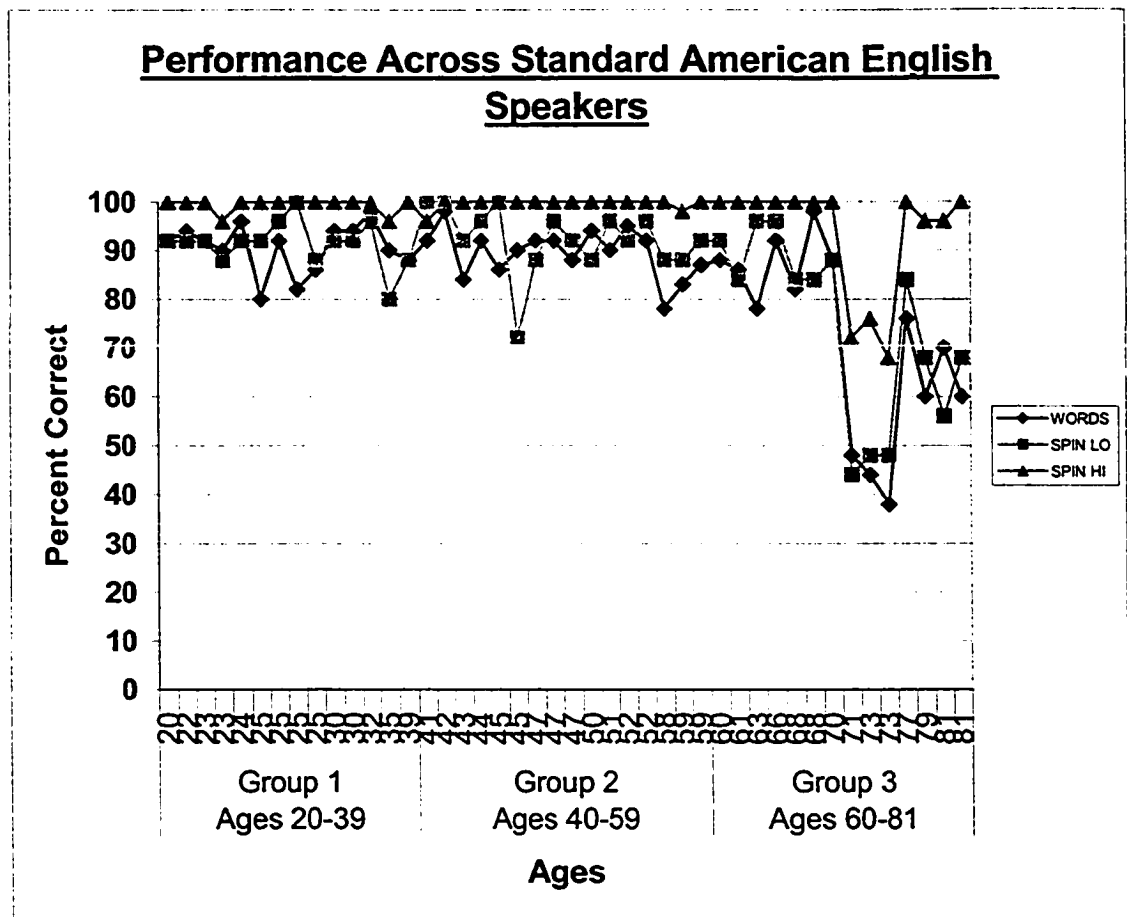


WORDS=speech-recognition performance for words

SPIN LO=speech-recognition performance for final words in low-predictability sentences

SPIN HI= speech-recognition performance for final words in high-predictability sentences

Figure 8

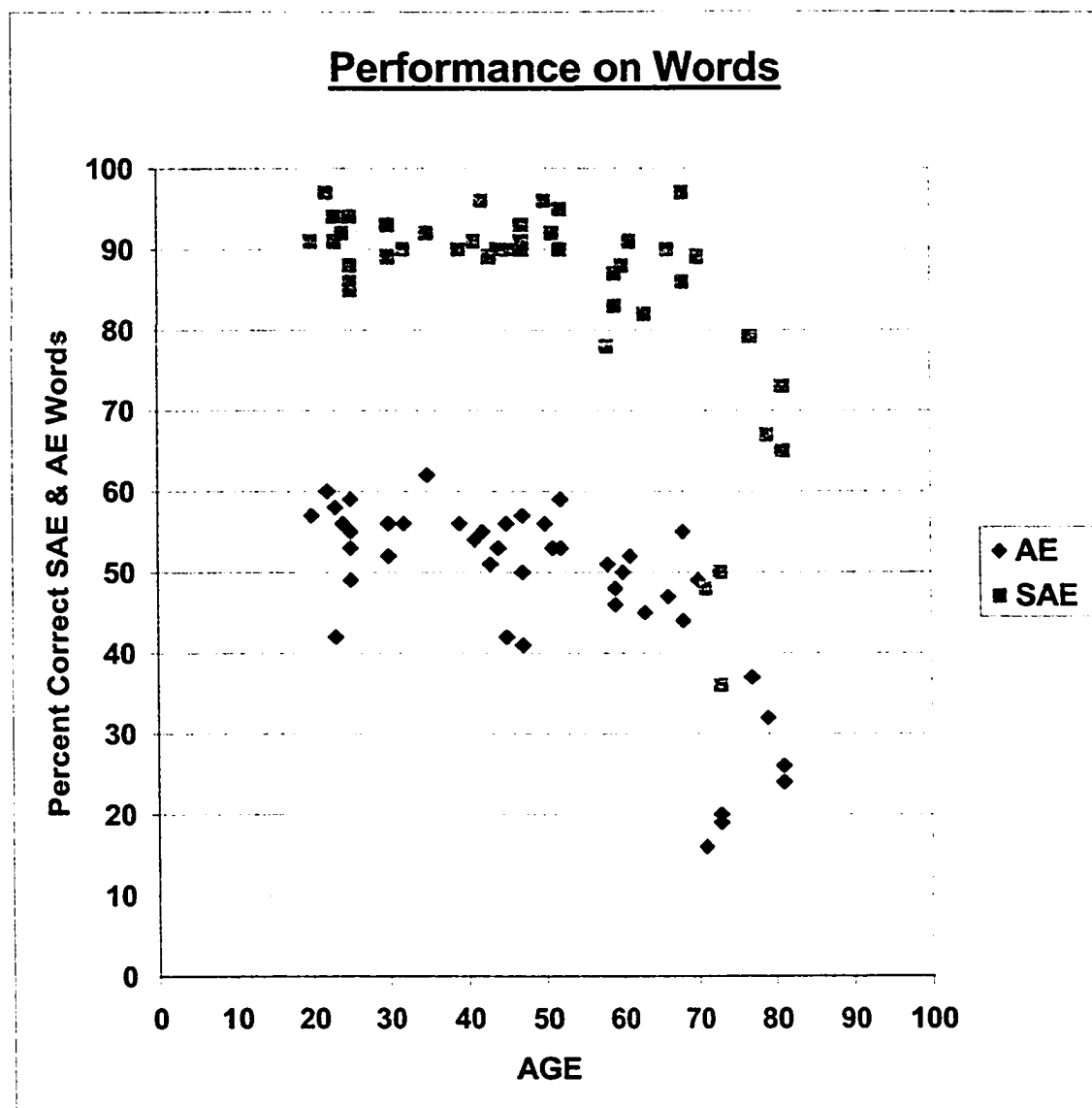


WORDS=speech-recognition performance for words

SPIN LO=speech-recognition performance for final words in low-predictability sentences

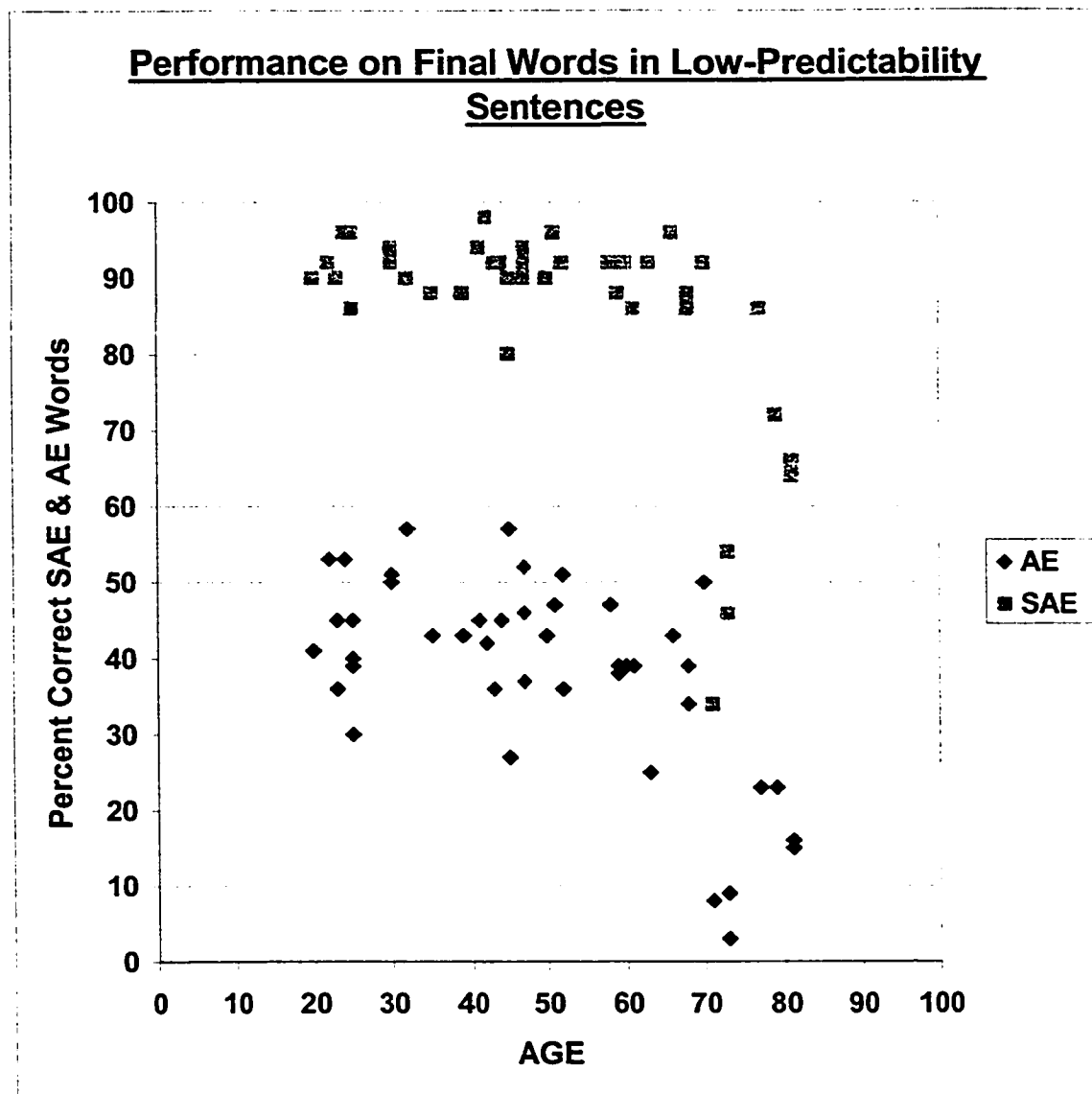
SPIN HI= speech-recognition performance for final words in high-predictability sentences

Figure 9



AE=speech-recognition performance on accented English single words
SAE=speech-recognition performance on Standard American English single words

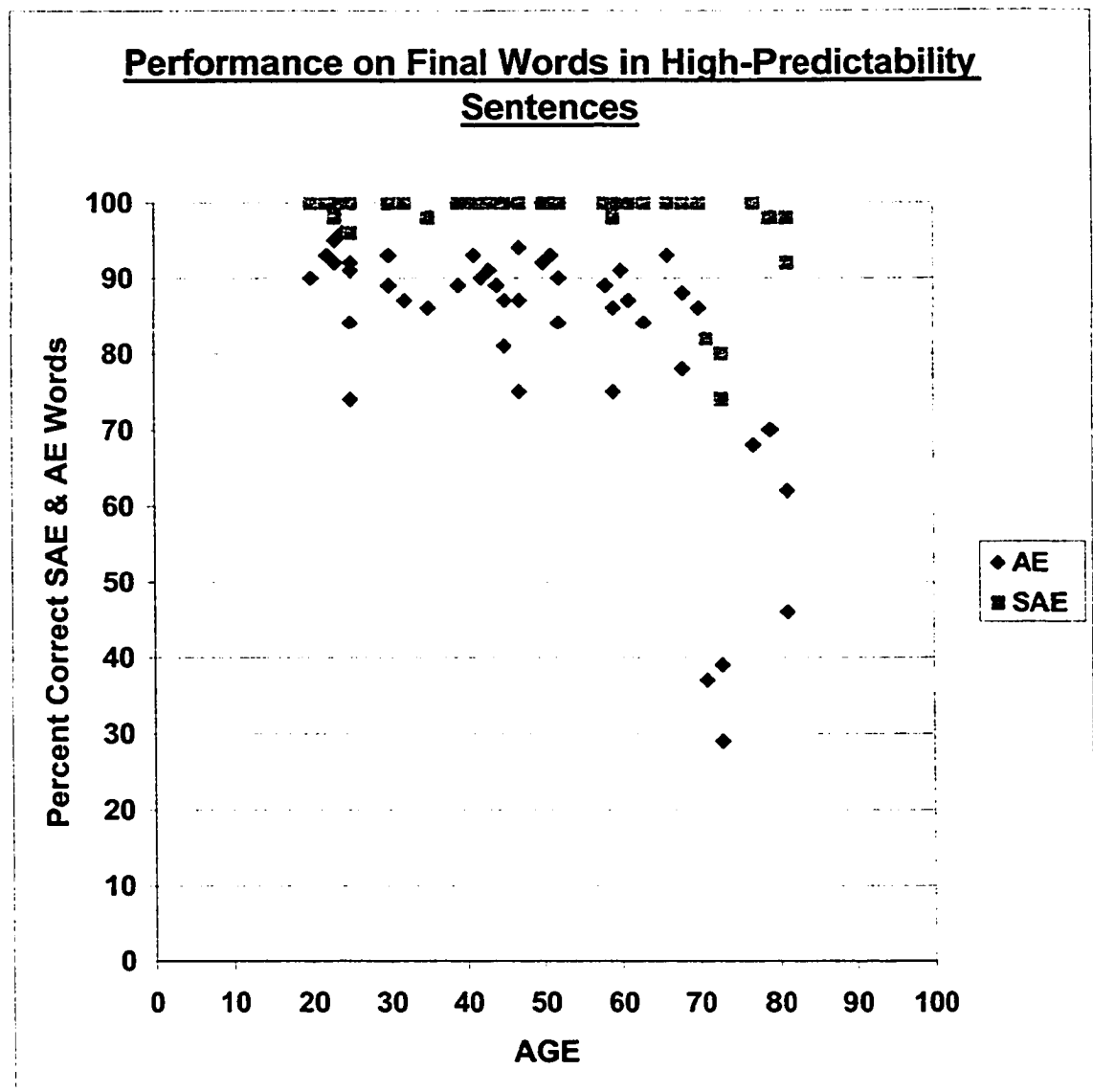
Figure 10



AE=speech-recognition performance on accented English final words in low-predictability sentences

SAE=speech-recognition performance on Standard American English final words in low-predictability sentences

Figure 11



AE=speech-recognition performance on accented English final words in high-predictability sentences
SAE=speech-recognition performance on Standard American English final words in high-predictability sentences

Figure 12

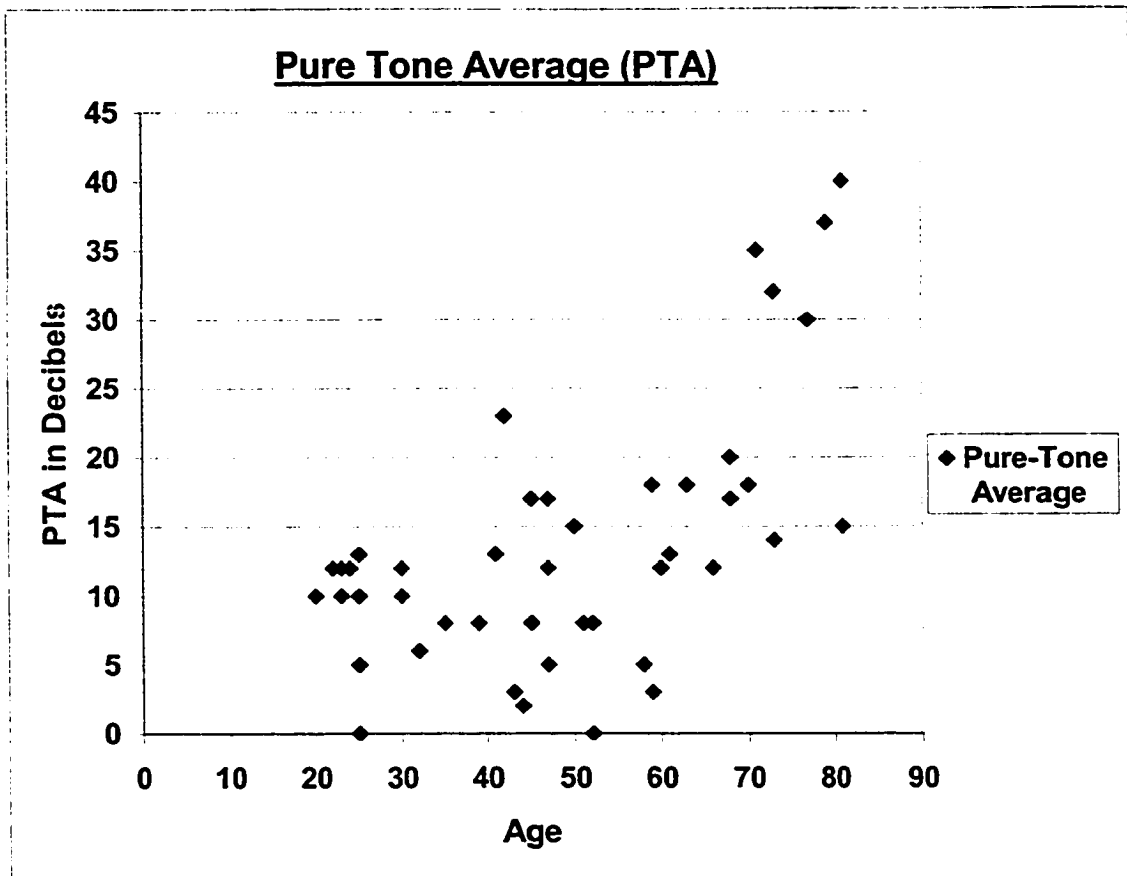


Figure 13

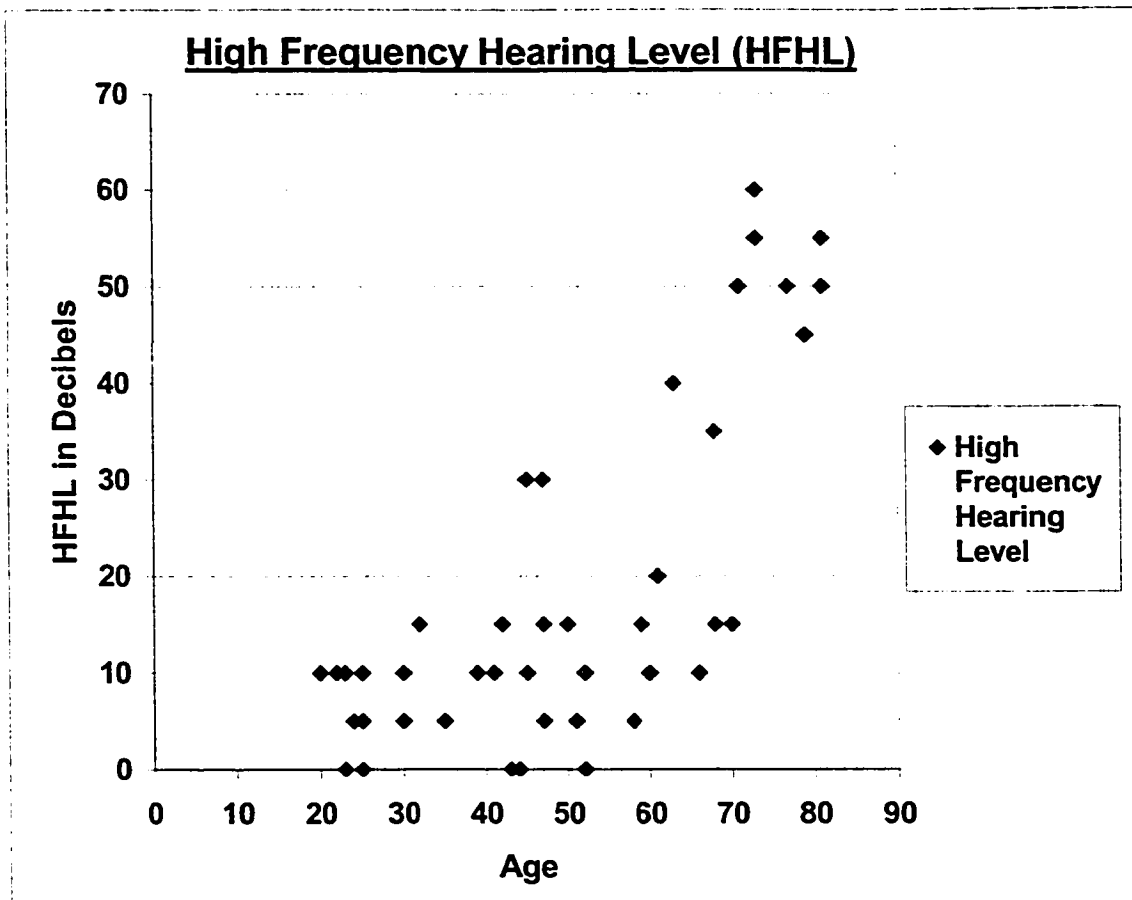


Figure 14

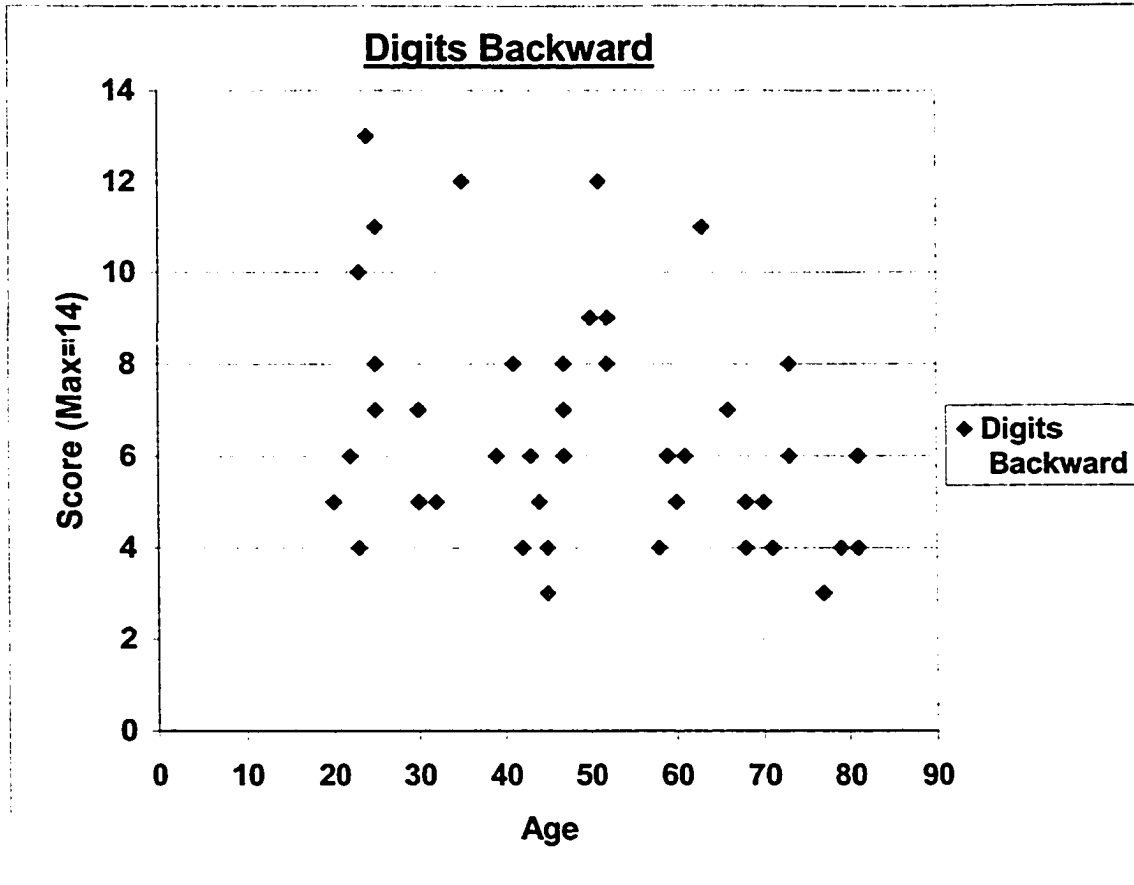


Figure 15

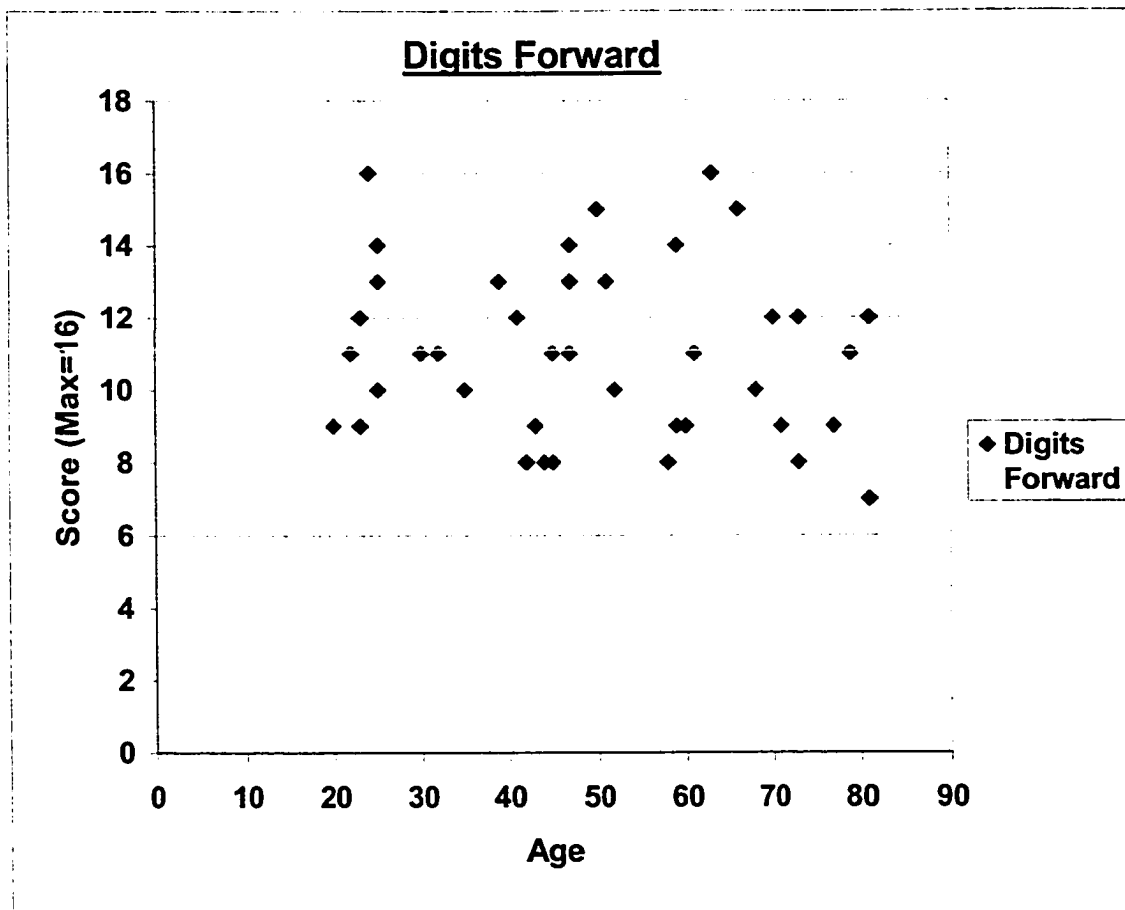
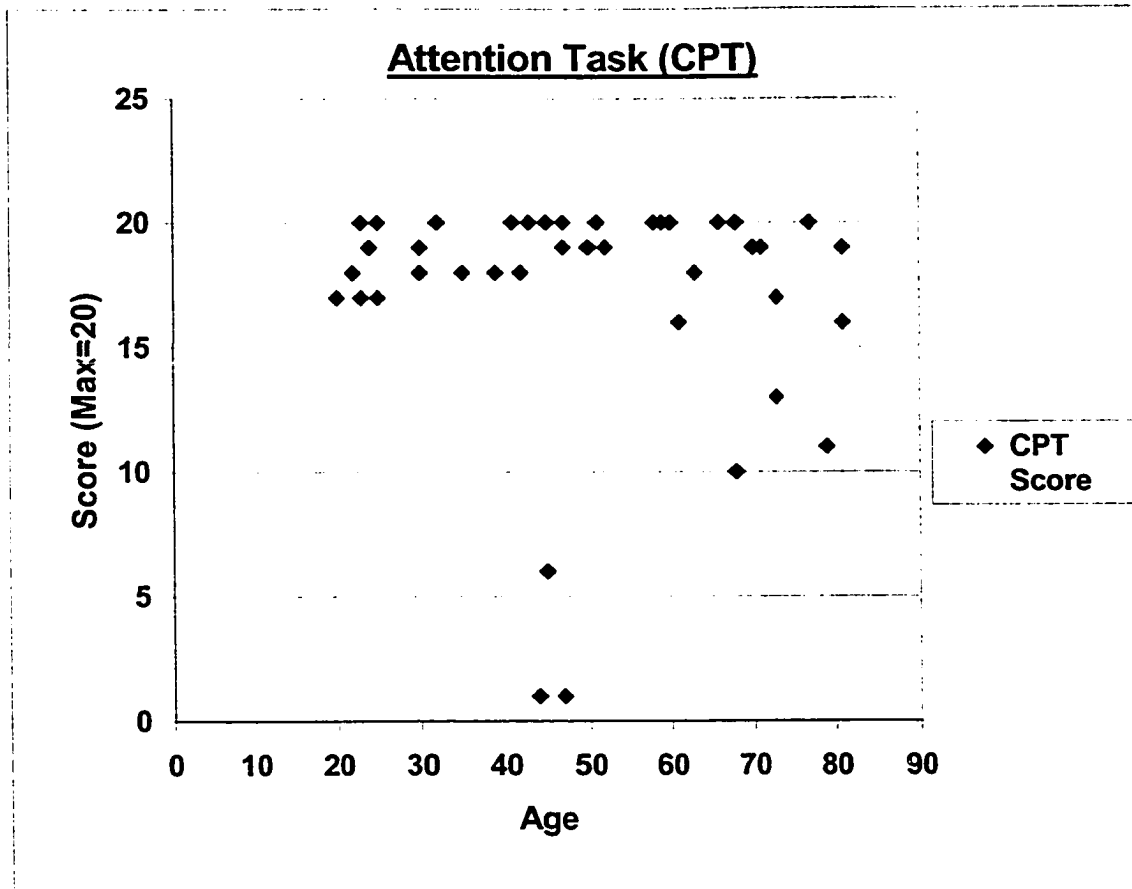
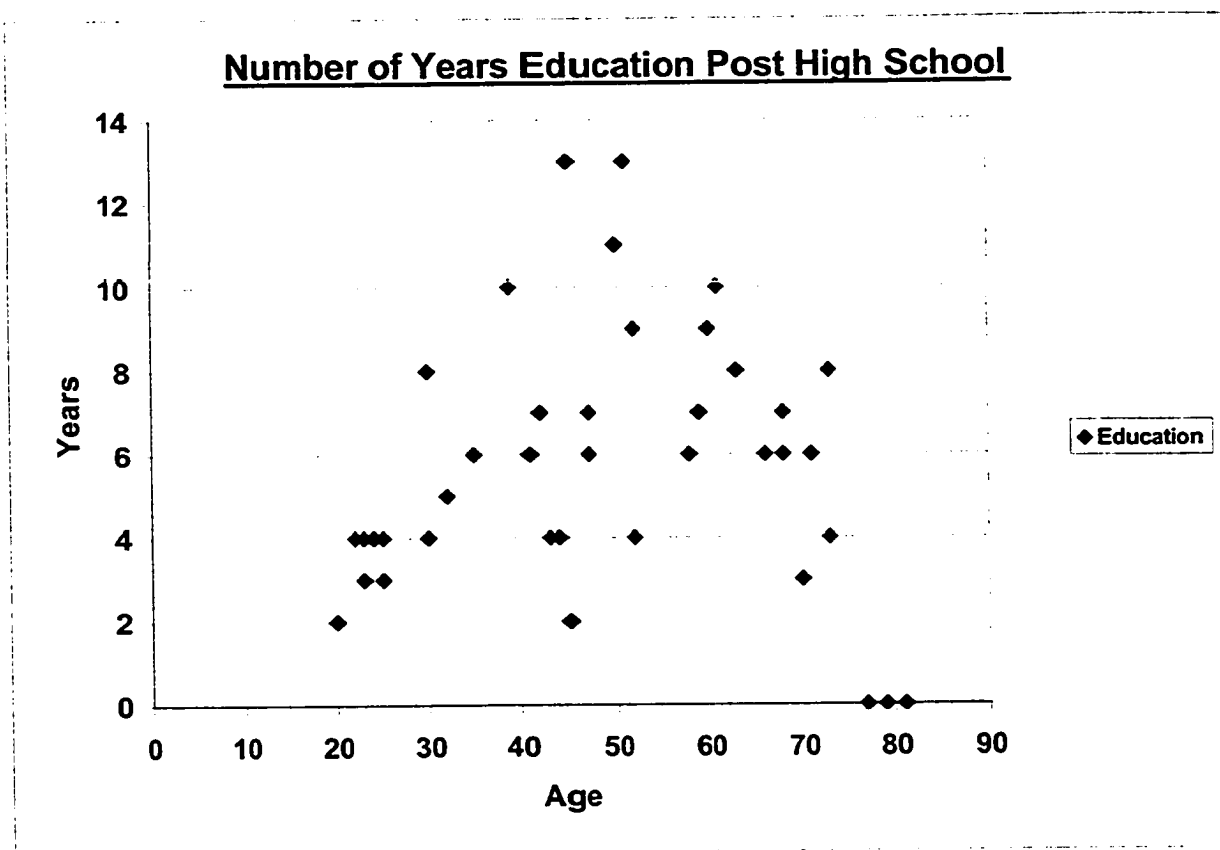


Figure 16



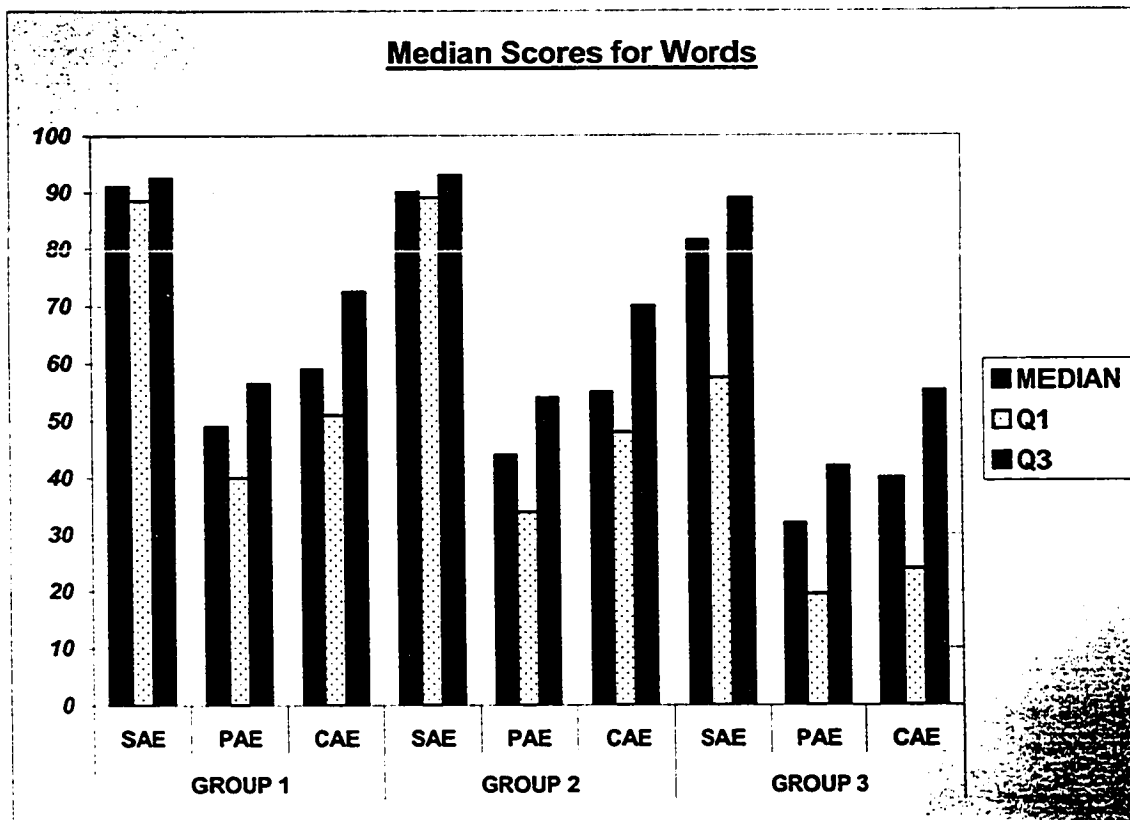
CPT=Continuous Performance Task

Figure 17



Number of Years Education Post High School – this includes participants' report of number of years undergraduate education as well as graduate education (if applicable) after graduating high school

Figure 18



Median=the middle of the distribution

Q1=first quartile, the lower bound of the interquartile range

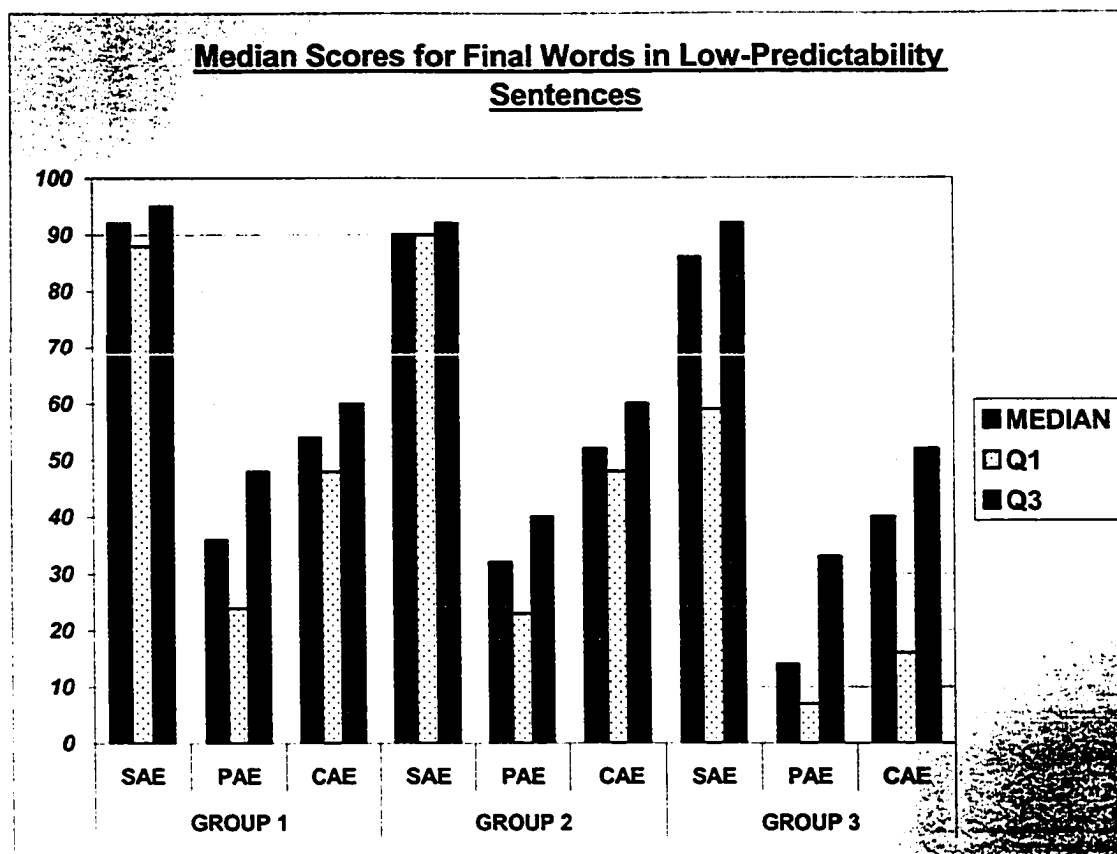
Q3=third quartile, the upper bound of the interquartile range

SAE=Standard American English

PAE=Portuguese-Accented English

CAE=Chinese-Accented English

Figure 19



Median=the middle of the distribution

Q1=first quartile, the lower bound of the interquartile range

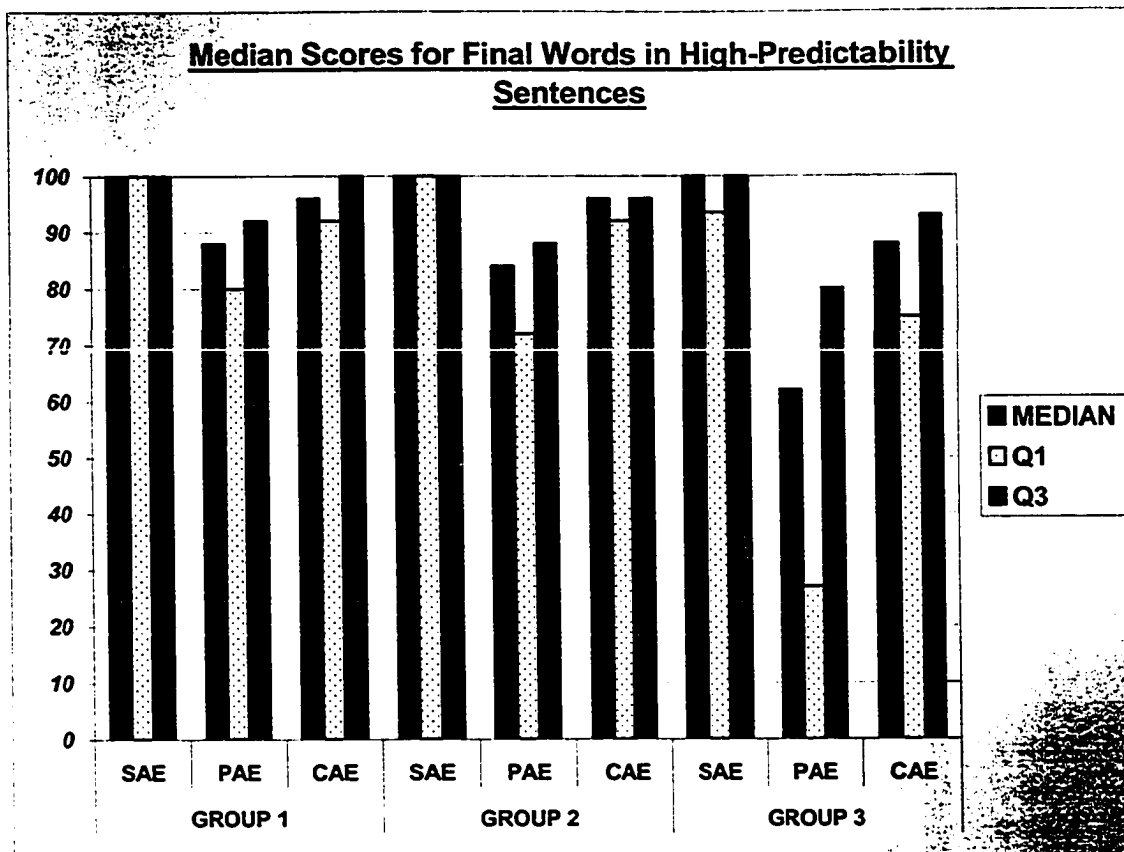
Q3=third quartile, the upper bound of the interquartile range

SAE=Standard American English

PAE=Portuguese-Accented English

CAE=Chinese-Accented English

Figure 20



Median=the middle of the distribution

Q1=first quartile, the lower bound of the interquartile range

Q3=third quartile, the upper bound of the interquartile range

SAE=Standard American English

PAE=Portuguese-Accented English

CAE=Chinese-Accented English

Figure 21

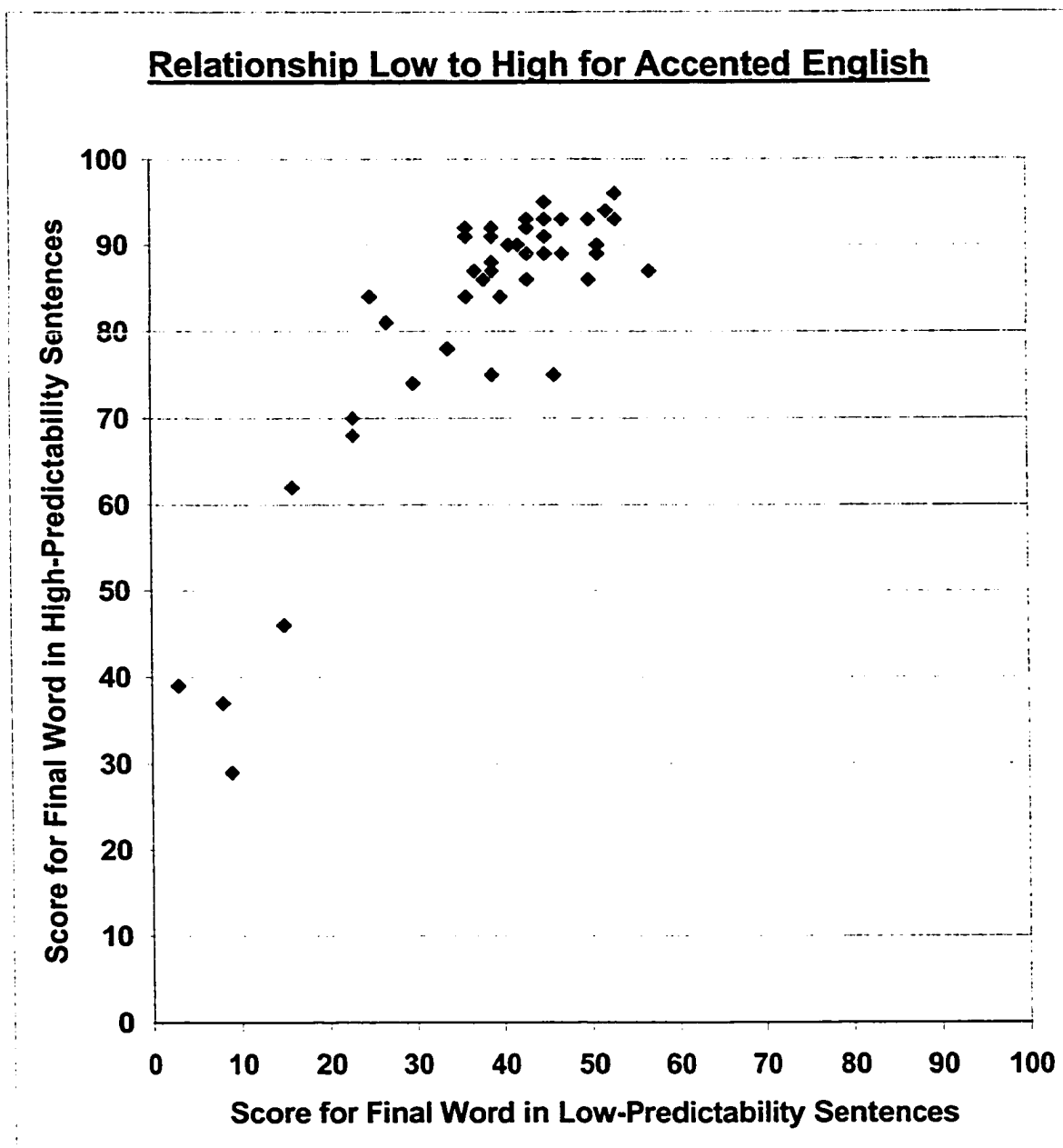


Figure 22

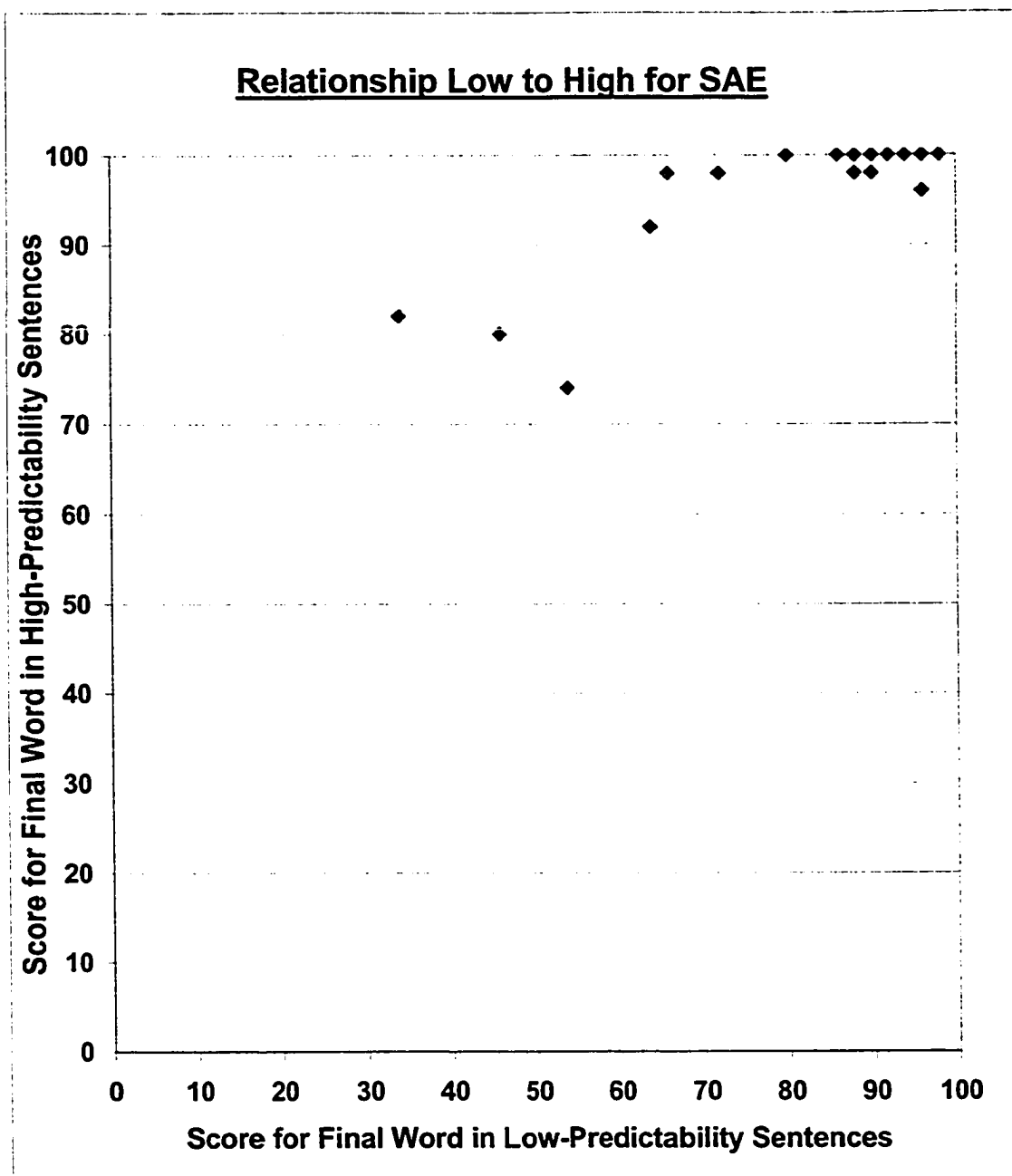
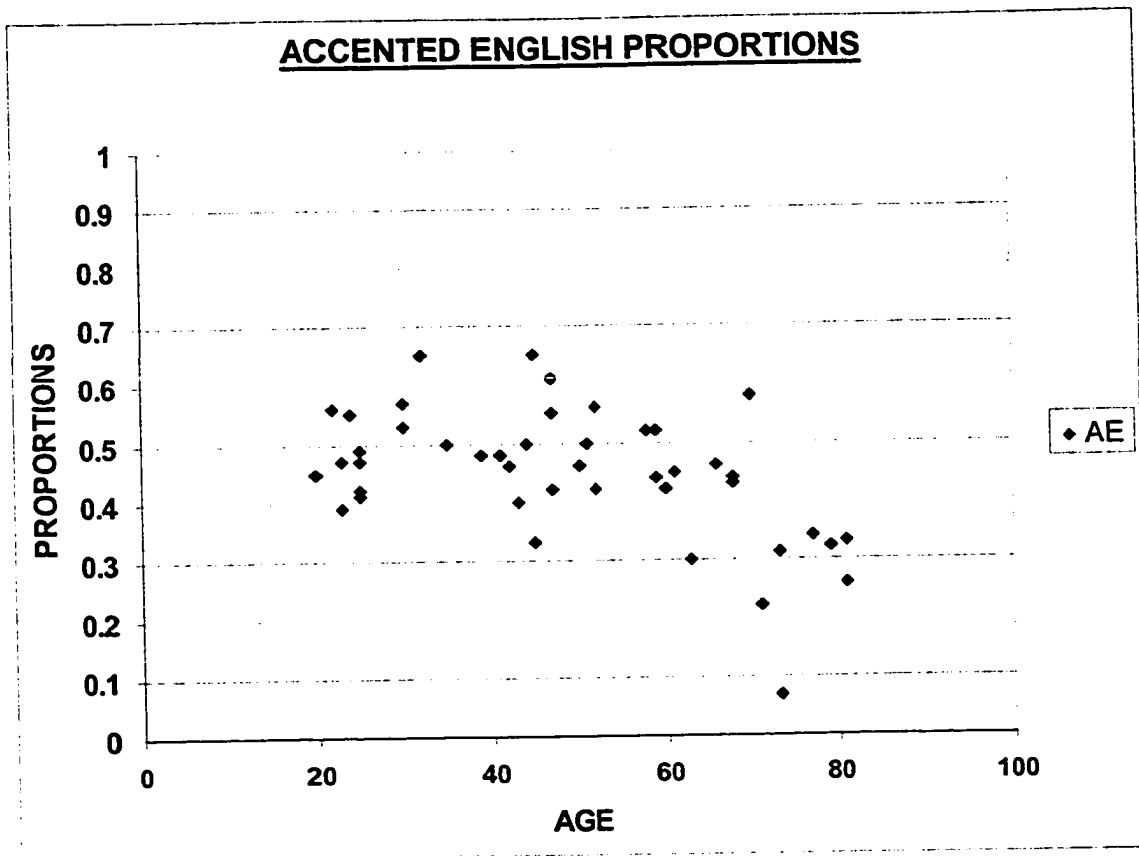
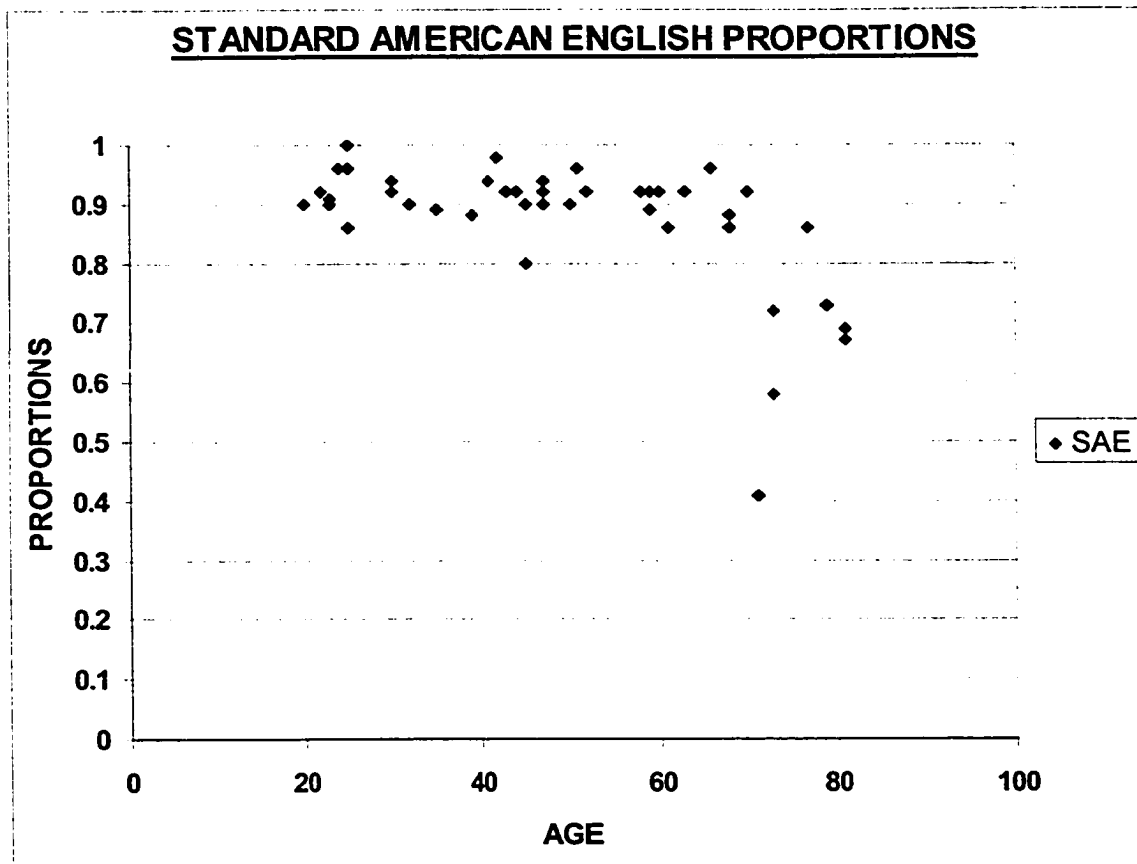


Figure 23



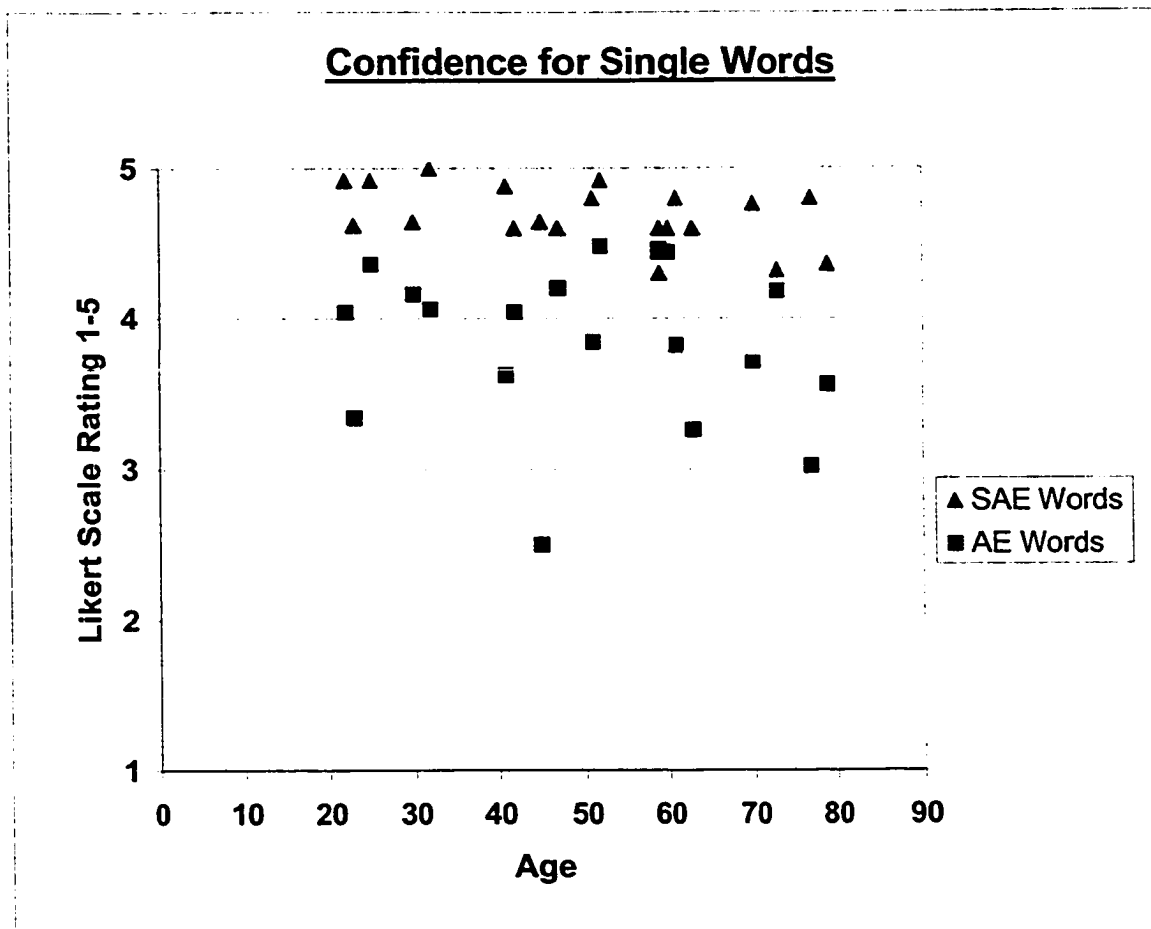
ACCENTED ENGLISH PROPORTIONS = proportions of percent correct for final words of low-predictability sentences relative to percent correct for final words in high-predictability sentences in accented English

Figure 24



STANDARD AMERICAN ENGLISH PROPORTIONS = proportions of percent correct for final words of low-predictability sentences relative to percent correct for final words in high-predictability sentences in Standard American English

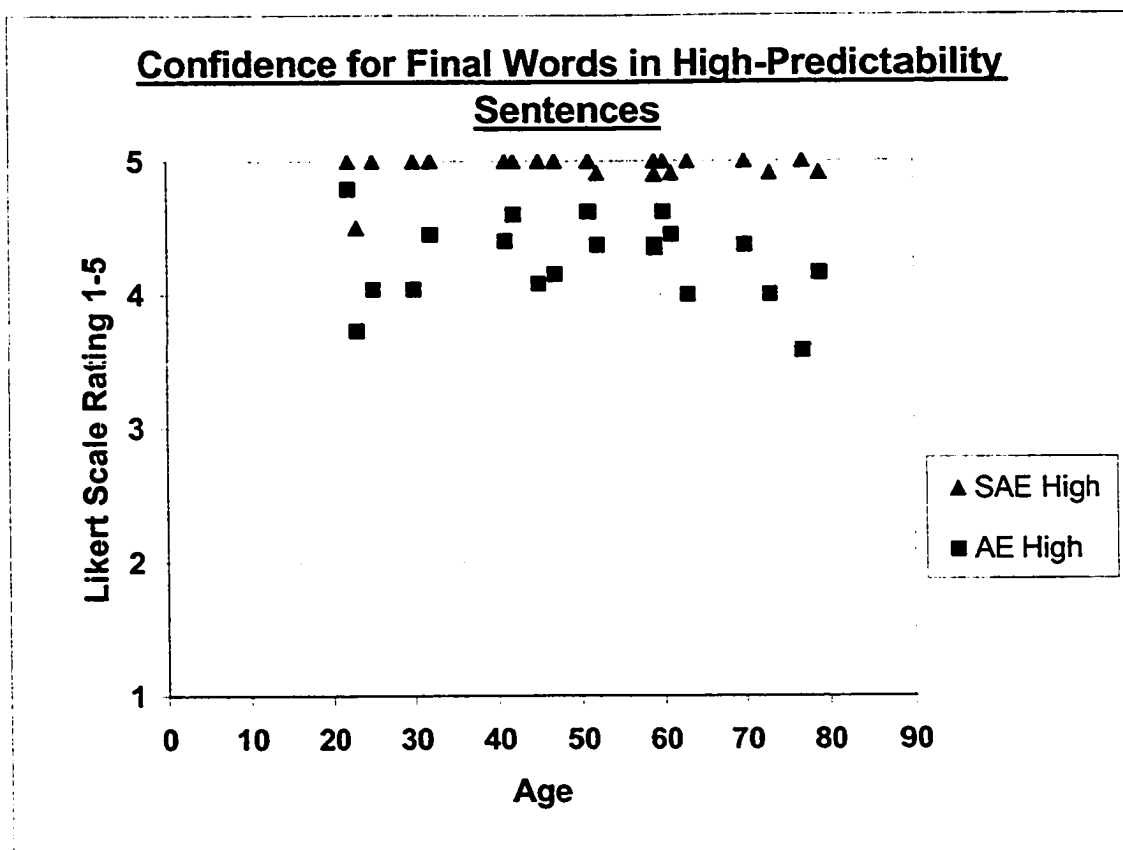
Figure 25



SAE Words = confidence ratings for words spoken in Standard American English

AE Words = confidence ratings for words spoken in Accented English

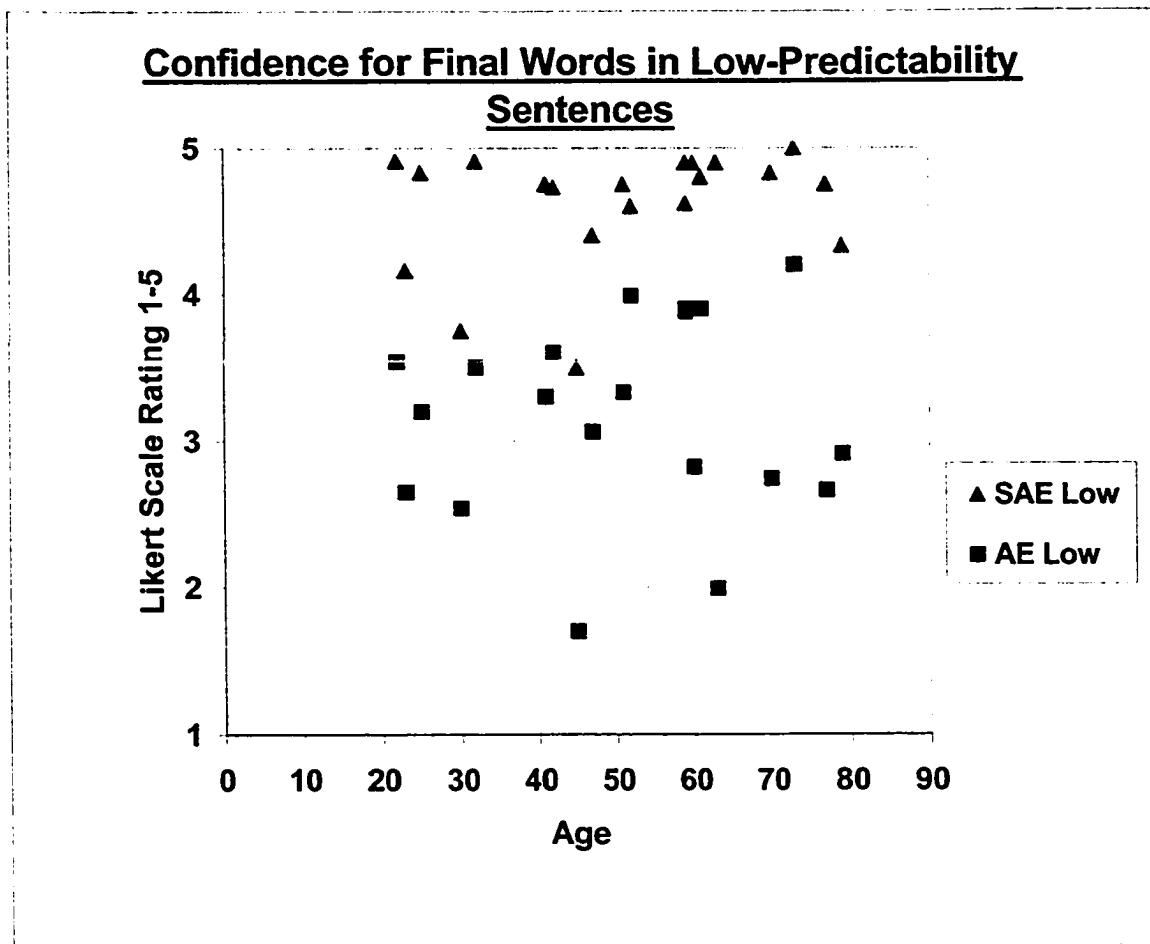
Figure 26



SAE High = confidence ratings for final words in high-predictability sentences spoken in Standard American English

AE High = confidence ratings for final words in high-predictability sentences spoken in Accented English

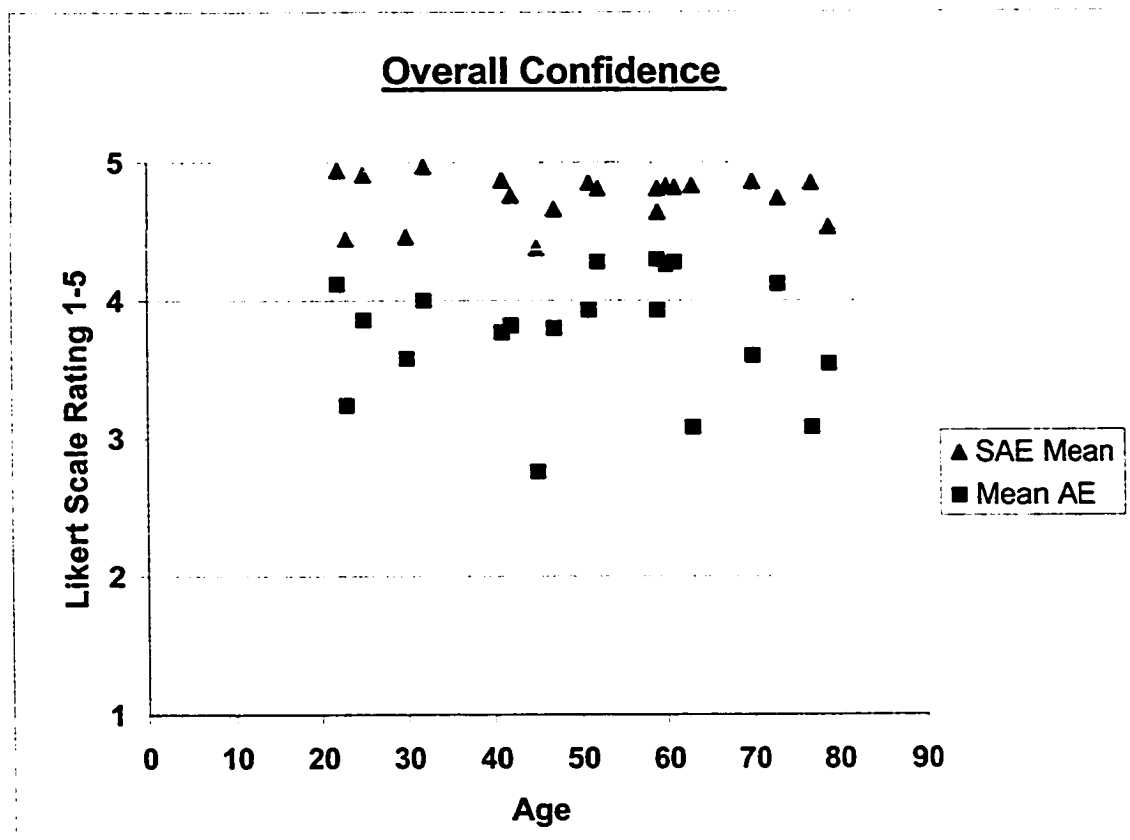
Figure 27



SAE Low = confidence ratings for final words in low-predictability sentences spoken in Standard American English

AE Low = confidence ratings for final words in low-predictability sentences spoken in Accented English

Figure 28



SAE Mean = average of confidence ratings for words, final words in high-predictability sentences, and final words in low-predictability sentences spoken in Standard American English

AE Mean = average of confidence ratings for words, final words in high-predictability sentences, and final words in low-predictability sentences spoken in Accented English

Table 1: Percent Correct for Portuguese-Accented English Speaker 1

Age	Word Score	High Predictability Sentence Score	Low Predictability Sentence Score	Participant Number
20	42	88	32	32
22	40	92	44	48
23	40	96	28	33
23	42	88	12	40
24	48	92	52	34
25	46	80	16	16
25	44	84	24	29
25	36	76	36	38
25	36	64	20	12
30	38	68	40	50
30	30	84	32	35
32	46	86	12	44
35	50	76	20	53
39	40	88	24	54
41	40	92	40	46
42	42	84	32	30
43	30	84	4	21
44	38	88	24	20
45	44	80	60	43
45	26	72	8	14
47	30	44	16	18
47	34	76	20	24
47	44	96	32	45
50	38	84	40	52
51	34	88	20	37
52	46	76	28	47
52	30	88	24	25
58	34	76	32	23
59	34	60	28	26
59	32	84	20	27
60	16	92	12	31
61	36	76	12	28
63	38	72	8	36
66	32	88	20	11
68	30	56	16	22
68	38	80	16	51

Table 1: Percent Correct for Portuguese-Accented English Speaker 1, continued

Age	Word Score	High Predictability Sentence Score	Low Predictability Sentence Score	Participant Number
70	32	80	60	42
71	2	00	0	10
73	10	28	0	19
73	16	20	0	39
77	24	44	8	41
79	20	60	8	49
81	18	24	0	15
81	18	28	4	17

Table 2: Descriptive Statistics for Portuguese-Accented English Speaker 1

Group	List	Median	Q1	Q3	IQR	N
1	Word	40	37	45	8	14
2	Word	34	32	43	11	16
3	Word	22	16	32	16	14
<hr/>						
1	High	85	76	90	14	14
2	High	84	76	88	12	16
3	High	58	26	80	54	14
<hr/>						
1	Low	26	18	38	20	14
2	Low	26	20	32	12	16
3	Low	8	0	16	16	14

Word=word list

High=high-predictability-sentence list

Low=low-predictability-sentence list

Median=the middle of the distribution

Q1=first quartile, the lower bound of the interquartile range

Q3=third quartile, the upper bound of the interquartile range

IQR=the range of scores within which resides the middle 50% of scores

Table 3: Percent Correct for Portuguese-Accented English Speaker 2

Age	Word Score	High Predictability Sentence Score	Low Predictability Sentence Score	Participant Number
20	60	72	28	32
22	64	92	64	48
23	54	96	36	33
23	62	92	24	40
24	56	92	48	34
25	52	96	48	16
25	60	96	48	29
25	48	80	40	38
25	60	68	28	12
30	50	92	48	50
30	56	92	48	35
32	50	92	44	44
35	66	80	48	53
39	58	84	48	54
41	54	88	32	46
42	58	84	40	30
43	60	84	36	21
44	56	80	40	20
45	62	86	72	43
45	44	68	16	14
47	40	68	48	18
47	52	88	28	24
47	54	88	56	45
50	62	88	20	52
51	54	92	44	37
52	52	92	56	47
52	56	72	36	25
58	58	88	40	23
59	52	60	24	26
59	34	72	40	27
60	48	88	40	31
61	48	84	40	28
63	42	76	20	36
66	48	92	40	11
68	48	68	44	22
68	52	84	32	51

Table 3: Percent Correct for Portuguese-Accented English Speaker 2, continued

Age	Word Score	High Predictability Sentence Score	Low Predictability Sentence Score	Participant Number
70	58	76	36	42
71	18	8	0	10
73	24	16	0	19
73	24	12	12	39
77	40	60	24	41
79	42	44	16	49
81	28	20	8	15
81	34	64	48	17

Table 4: Descriptive Statistics for Portuguese-Accented English Speaker 2

Group	List	Median	Q1	Q3	IQR	N
1	Word	57	51	61	10	14
2	Word	54	52	58	6	16
3	Word	48	18	56	38	14
1	High	92	80	94	14	14
2	High	85	72	88	18	16
3	High	66	18	84	66	14
1	Low	48	32	48	16	14
2	Low	40	28	48	20	16
3	Low	28	10	40	30	14

Word=word list

High=high-predictability-sentence list

Low=low-predictability-sentence list

Median=the middle of the distribution

Q1=first quartile, the lower bound of the interquartile range

Q3=third quartile, the upper bound of the interquartile range

IQR=the range of scores within which resides the middle 50% of scores

Table 5: Percent Correct for Chinese-Accented English Speaker 1

Age	Word Score	High Predictability Sentence Score	Low Predictability Sentence Score	Participant Number
20	78	100	44	32
22	76	96	64	48
23	76	100	60	33
23	72	96	52	40
24	76	100	60	34
25	74	92	56	16
25	76	96	48	29
25	56	96	52	38
25	66	84	36	12
30	78	100	60	50
30	74	100	60	35
32	72	100	52	44
35	78	92	48	53
39	66	92	44	54
41	76	96	48	46
42	74	96	48	30
43	66	96	56	21
44	68	100	64	20
45	70	96	52	43
45	50	96	40	14
47	52	100	64	18
47	72	100	52	24
47	70	96	60	45
50	70	100	52	52
51	68	96	60	37
52	80	96	64	47
52	74	84	44	25
58	64	96	56	23
59	60	88	52	26
59	70	100	40	27
60	80	92	44	31
61	76	100	52	28
63	56	96	40	36
66	68	96	56	11
68	58	96	32	22
68	74	100	64	51

Table 5: Percent Correct for Chinese-Accented English Speaker 1, continued

Age	Word Score	High Predictability Sentence Score	Low Predictability Sentence Score	Participant Number
70	64	96	52	42
71	24	62	16	10
73	22	52	04	19
73	22	48	16	39
77	52	88	48	41
79	44	88	28	49
81	32	64	12	15
81	20	72	04	17

Table 6: Descriptive Statistics for Chinese-Accented English Speaker 1

Group	List	Median	Q1	Q3	IQR	N
1	Word	75	69	77	8	14
2	Word	70	64	74	10	16
3	Word	54	23	71	48	14
1	High	96	92	100	8	14
2	High	96	96	100	4	16
3	High	90	63	96	33	14
1	Low	52	46	60	14	14
2	Low	52	48	60	12	16
3	Low	36	14	52	38	14

Word=word list

High=high-predictability sentence list

Low=low-predictability sentence list

Median=the middle of the distribution

Q1=first quartile, the lower bound of the interquartile range

Q3=third quartile, the upper bound of the interquartile range

IQR=the range of scores within which resides the middle 50% of scores

Table 7: Percent Correct for Chinese-Accented English Speaker 2

Age	Word Score	High Predictability Sentence Score	Low Predictability Sentence Score	Participant Number
20	46	100	60	32
22	60	92	40	48
23	46	88	56	33
23	54	92	56	40
24	44	100	52	34
25	48	96	60	16
25	56	92	48	29
25	56	84	32	38
25	48	80	36	12
30	58	96	56	50
30	48	92	60	35
32	48	96	48	44
35	52	96	56	53
39	58	92	56	54
41	46	96	60	46
42	44	96	48	30
43	48	100	48	21
44	48	88	52	20
45	46	86	44	43
45	46	88	44	14
47	42	88	56	18
47	42	84	48	24
47	58	96	60	45
50	54	96	60	52
51	54	96	64	37
52	56	96	56	47
52	52	92	40	25
58	48	96	60	23
59	46	92	52	26
59	48	88	52	27
60	55	92	60	31
61	46	88	52	28
63	44	92	32	36
66	40	96	56	11
68	38	92	44	22
68	54	88	44	51

Table 7: Percent Correct for Chinese-Accented English Speaker 2, continued

Age	Word Score	High Predictability Sentence Score	Low Predictability Sentence Score	Participant Number
70	40	92	52	42
71	20	76	16	10
73	24	60	8	19
73	14	36	8	39
77	32	80	32	41
79	20	88	40	49
81	26	76	40	15
81	24	84	8	17

Table 8: Descriptive Statistics for Chinese-Accented English Speaker 2

Group	List	Median	Q1	Q3	IQR	N
1	Word	50	47	57	10	14
2	Word	48	46	54	8	16
3	Word	35	22	45	23	14
High						
1	High	92	90	96	6	14
2	High	94	88	96	8	16
3	High	88	76	92	16	14
Low						
1	Low	56	44	58	14	14
2	Low	52	48	60	12	16
3	Low	40	12	52	40	14

Word=word list

High=high-predictability sentence list

Low=low-predictability sentence list

Median=the middle of the distribution

Q1=first quartile, the lower bound of the interquartile range

Q3=third quartile, the upper bound of the interquartile range

IQR=the range of scores within which resides the middle 50% of scores

Table 9: Percent Correct for Standard American English (average of two speakers)

Age	Word Score	High Predictability Sentence Score	Low Predictability Sentence Score	Proportion Low / High	Participant Number
20	91	100	90	.90	32
22	97	100	92	.92	48
23	94	100	90	.90	33
23	91	98	90	.91	40
24	92	100	96	.96	34
25	85	100	96	.96	16
25	94	100	86	.86	29
25	88	96	96	1.0	38
25	86	100	86	.86	12
30	93	100	94	.94	50
30	89	100	92	.92	35
32	90	100	90	.90	44
35	92	98	88	.89	53
39	90	100	88	.88	54
41	91	100	94	.94	46
42	96	100	98	.98	30
43	89	100	92	.92	21
44	90	100	92	.92	20
45	90	100	90	.90	43
45	90	100	80	.80	14
47	90	100	90	.90	18
47	93	100	94	.94	24
47	91	100	92	.92	45
50	96	100	90	.90	52
51	92	100	96	.96	37
52	95	100	92	.92	47
52	90	100	92	.92	25
58	78	100	92	.92	23
59	83	98	88	.89	26
59	87	100	92	.92	27
60	88	100	92	.92	31
61	91	100	86	.86	28
63	82	100	92	.92	36
66	90	100	96	.96	11
68	86	100	86	.86	22
68	97	100	88	.88	51

Table 9: Percent Correct for Standard American English (average of two speakers)

Age	Word Score	High Predictability Sentence Score	Low Predictability Sentence Score	Proportion Low / High	Participant Number
70	89	100	92	.92	42
71	48	82	34	.41	10
73	50	80	46	.58	19
73	36	74	54	.72	39
77	79	100	86	.81	41
79	67	98	72	.73	49
81	73	92	64	.69	15
81	65	98	66	.67	17

Table 10: Percent Correct for Accented English (average of four speakers)

Age	Word Score	High Predictability Sentence Score	Low Predictability Sentence Score	Proportion Low / High	Participant Number
20	57	90	41	.45	32
22	60	93	53	.56	48
23	42	95	45	.47	33
23	58	92	36	.39	40
24	56	96	53	.55	34
25	55	91	45	.49	16
25	59	92	39	.42	29
25	49	84	40	.47	38
25	53	74	30	.41	12
30	56	89	51	.57	50
30	52	93	50	.53	35
32	56	87	57	.65	44
35	62	86	43	.50	53
39	56	89	43	.48	54
41	54	93	45	.48	46
42	55	90	42	.46	30
43	51	91	36	.40	21
44	53	89	45	.50	20
45	56	87	57	.65	43
45	42	81	27	.33	14
47	41	75	46	.61	18
47	50	87	37	.42	24
47	57	94	52	.55	45
50	56	92	43	.46	52
51	53	93	47	.50	37
52	59	90	51	.56	47
52	53	84	36	.42	25
58	51	89	47	.52	23
59	48	75	39	.52	26
59	46	86	38	.44	27
60	50	91	39	.42	31
61	52	87	39	.45	28
63	45	84	25	.30	36
66	47	93	43	.46	11
68	44	78	34	.43	22
68	55	88	39	.44	51

Table 10: Percent Correct for Accented English (average of four speakers)

Age	Word Score	High Predictability Sentence Score	Low Predictability Sentence Score	Proportion Low / High	Participant Number
70	49	86	50	.58	42
71	16	37	08	.22	10
73	20	39	03	.07	19
73	19	29	09	.31	39
77	37	68	23	.34	41
79	32	70	23	.32	49
81	26	46	15	.33	15
81	24	62	16	.26	17

Table 11: Median Test and Chi Square for Accented English Words

Median	52
Chi-Square	10.02**
df	2

**p≤.01

	Group 1	Group 2	Group 3
# cases > median	12	10	2
# cases < median	2	6	12

Pairwise Comparisons of Groups

	Group 1	Group 2	Group 3
Median	56	53	40.5
Q1	52.5	48	25
Q3	58.5	56	49.5

Median=the middle of the distribution

Q1=first quartile, the lower bound of the interquartile range

Q3=third quartile, the upper bound of the interquartile range

Table 12: Median Test and Chi-Square for AE High-Predictability Sentences

Median	87.5
Chi-Square	7.85*
df	2

** $p \leq .05$

	Group 1	Group 2	Group 3
# cases > median	10	8	3
# cases < median	4	6	11

Pairwise Comparisons of Groups

	Group 1	Group 2	Group 3
Median	90.5	89	74
Q1	86.5	81	42.5
Q3	93	92	87.5

Median=the middle of the distribution

Q1=first quartile, the lower bound of the interquartile range

Q3=third quartile, the upper bound of the interquartile range

Table 13: Median Test and Chi-Square for AE Low-Predictability Sentences

Median	39.5
Chi-Square	12.7**
df	2

** $p \leq .01$

	Group 1	Group 2	Group 3
# cases > median	11	10	2
# cases < median	3	6	12

Pairwise Comparisons of Groups

	Group 1	Group 2	Group 3
Median	44	44	22.5
Q1	39.5	37	12
Q3	52	47	34

Median=the middle of the distribution

Q1=first quartile, the lower bound of the interquartile range

Q3=third quartile, the upper bound of the interquartile range

Table 14: Median Test and Chi-Square for SAE Words

Median	90
Chi-Square	10.48**
df	2

**p \leq .01

	Group 1	Group 2	Group 3
# cases > median	9	11	2
# cases < median	6	5	12

Pairwise Comparisons of Groups

	Group 1	Group 2	Group 3
Median	91	90	81.5
Q1	88.5	89	57.5
Q3	92.5	93	89

Median=the middle of the distribution

Q1=first quartile, the lower bound of the interquartile range

Q3=third quartile, the upper bound of the interquartile range

Table 15: Median Test and Chi-Square for SAE Low-Predictability Sentences

Median	90
Chi-Square	7.22*
df	2

* $p \leq .05$

	Group 1	Group 2	Group 3
# cases > median	7	11	3
# cases < median	7	5	11

Pairwise Comparisons of Groups

	Group 1	Group 2	Group 3
Median	92	90	86
Q1	88	90	59
Q3	95	92	92

Median=the middle of the distribution

Q1=first quartile, the lower bound of the interquartile range

Q3=third quartile, the upper bound of the interquartile range

Table 16: Number Correct for Neuropsychological Tasks

Age	Digits Forward Score out of 16	Digits Backward Score out of 14	CPT Score out of 20	Participant Number
20	9	5	17	32
22	11	6	18	48
23	12	10	20	33
23	9	4	17	40
24	16	13	19	34
25	14	7	20	16
25	13	8	20	29
25	10	7	17	38
25	14	11	20	12
30	11	5	18	50
30	11	7	19	35
32	11	5	20	44
35	19	12	18	53
39	13	6	18	54
41	12	8	20	46
42	8	4	18	30
43	9	6	20	21
44	8	5	19	20
45	8	4	20	43
45	11	3	6	14
47	14	8	19	18
47	11	6	20	24
47	13	7	19	45
50	15	9	19	52
51	13	12	20	37
52	10	9	19	47
52	10	8	19	25
58	8	4	20	23
59	14	6	20	26
59	9	6	20	27
60	9	5	20	31
61	11	6	16	28
63	16	11	18	36
66	15	7	20	11
68	10	4	20	22
68	10	5	10	51

Age	Digits Forward Score out of 16	Digits Backward Score out of 14	CPT Score out of 20	Participant Number
70	12	5	19	42
71	9	4	19	10
73	12	8	17	19
73	8	6	13	39
77	9	3	20	41
79	11	4	11	49
81	7	4	16	15
81	12	6	19	17

Table 17: Correlations Among Predictor Variables

	Age	DF	DB	CPT	PTA	HFHL	ED
Age		-.17	-.32*	-.21	.59**	.73**	-.033
DF			.63**	.17	-.15	-.11	.16
DB				.29	-.31*	-.31*	.26
CPT					-.32*	-.36*	.25
PTA						.77**	-.37*
HFHL							-.26

* $p < .05$;

** $p < .01$

DF=Digits Forward

DB=Digits Backward

CPT=Continuous Performance Test

PTA=pure-tone average threshold

HFHL=threshold at 4000 Hz

ED=number of years of college education

Table 18: Average Confidence Rating Based on Likert Scale 1-5 (1 = 0% confidence, 5 = 100% confidence)

Age	SAE Words	SAE High	SAE Low	Overall SAE	AE Words	AE High	AE Low	Overall AE
22	4.92	5.00	4.91	4.94	4.04	4.79	3.54	4.12
23	4.62	4.50	4.16	4.44	3.34	3.73	2.65	3.24
25	4.92	5.00	4.83	4.91	4.36	4.04	3.20	3.86
30	4.64	5.00	3.75	4.46	4.16	4.04	2.54	3.58
32	5.00	5.00	4.91	4.97	4.06	4.45	3.50	4.00
41	4.88	5.00	4.75	4.87	3.62	4.40	3.30	3.77
42	4.60	5.00	4.73	4.76	4.04	4.60	3.60	4.08
45	4.64	5.00	3.50	4.38	2.50	4.08	1.70	2.76
47	4.60	5.00	4.40	4.66	4.20	4.15	3.06	3.80
51	4.80	5.00	4.75	4.85	3.84	4.62	3.33	3.93
52	4.92	4.91	4.60	4.81	4.48	4.37	3.99	4.28
59	4.30	5.00	4.62	4.64	4.44	4.35	4.64	4.47
59	4.69	4.91	4.90	4.80	4.46	4.37	3.90	4.24
60	4.60	5.00	4.90	4.83	4.62	4.62	2.82	4.02
61	4.80	4.91	4.80	4.83	3.82	4.45	3.22	3.33
63	4.60	5.00	4.90	4.83	3.26	4.00	1.99	3.08
70	4.76	5.00	4.83	4.86	3.70	4.37	2.74	3.60
73	4.32	4.91	5.00	4.74	4.18	4.00	4.20	4.12
77	4.80	5.00	4.75	4.85	3.02	3.58	2.66	3.08
79	4.36	4.91	4.33	4.53	3.56	4.16	2.91	3.54

Table 19: Correlations Between Age and Confidence Ratings Based on Self-Report

	SAE Words	SAE High	SAE Low	Overall SAE	AE Words	AE High	AE Low	Overall AE
Age	-.55*	.21	.21	.02	-.26	-.26	-.03	-.19
p value	.03	.45	.44	.93	.33	.34	.90	.49

*p<.05

Table 20: Significant Correlations - Performance and Confidence for Oldest Participants**Participant 42 - age 70**

List	Correlation
SAE Words	.579**
PAE High Predictability	.630*
CAE High Predictability	.932**
CAE Low Predictability	.635*

Participant 39 – age 73

List	Correlation
SAE High Predictability	.674*

Participant 41- age 77

List	Correlation
SAE Words	.579**
PAE High Predictability	.630*
CAE High Predictability	.932**

**p ≤ .01

*p ≤ .05

Table 20: Significant Correlations - Performance and Confidence for Oldest Participants, continued

Participant 49- age 79

List	Correlation
SAE Words	.657**
CAE Words	.560**
PAE High Predictability	.824*

** $p \leq .01$

* $p \leq .05$

SAE = Standard American English
 PAE = Portuguese-Accented English
 CAE = Chinese-Accented English

Appendix A: Foreign-Accent Scale for Rating Speakers and Accent Ratings for Each Speaker

No Accent

Heavy Accent

0 1 2 3 4 5 6 7 8

Rating	PAE1	PAE2	CAE1	CAE2
Rater 1		7	5	7
Rater 2		8	5	6
Rater 3		7	6	5
mean		7.3	5.3	6

PAE1=Portuguese-accented English speaker 1

PAE2=Portuguese-accented English speaker 2

CAE1=Chinese-accented English speaker 1

CAE2=Chinese-accented English speaker 2

Please read the following statements and circle the number that best represents your experience. The range of the scale is 0 – 4. Zero means that you strongly **disagree** with the statement and the number four means that you strongly **agree** with the statement.

- | | strongly disagree | | | | | strongly agree |
|----|--|---|---|---|---|-----------------------|
| | 0 | 1 | 2 | 3 | 4 | |
| 1. | I can understand another language besides English. | | | | | |
| | 0 | 1 | 2 | 3 | 4 | |
| 2. | I am fluent in another language besides English | | | | | |
| | 0 | 1 | 2 | 3 | 4 | |
| 3. | I am particularly good at learning foreign languages. | | | | | |
| | 0 | 1 | 2 | 3 | 4 | |
| 4. | I have had a lot of opportunities to learn or study foreign languages. | | | | | |
| | 0 | 1 | 2 | 3 | 4 | |
| 5. | I enjoy learning a foreign language. | | | | | |
| | 0 | 1 | 2 | 3 | 4 | |
| 6. | No one I live with uses another language besides English. | | | | | |
| | 0 | 1 | 2 | 3 | 4 | |
| 7. | In my neighborhood now people speak mostly English. | | | | | |
| | 0 | 1 | 2 | 3 | 4 | |
| 8. | In my life I have heard a lot of people who speak English with a foreign accent. | | | | | |
| | 0 | 1 | 2 | 3 | 4 | |
| 9. | In my life I have had a lot of experience talking to people who speak English with a Spanish accent. | | | | | |
| | 0 | 1 | 2 | 3 | 4 | |

strongly disagree**strongly agree**

0 1 2 3 4

10. In my life I have had a lot of experience talking to people who speak English with a Chinese accent.

0 1 2 3 4

11. In my life I have had a lot of experience talking to people who speak English with a Korean accent.

0 1 2 3 4

12. In my life I have had a lot of experience talking to people who speak English with a Portuguese accent.

0 1 2 3 4

13. When I talk with people who have a different accent from mine, I find myself speaking with that accent.

0 1 2 3 4

Appendix C: Mini-Mental State Examination (Folstein et al., 1975).

Participant # _____

<u>Task</u>	<u>Instructions</u>	<u>Scoring</u>
Date Orientation	“Tell me the date.” Ask for omitted items.	One point each for season, date, day of week, and month
Place Orientation	“Where are you?” Ask for omitted items.	One point each for state, county, town, building, and floor or room
Register 3 Objects	Name three objects slowly and clearly. Ask the patient to repeat them.	One point for each item correctly repeated
Serial Sevens	Ask the patient to count backwards from 100 by 7. Stop after five answers. (or ask them to spell “world” backwards.	One point for each correct answer (or letter)
Recall 3 Objects	Ask the patient to recall the objects mentioned above.	One point for each item correctly remembered
Naming	Point to your watch and ask the patient “what is this?” Repeat with a pencil.	One point for each correct answer.
Repeating a Phrase	Ask the patient to say “no ifs, ands, or or buts.”	One point if successful on first try.
Verbal Commands	Give the patient a plain piece of paper and say “Take this paper in your right hand, fold it in half, and put it on the floor.”	One point for each correct action
Written	Show the patient a piece of paper with	One point if the

Commands	“CLOSE YOUR EYES” printed on it.	patient’s eyes close
Writing	Ask the patient to write a sentence.	One point if sentence has a subject, a verb, and makes sense
Drawing	Ask the patient to copy a pair of intersecting pentagons onto a piece of paper.	One point if the figure has ten corners and two intersecting lines

Scoring A score of 24 or greater is considered normal.

Appendix D: Health and History Questionnaire

Please answer the following questions:

1. Male _____ Female _____
2. Number of years of high school education _____
3. Number of years of college education _____ List degrees earned:

4. Which of the following do you consider yourself to be?
 - right-handed _____
 - left-handed _____
 - ambidextrous _____
5. Have you ever had a stroke?
 - yes _____ no _____
6. Do you have any neurological problems?
 - yes _____ no _____
 - If so, list: _____

7. Do you have high blood pressure?
 - yes _____ no _____
8. Do you have diabetes?
 - yes _____ no _____

9. Do you have any medical problems?

yes _____ no _____

If so, list: _____

10. Do you take any medications?

yes _____ no _____

If so, list: _____

Appendix E: Participant Information and Participant Summary Data

Age	PTA	HFHL	Dominant hand	Years College	College degree	Exposure Score Chinese Accent (from Likert scale 0-4)	Exposure Score Portuguese Accent (from Likert scale 0-4)	Participant Number
20	10	10	Right	2	N/A	1	0	32
*22	12	10	Right	4	BA	1	2	48
23	12	0	Right	4	BSc	1	1	33
*23	10	10	Right	3	N/A	4	3	40
24	12	5	Right	4	N/A	1	1	34
25	10	10	Right	4	BA	2	3	16
25	13	5	Right	4	N/A	1	0	29
*25	5	5	Right	4	BS	3	0	38
25	0	0	Right	3	N/A	0	0	12
30	10	10	Right	8	AA	4	0	50
*30	12	5	Right	4	BA	1	0	35
*32	6	15	Right	5	BA	2	2	44
35	8	5	Right	6	MA	1	0	53
39	8	10	Right	10	PhD	1	0	54
*41	13	10	Right	6	MS	1	2	46
*42	23	15	Right	7	MSN	1	2	30
43	3	0	Right	4	BS	4	3	21
44	2	0	Right	4	BFA	1	0	20
*45	8	10	Right	13	PhD	3	2	43
45	17	30	Right	2	AA	2	0	14
47	17	30	Right	6	MFA	2	0	18
47	5	5	Right	7	JD	1	0	24
*47	12	15	Right	6	MS	1	0	45
50	15	15	Right	11	PhD	2	0	52
*51	8	5	Left	13	PhD	1	0	37
*52	8	10	Right	9	EdD	4	0	47
52	0	0	Right	4	BA	1	1	25
58	5	5	Right	6	PhD	4	0	23
*59	3	15	Right	7	MS	1	0	26
*59	18	15	Right	7	JD	1	0	27
*60	12	10	Right	9	PhD	3	1	31
*61	13	20	Right	10	EdD	0	0	28
*63	18	40	Right	8	PhD	1	0	36
66	12	10	Left	6	MS	0	0	11
68	20	35	Right	6	MA	2	0	22
68	17	15	Right	7	MA	0	0	51

Age	PTA	HFHL	Dominant Hand	Years College	College degree	Exposure Score Chinese Accent (from Likert scale 0-4)	Exposure Score Portuguese Accent (from Likert scale 0 - 4)	Participant Number
*70	18	15	Left	3	N/A	0	2	42
71	35	50	Right	6	MS	0	0	10
73	32	55	Right	8	MSW	0	0	19
*73	14	60	Right	4	BA	2	1	39
*77	30	50	Right	0	N/A	0	0	41
*79	37	45	Right	0	N/A	0	0	49
81	40	50	Right	0	N/A	2	0	15
81	15	55	Right	0	N/A	0	0	17

PTA = pure-tone hearing threshold average of 500 Hz, 1000 Hz, 2000 Hz in dB (soundfield thresholds for participants 27-54)

HFHL = 4000 Hz threshold in dB (soundfield threshold for participants 27-54)

*participants who completed the confidence ratings

Participant Summary (averages per decade)

Age Group	PTA in dB	HFHL in dB	Number Years College	Number Participants with College Degrees	Chinese AE Exposure Score (from Likert scale 0-4)	Portuguese AE Exposure Score (from Likert Scale 0-4)
20s	4.2	5.5	3.5	4/9	1.5	1.1
30s	8.8	9	6.6	5/5	1.8	.48
40s	11.1	12.7	6.1	9/9	1.7	1.0
50s	8.1	10.7	8.1	7/7	2	.14
60s	12	21.6	7.7	6/6	1	0.0
>70	27.6	47.5	2.7	3/8	.5	.38

PTA=pure-tone average

HFHL=threshold at 4000 Hz

dB=decibel level

AE=accented English

Appendix F: Questions for Raters

1. Are you monolingual?
2. Is English your native language?
3. Have you been accustomed to speaking with English speakers who have a Portuguese accent?
4. Have you been accustomed to speaking with English speakers who have a Chinese accent?
5. Have you lived abroad for three months or more?

Raters will be acceptable if answers to numbers one and two are “yes” and answers to numbers three, four, and five are “no.”

Appendix G: Participants' Confidence-Rating Form

Please circle the percentage that corresponds to how confident you are that you heard the item correctly.

0% = zero percent confidence I heard the item correctly
 25% = twenty-five percent confidence I heard the item correctly
 50% = fifty percent confidence I heard the item correctly
 75% = seventy-five percent confidence I heard the item correctly
 100% = total confidence I heard the item correctly

	<u>No Confidence</u>				<u>Total Confidence</u>
1.	0%	25%	50%	75%	100%
2.	0%	25%	50%	75%	100%
3.	0%	25%	50%	75%	100%
4.	0%	25%	50%	75%	100%
5.	0%	25%	50%	75%	100%
6.	0%	25%	50%	75%	100%
7.	0%	25%	50%	75%	100%
8.	0%	25%	50%	75%	100%
9.	0%	25%	50%	75%	100%
	<u>No Confidence</u>				<u>Total Confidence</u>

No Confidence Total Confidence

10. 0% 25% 50% 75% 100%

11. 0% 25% 50% 75% 100%

12. 0% 25% 50% 75% 100%

13. 0% 25% 50% 75% 100%

14. 0% 25% 50% 75% 100%

15. 0% 25% 50% 75% 100%

16. 0% 25% 50% 75% 100%

17. 0% 25% 50% 75% 100%

18. 0% 25% 50% 75% 100%

19. 0% 25% 50% 75% 100%

20. 0% 25% 50% 75% 100%

21. 0% 25% 50% 75% 100%

22. 0% 25% 50% 75% 100%

No Confidence Total Confidence

No Confidence Total Confidence

23. 0% 25% 50% 75% 100%

24. 0% 25% 50% 75% 100%

25. 0% 25% 50% 75% 100%

26. 0% 25% 50% 75% 100%

27. 0% 25% 50% 75% 100%

28. 0% 25% 50% 75% 100%

29. 0% 25% 50% 75% 100%

30. 0% 25% 50% 75% 100%

31. 0% 25% 50% 75% 100%

32. 0% 25% 50% 75% 100%

33. 0% 25% 50% 75% 100%

34. 0% 25% 50% 75% 100%

35. 0% 25% 50% 75% 100%

No Confidence Total Confidence

	<u>No Confidence</u>				<u>Total Confidence</u>
36.	0%	25%	50%	75%	100%
37.	0%	25%	50%	75%	100%
38.	0%	25%	50%	75%	100%
39.	0%	25%	50%	75%	100%
40.	0%	25%	50%	75%	100%
41.	0%	25%	50%	75%	100%
42.	0%	25%	50%	75%	100%
43.	0%	25%	50%	75%	100%
44.	0%	25%	50%	75%	100%
45.	0%	25%	50%	75%	100%
46.	0%	25%	50%	75%	100%
47.	0%	25%	50%	75%	100%
48.	0%	25%	50%	75%	100%
49.	0%	25%	50%	75%	100%
50.	0%	25%	50%	75%	100%

Appendix H: Informed Consent

My name is Elizabeth Galletta and I am a student in the Ph.D. Program in Speech and Hearing Sciences at the Graduate Center of the City University of New York, and principal investigator of this project about people's abilities to understand accented speech. This is a research study investigating individuals' ability to understand accented American English speech. The purpose of this study is to investigate people's abilities to understand accented English.

Participation will involve one testing session. The time required to complete the testing session will be approximately 90 minutes. You will be asked to fill out two written questionnaires and I will administer a short oral questionnaire.

Responses to these questionnaires will be kept confidential. Your name will not be written on the questionnaires. Instead, a participant number will be written on the questionnaires. The names that correspond with each participant number will be kept in a separate locked file drawer. You will also complete a hearing test and listen and repeat some lists of words, sentences, and numbers.

There will be an audio recording made of each session. This tape will be stored in a secure place accessible only by the research team to check my accuracy of scoring.

You are participating voluntarily in this study and will be provided with a stipend of \$10.00 for participation in each part of the study.

There are no foreseeable risks or discomforts in participation in this study, and, while there are no personal benefits, the information gathered is expected to further knowledge regarding the processes involved in the perception of speech. I will discuss the results of testing with you and/or your significant other. I will suggest audiological follow-up if it is indicated as well as anything else you may want to discuss with your physician.

The results of this study may be published, but the names of the 60 participants and any identification characteristics will not be used in any of the publications. If you would like a summary of the results, please provide me with your name and address below and I will send you a results summary in the future.

You may terminate participation in this study at any time, without penalty. At the completion of this project, you are invited to ask questions regarding the study and its conclusions.

Appendix H: Informed Consent, continued

You may contact members of the research team (Elizabeth Galletta 914-674-7740, e-mail: egalletta@juno.com; Dr. Loraine K. Obler 212-817-8809) at any point during the study with questions. You may also contact Ms. Hilry Fisher, Director of Sponsored Research, Graduate Center of the City University of New York at (212) 817-7523 (e-mail: hfisher@gc.cuny.cdu).

Thank you for your participation. I will give you a copy of this form to take with you. If you agree to participate, please sign below.

I agree to be audio-taped: YES NO

Date: _____ Participant's Signature: _____

Date: _____ Researcher's Signature: _____

If you would like a summary of results mailed to you in the future, write your name and address below:

Appendix I: Oral Instructions to Participants

1. Exposure Questionnaire and Health and Handedness Questionnaire

Please fill out each questionnaire to your best ability. Please answer each question on each questionnaire.

2. Mental Status Questionnaire

Now I am going to ask you some questions. Please answer each question as completely as possible.

3. Pure-Tone Hearing Testing

You will hear some tones presented to each ear. Every time you hear a tone raise your hand. It does not matter which hand you raise, but raise your hand every time you hear a tone. Even if you think you hear it, raise your hand.

4. Psychoacoustic Laboratory Word Lists (PALs)

You will hear a speaker say "Say the word _____." Repeat the word you are instructed to repeat. For example, if the speaker says 'say the word real' you repeat the word 'real.'

5. Sentence Lists

You will hear a list of sentences, one sentence presented at a time. After you hear an entire sentence, say the sentence out loud.

6. Digit Span

Digits Forward (the directions below are on the CD which is presented at MCL):

I am going to say some numbers. Listen carefully, and when I am through, I want you to say them right after me. Just say what I say.

Digits Backward (as in Digits Forward, directions are on the CD which is presented at MCL):

Now I am going to say some more numbers. But this time when I stop I want you to say them backward. For example, if I say, 7-1-9, what would you say?

(If the participant says 9-1-7, I'll say...)

Appendix I: Oral Instructions to Participants, continued

That's right.

(If the participant responds incorrectly, I'll say...)

No, you would say 9-1-7. I said 7-1-9, so to say it backward, you would say 9-1-7. Now try these numbers. Remember, you are to say them backwards: 3-4-8.

7. Continuous Performance Test

You are going to hear a list of numbers. Raise your hand every time you hear three odd number in a row. For example,

2, 4, 1, 6, 5, 8, 3, 7, 1, 6

That's right.

If the participant does not respond accurately the directions will be repeated and researcher will raise her hand at the correct time giving the participant the visual cue.

8. Confidence Rating

Participants will be told to repeat the word or sentence they think they heard and to indicate on the five-point Likert scale the degree to which they are confident they heard the word correctly (for the single words) or the degree to which they heard last word correctly (for the sentences).

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