AN ANALYSIS OF SENTENCE REPETITIONS IN A SINGLE-TALKER INTERFERENCE TASK

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ABSTRACT

Listening to speech is a complex process which is made more difficult when distractions, such as noise or other speech, occur at the same time. People often experience competing speech signals in daily life, such as at a noisy restaurant where they must regulate their attention to focus on the target and block out distractions. This study examined complex speech processing using a single-talker interference task, which requires participants to listen to two talkers simultaneously, ignoring a distracter talker while repeating a target talker. The talkers in this study were a native speaker of English (NS) and a non-native speaker of English (NNS). Twelve nonimpaired participants’ listening accuracy (measured by target words repeated) was observed in the contexts of nativeness of speaker, participant characteristics, and performance of standardized measures. No significant correlations were found between cognitive measures and repetition accuracy. An interaction effect was found between the variables of foreign language experience and repetition accuracy of the NS target sentences. This study also included a descriptive observation of participants’ repetition errors, intended as a first step toward identifying possible strategies nonimpaired individuals use in difficult listening situations. The most common types of errors participants made during sentence repetitions were phonetic and semantic errors. There were no significant correlations between error types and accuracy of target repetition. Future research should continue to explore patterns and strategies in complex listening by including participant interviews. Additionally, a future study should include participants with traumatic brain injury to compare their performance on this single-talker interference task as well as their error types to those of nonimpaired participants.
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INTRODUCTION

People with and without intact auditory and cognitive systems sometimes experience challenges during difficult listening situations. For example, in social situations, people constantly choose what information to listen to from among a variety of sources. They must also make inferences regarding content and meaning based on incomplete speech signals. This can happen at parties, restaurants, sporting events, schools, and within countless other noisy, stimulating environments. These situations place demands on a variety of cognitive abilities such as attention (Cicerone, 1996), working memory (Mathias & Wheaton, 2007), and processing speed (Burkholder & Pisoni, 2003; Schneider, Li, & Daneman, 2007).

There is a breadth of research regarding how this background noise and speech makes listening more difficult for people who have trouble processing speech input, such as elderly adults (e.g., Humes, Lee, & Coughlin, 2006), cochlear implant users (e.g., Burkholder & Pisoni, 2006), and people with traumatic brain injury (e.g. Mathias & Wheaton, 2007). Additional research about how people with normal and impaired cognitive systems function and compensate in these situations could be useful in developing and teaching effective listening strategies. For example, when a word is not heard clearly, how do normal individuals compensate for missing information? Do people with less intact processing and/or executive functioning abilities use the same strategies when faced with masking and other difficult listening situations? Redintegration, or reconstructing missing information due to memory decay or competing signals, is often how people form “educated guesses” about a word they do not know when asked to repeat sentences (Schweickert, Chen, & Poirier, 1999). Learning more about how normal listeners deal with complex listening situations may help develop treatment strategies for those with cognitive and linguistic impairments. The study in this thesis explored these questions by observing how
successful nonimpaired individuals are in repeating sentences spoken by a native English speaker (NS) and a non-native English speaker (NNS) during a single-talker interference task. In addition, an analysis of sentence repetition errors provides insight into how people attempt to process speech when they are missing information due to the competing signals of two simultaneous talkers.

**Unimpaired Sentence Processing and Repetition**

A variety of research exists regarding how people process spoken language, as well as what types of speech input pose challenges to listeners. Chermak and Musiek (1997) summarize how people recall verbal stimuli, revealing that patterns related to words that are easier to recall are still unclear. Some research shows that highly stressed syllables of a word are used primarily to access the lexical system, and that listeners retrieve higher frequency words more quickly and easily. Research has shown that infrequent words and fast speech both result in more listener repetition errors, while other studies show that very slow speech results in frequent errors. Chermak and Musiek explain that research has found that more errors occur for shorter words, possibly because less distinguishing phonetic information is available.

A word’s frequency of occurrence in a language and shared phonetic characteristics with other words can be referred to as “frequency-weighted neighborhood density.” Phonetically similar words, differing only by one phoneme are referred to as neighbors. Luce and Pisoni (1998) found that people have more difficulty recognizing words that share similar phonetic characteristics to many other words compared to words with more distinct phonetic features. This relates to Chermak and Musiek’s discussion of the difficulty of repeating shorter words due to their shared characteristics with other words.
**Extra-phonemic Information.** While phonemic properties of a word affect the listener’s ability to recognize and retrieve spoken information, other factors, such as a speaker’s vocal characteristics, also affect how listeners process words and sentences. These specific properties of a speaker’s voice and delivery are considered “extra-phonemic” information, and can convey social and emotional information necessary for effectively communicating a message (Creel, Aslin, & Tanenhaus, 2008). While extra-phonemic characteristics such as fundamental frequency, voice onset time, rate of speech, and dialectal variations differ greatly by speaker, listeners are still able to comprehend the same word whether it is spoken by a young child or a grown adult, each of whom possess different vocal and speech characteristics (Creel et al., 2008).

This flexibility in automatic speech processing develops early. Barker and Newman (2004) found that 7.5 month old children were only able to recognize words when they were said by the person from whom they first learned the word. However, just three months later children were able to adjust for extra-phonemic variability and could recognize words from other speakers. Kraljic and Samuel (2005) found that adult listeners were able to shift their expectations to understand a target word correctly when a speaker consistently made a phoneme substitution error (shifting /sh/ to /s/), suggesting listeners have the ability to quickly adapt to speaker variation.

Creel and Bregman (2011) explained in a literature review that speech recognition becomes more difficult when the talker changes rapidly during an experiment. In one study by Green, Tomiak, and Kuhl (1997), listeners were slower and less accurate at identifying the speech sounds /b/ and /p/ in words from a list when different speakers randomly spoke each word. When the speaker of each list was consistent, facilitation effects and normalization for the speaker’s vocal characteristics occurred, making it easier to accurately decide the target word.
Listeners also recalled fewer words from a list when the list was spoken by two different talkers compared to one (Martin, Mullennix, Pisoni, & Summers, 1989). Van Berkum, Van Den Brink, Tesink, Kos, & Hagoort, 2008) used electroencephalography to observe the N400 response, which occurs when listeners do not expect to hear a specific word or phrase. They found that the speaker’s identity affects the listener’s expectation for what words will be spoken. For example, listeners showed the N400 response when they heard a male make the comment, “If only I looked like Britney Spears,” because they would not expect a male to make this comment. These studies conclude that speaker variables influence how the listener interprets speech.

There are many other factors that can influence the recognition of words, both in isolation and in conversational speech. For example, Goldwater, Jurafsky, and Manning (2010) compared human listeners to automatic speech recognition (ASR) systems. They found individual speaker differences in such aspects as prosody and fluency and that these affected the listener’s ability to understand the target word. Features such as extreme prosodic variations and words at the beginning of a speaker’s turn were more difficult to recognize, likely because there was not yet a context for that speaker and his or her individual voice and speech differences. Words with more phonological neighbors were slightly more likely to be misrecognized, presumably because there were more options for words that sound similar. This is consistent with Luce and Pisoni’s (1998) findings discussed earlier. Their results show that individual speaker variability has an effect on errors in speech recognition by an ASR system, which serves as a reminder that speech processing is not a straightforward, unambiguous process. Discovering which features are salient to or hinder word recognition by computers may provide insight as to what features distort speech and make it less recognizable to humans as well.
**Single-talker Interference.** People often encounter difficult listening situations in daily life involving competing auditory signals, which result in missing speech information. Situations may include multiple people speaking at a party, or carrying on a conversation in a noisy shopping mall (Schneider, Li, & Daneman, 2007). Researchers study how people respond to competing speakers through talker-interference tasks. A single-talker interference task involves two speakers talking at the same time, with the participant instructed to listen to one talker while blocking out the other (Brungart, 2001).

To further understand how people respond to competing speech input, or more than one talker speaking at once, Brungart (2001) studied how one talker masks another talker using a single-talker interference task. When the two voices are coming from the same direction, or audio speaker, listeners are not able to take advantage of directional cues to separate the talkers. Without the directional distinction, listeners must use cues such as differences in each speaker’s vocal characteristics (e.g., fundamental frequency, accent, inferred vocal tract size and shape) to distinguish and attempt to separate the talkers. Brungart found that informational masking (i.e., linguistic interference from a second talker), made phrase repetition more challenging for participants than energetic masking (i.e., noise interference). This study also found performance decreased significantly when the loudness of the interfering talker was presented within a 10 dB difference. That is, when the target talker was presented at +10 dB or more than the interfering talker, significant interference did not occur. Single-talker interference is used in the current study to parallel real life situations that require people to listen to a target talker while attempting to block out competing speech from another talker.

**Redintegration.** Research has shown that listeners miss important auditory information that forms the target sentence due to the intrusion of the distracter noise or speech (Brungart,
Using the available information, listeners often make educated guesses as to what the target word or entire sound pattern was, a process known as redintegration. Schweickert, Chen and Poirier (1999) observed how factors such as position in a list, word length, and word frequency influence the likelihood that words will be recalled and/or redintegrated. The authors of this study define redintegration as the ability to “use degraded information to reconstruct an item and recall it correctly.” The study observed degradation, or loss of information due to memory decay, when participants were asked to recall words from a list. If information is “degraded,” it means it is unable to be recalled. The authors’ goal of this experiment was to determine an equation for the likelihood that a list would be successfully recalled. As this study and previous research has found, items at the beginning and end of a list are more likely to be recalled. This study and a previous study by Li, Schweickert, and Gandour (2000), found that people are less likely to recall or remember a word when other words on the list share the same phonemes. This suggests there is not a phonological redintegration effect that facilitates recall, but that it is more difficult to recall information when words sound similar. Results also showed that longer words and less frequent words were also more difficult to be recalled.

People have individual differences that need to be considered when discussing the ability to recognize and understand speech. Individual differences could include factors such as verbal intelligence quotient (verbal IQ), working memory, and processing speed. Strong verbal abilities have been shown to help individuals with autism cope in social and pragmatic situations. For example, Skuse et al. (2009) found that high verbal IQ was protective against social communication deficits for females with autism, though not for males. That study did not examine speech processing at the sentence level or for typically developing individuals, but is relevant to the current study because it shows that verbal IQ can relate to communication in daily
life. Verbal IQ might be predicted to affect speech processing abilities because it involves both expressive and receptive language skills, as well as one’s ability to learn words. Comprehending speech may be less effortful for people with stronger expressive and receptive language skills. Working memory is predicted to relate to complex speech processing because in order to comprehend and respond to a sentence, the listener must store words in his or her working memory for recall purposes. Processing speed may also influence a listener’s ability to process speech in the presence of interference because, in the case of the current experiment, participants must quickly decide which talker is the target and which talker is the distracter, then block out the distracting talker while processing and remembering the words spoken by the target talker. This is a complicated task that must happen quickly for success.

The current study provides additional research involving speech and word recognition during interference to provide insight as to what strategies people use to compensate in difficult listening situations. Further understanding of how well nonimpaired individuals comprehend what a target talker says during a single talker interference task, as well as any patterns in participants’ repetitions of the talker, will allow for the possible identification of strategies used in complex listening situations. The current study considers potential relationships between estimated verbal IQ, working memory, and decision speech with recall and reintegration abilities.

**Auditory Processing Deficits**

As discussed above, processing and integrating speech information is a complicated and detailed process. People may perform differently based on the presence of a disorder, impairment, or other individual differences (Schneider et al., 2007). Examples relevant to the
background and purpose of the current study include older age, cochlear implants, and traumatic brain injury (TBI).

**Aging.** Age-related changes in the central nervous system may affect auditory processing. Tun, Wingfield, Stine, and Mecsas (1992) conducted a study using a sentence recall task with a picture recognition task to compare younger and older individuals’ performances. Sentences were presented at different rates. For one block they were presented alone and for the other block they were presented simultaneously with the secondary picture recognition task. The latter block was designed as a divided attention task between the sentences aurally presented and the picture recognition task presented visually. Results showed that compared to the younger adult group, the older adults experienced decreased immediate memory in sentence recall and repetition when the sentences were presented at a fast rate in the single-task procedure. The dual-task procedure did not result in age-related differences in performance between the two groups, although this task was more difficult for participants in general. These findings suggest that elderly adults experience deficits in speech processing speed, but not in divided attention.

**Cochlear Implants.** Research not only with older adults but also with children with hearing impairments and cochlear implants contributes to our understanding of auditory processing. In addition to receiving restricted acoustic signals relative to individuals without implants, the children’s auditory processing systems are less developed than those of nonimpaired children due to a lack of early input. Burkholder and Pisoni (2006) reviewed research about the development and differences of prelingually deaf children with cochlear implants. They explain that prelingually deaf children do not receive the same sensory auditory input as children with typical hearing, which can cause hindered language and auditory development. Infants, even before they are born, recognize vocal sounds. Because visual acuity
is not as developed in infants as hearing, many of their first learning experiences occur through auditory input, thus strengthening auditory pathways in the brain. Many parents who have a child born deaf are encouraged to have their child receive a cochlear implant early in hopes of avoiding developmental effects of missing auditory information. Cleary, Pisoni, and Geers (2001) conducted a study consisting of children with typical hearing and children with cochlear implants after prelingual deafness. They found that a specific side effect of early auditory deprivation is shorter auditory immediate memory spans, tested by the WISC-III auditory digit span recall. They posit that children with cochlear implants are not able to encode auditory information into memory as quickly as children with normal hearing.

Burkholder and Pisoni (2003) found that not only did prelingually deaf children with cochlear implants struggle to repeat nonwords more than children without hearing loss, but the prelingually deaf group had latency times nearly twice as long as the group of age matched peers with normal hearing. In other words, not only were they less accurate in their repetition, but it took them longer to process and/or produce the nonword. Nelson and Jin (2004) found that those without intact auditory systems, such as cochlear implant users, are less able to take advantage of masking release, or gaps in acoustic masking, to obtain important speech information than normal hearing individuals. As discussed above, the ability to process auditory information quickly and hold it in working memory is necessary to participate in conversation. This becomes more challenging in the presence of background noise and interfering speech signals.

**Specific Language Impairment.** Another group that has shown evidence of auditory processing deficits is those with specific language impairment (SLI). McArthur and Bishop (2004) conducted a study with 10-19 year olds with SLI as well as typically developing controls, and found that the SLI group was less successful in discriminating between frequencies of non-
speech sounds. The younger participants with SLI were less successful than their age-matched typically developing peers as well as the older participants with SLI, while this same gap in performance did not exist between the younger and older typically developing participants. This suggests the underdevelopment or delayed development of auditory processing and identification skills, making it more difficult to identify and synthesize auditory information compared to nonimpaired children.

Stokes, Wong, Fletcher, and Leonard (2007) explain that working memory, sentence repetition, and simultaneous processing often cause difficulty for people with specific language impairment (SLI). They found that impaired nonword repetition and sentence repetition can be markers of SLI, and furthermore suggest that processing phonological input is impaired in children with SLI. In this study, researchers hypothesized that the control group would use increased redintegration skills compared to the SLI group when repeating nonwords, as judged on a phonemic level. Redintegration skills were identified when participants said phoneme combinations that are likely to occur based on patterns of the language. Additionally, children with SLI made more errors per sentence during the sentence repetition task than their typically developing peers. This research emphasizes the importance of the development and complexity of the auditory system, as well as how successful auditory processing is related to working memory and redintegration abilities.

The current study observed not only how well nonimpaired individuals performed on a task involving single talker interference, but how they coped and redintegrated when they missed chunks of auditory information. This experiment allows for later comparison of unimpaired versus impaired individuals to pinpoint deficits and identify possible listening strategies to target in intervention.
**Traumatic Brain Injury**

While the current experiment involves nonimpaired individuals as participants, the structure of this study is intended to lay the foundation for future studies of individuals with traumatic brain injury (TBI) and their abilities to identify and repeat what a talker has said during this task. Since people with TBI often experience impairments regarding executive functioning, memory, attention, and speech perception (Mathias & Wheaton, 2007), these are areas that are addressed during rehabilitation. Researchers study these impairments in order to contribute to the understanding of deficits in individuals with TBI and the creation of successful treatment programs. This section will review research about areas of cognition (e.g., attention and working memory) that people with TBI experience and how these deficits could contribute to difficulty in complex listening situations including daily life communication.

**Attention and Processing Speed.** To learn more about attention and information processing after TBI, Mathias and Wheaton (2007) conducted a meta-analysis regarding attention deficits in people with severe TBI. The analysis included 41 studies from 1980-2005. Results showed that after severe TBI, patients experienced deficits in processing speed, attention span, focused/selective attention, and sustained attention. Tests for information-processing speed were commonly used in experiments, and showed that participants with TBI did experience significant deficits in information processing speed after injury. Some measures of attention span (alphabet span, digits forward), were also negatively affected after TBI. Focused attention (selectively attending to one task while ignoring other stimuli) was assessed the most often in research, and showed large effect sizes indicating deficits. Divided attention (processing more than one source of information simultaneously), was often tested through dual task measures. It
showed smaller effect sizes compared to the other types of attention. This meta-analysis provided evidence that people with severe TBI take longer to process both simple and complex stimuli and experience attentional deficits unrelated to age and education.

**Working Memory.** McAllister et al. (2001) conducted research specific to working memory deficits in people with TBI. Previous studies of nonimpaired adults have shown that bilateral frontal lobe and parietal lobe activity occurs during tasks involving working memory, or storing information for performing cognitive tasks (McAllister et al., 2001). When completing the *n*-back task which required a moderate cognitive load, there was no significant difference in performance between participants with mild TBI and the controls, but the participants with mild TBI did show increased brain activation in the right dorsolateral prefrontal cortex and right lateral parietal regions during the task compared to nonimpaired controls. This suggests that the mild TBI group increased the utilization of structures associated with working memory to perform as well as the nonimpaired controls on the task. Another important note from this study is that the mild TBI participants complained of “significantly more memory difficulties” compared to the control group. Further research involving individuals with moderate and severe TBI may provide more clarity regarding working memory deficits after TBI.

Narrative discourse is a specific, complex aspect of pragmatics used on a regular basis that includes storytelling and descriptions. Youse and Coelho (2005) conducted a study to observe the impact of memory deficits on narrative discourse. Their study included 55 participants who had experienced a closed head injury, but who maintained functional language and were able to maintain fluent conversations. All participants completed two discourse activities, one in which they were asked to retell a story, and one in which they generated a story. The stories were recorded, transcribed, and analyzed regarding within-sentence (e.g., sentence
length and complexity) and between-sentence measures (e.g., cohesiveness, completion of the points made in the narrative). Youse and Coelho (2005) also administered subtests of the Wechsler Memory Scale (WMS) to test working memory. The authors note that while the purpose of the WMS was to evaluate information processing and storage, some research shows that “list span measurements” in standardized testing are quite different from sentence processing in language. Despite this, a modest significant correlation was found between this test and the measures of narrative discourse. Four out of five of the significant correlations were with measures from the story retelling task, and only one from the story generation task. Most of the significant WMS correlations were from the Associate Learning subtest rather than from the Logical Memory subtest, which was not what the authors predicted since the Logical Memory subtest was considered to be more representative of the narrative retelling task. While the correlations were task and subtest specific, these results supported the hypothesis that there would be a relationship between working memory abilities depicted by the WMS and narrative discourse. This provides evidence that working memory plays an important role in complex communication tasks, and those with working memory deficits are likely to struggle with language tasks like narrative discourse.

**Pragmatics.** The processing speed, attention, and working memory deficits described above may underlie some of the difficulties experienced by people with TBI in maintaining conversation, because this skill involves maintaining topic focus, storing information, and forming appropriate responses (Douglas, 2010). Pragmatics includes the social context of speech and language, which is crucial in processing the complete meaning of a message in a conversation.
McDonald and Flanagan (2004) conducted a study to observe how well individuals with TBI recognize informational and emotional messages through facial expression and tone of voice. They found that when adults with severe TBI were instructed to determine speakers’ emotions, beliefs, and intentions based on a video tape, these participants had significantly more difficulty inferring this information compared to nonimpaired adults. The TBI group also had more trouble recognizing sarcastic comments. These interpersonal skills are necessary in daily, social conversations as well as in the workplace.

To understand how adults with post-acute TBI perceive their own pragmatic communication deficits, Douglas’ (2010) research used the La Trobe Communication Questionnaire (LCQ). By comparing the reports of the participants with TBI (two years post injury) about their own performance to how their relatives described them, the researchers were also able to observe differences in the reports in order to assess self-awareness deficits. To explore the relationship between executive functioning skills and pragmatic abilities, Douglas (2010) compared tests of cognitive control processes, including the Rey Auditory Verbal Learning Task (RAVLT), Weschler Memory Scale (WMS), the Speed of Comprehension subtest of the Speed and Capacity of Language Processing Test (SCOLP), and the FAS verbal fluency task. Participants with TBI completed an interview with a researcher while the relatives and control participants could select whether to complete the survey through an interview or in written form. The relatives answered the questions in reference to the individual with TBI. The answers by the participants with TBI and their relatives were statistically similar. This suggests that the people with TBI were aware of their own communication difficulties. When compared to the control participants, those with TBI had higher scores on the LCQ, indicating more pragmatic difficulties. Specific items of high difficulty included: “thinking of the particular word,”
“tracking of conversations in noisy places,” “sidetracked by irrelevant parts of conversation,” and “hesitate, pause, or repeat.” Rate of information processing (SCOLP) was not significantly correlated with pragmatic impairment; therefore, deficits in processing speed may not directly affect conversational capabilities. However, RAVLT scores indicated that poor “ability to maintain information over time” may cause trouble with conversational topic management. This could indicate that attention and working memory influence pragmatic conversation abilities more than processing speed. Overall, executive functioning abilities predicted 37% of LCQ variability. This supports previous research suggesting that brain injury affects executive functioning, and that this can result in complex, real life communication issues.

**Conclusions and Research Questions**

Processing auditory information is a complex, yet crucial process for all listeners. It involves encoding both phonemic and extra-phonemic information, as well as aspects of working memory that are necessary in order to repeat or respond. For people with deficits in pragmatics, attention, and/or working memory, complex listening may pose additional challenges. Understanding how nonimpaired individuals process complex speech and language may help professionals develop strategies for people with processing impairments and/or cognitive deficits. The current study sets out to examine complex speech processing in nonimpaired adults by testing sentence repetition in a single-talker interference task.

Sentence repetition in single-talker interference requires redintegration. In this study, redintegration refers to using what information is available to form an educated guess about what was said in the absence of a complete speech signal. This is an essential process that listeners use in daily life when speech they hear has been either degraded or interfered with (Schweikert et al., 1999). However, due to contradictory findings and lack of experiments covering a variety of
difficult listening situations, it is unclear which factors of speech significantly affect the reintegration process, as well as what approaches to reintegration are most used or most successful in challenging listening situations (e.g., word frequency, phonological information, semantic sentence completion/“fill in the blank”). Previous studies indicate what types of situations make it more difficult for listeners to repeat words, but the research has not addressed specific patterns or methods used to reintegrate information. One of the goals of the current study is to begin to focus on this gap. Do different listeners rely on certain reintegration techniques based on individual differences in automatic processes such as working memory or verbal intelligence abilities? Or do they deliberately choose one strategy over another based on the listening situation? For example, when repeating nonwords, it would be impossible to use a “fill in the blank” strategy based on word meaning since there is no context or meaning to the word, so using phonological patterns would make more sense. However, if limited semantic context is provided, such as in the current study, listeners might potentially use phonological and/or lexical information in their reintegration attempts.

Observing how nonimpaired adult participants attempt to repeat sentences during a single talker interference task by analyzing their sentence repetition accuracy and errors should help provide information as to how nonimpaired individuals strategize in difficult listening situations. The term strategy, in this case, is not metacognitive, but a rather automatic attempt to make a best guess as to what words were spoken based on available information. This research lays the groundwork for future studies examining whether or not participants with TBI and other impairments make the same errors and use similar listening strategies compared to nonimpaired controls. Additionally, exploring patterns of repetition for a native speaker (NS) versus a non-
native speaker (NNS) will contribute to the understanding of how extra-phonemic information affects speech recognition.

**Research Questions.**

1. How accurately are participants able to repeat the target talker? This will be measured as percent of words repeated correctly.
2. Is there a difference in sentence repetition accuracy between native speaker (NS) and nonnative speaker (NNS) targets (Independent variable=NS versus NNS; Dependent variable=% correct).
3. Do any significant correlations exist between test scores (estimated VIQ, decision speed, working memory) and accuracy of repeating target (% correct)?
4. When participants repeat sentences, do any error type patterns exist? (e.g., phonetic, semantic errors)
METHODS

Participants

Twelve nonimpaired participants (six male, six female) were recruited through a campus-wide email announcement at Bowling Green State University (BGSU) and through word of mouth. During recruitment, participants were told that two studies would take place over a single hour-and-a-half session. Participants received a $10 gift card after participating in the session. Via email, participants completed a screening form and scheduled an appointment day and time that was convenient for them. The screening form included demographic questions regarding age, years of education, non-English language experience, and relevant health history such as a communication disorder or traumatic brain injury. Those who indicated a history of brain injury or neurological disease, drug/alcohol abuse, or hearing impairment were excluded from participation. Because one of the talkers in the experiment speaks with a non-native accent, the screening form included a question about participants’ number of semesters/years of foreign language experience.

Demographics. Participants ranged from age 18 to 50. Nine of the 12 participants were students or employees at BGSU; the other four were residents in the greater Toledo area, and all passed an initial hearing screening at either 20 or 25 dB before completing the sentence repetition task. The screening threshold was only increased to 25 dB when ambient noise in the testing room was increased due to ventilation noises. At the beginning of the session, participants also completed a wellness survey. Survey and results are included in Appendices 1 and 2.

Procedures

After completing consent procedures and the wellness survey, participants completed the single-talker interference task in a sound-treated booth. Next, they exited the booth to complete a
number puzzle task intended to measure self-regulatory depletion from the listening task (participants were told this number puzzle was part of a separate study). The self-regulatory depletion portion of the experiment is not addressed in the current analysis.

After participants decided to stop the number puzzle or reached the maximum time to attempt it, they completed three standardized measures, explained in greater detail below. When all procedures were concluded, participants were debriefed about the “deception” aspect of the study, in which the researchers told the participants they were participating in two separate tasks even though the number puzzle task and sentence repetition task were actually part of the same experiment. They were invited to ask any questions, thanked for their participation, and received their gift card.

The informed consent process at the beginning of the session explained the structure of the experiment and any risks and benefits of participating in the study. BGSU’s Human Subjects Review Board (HSRB) approved the procedures of the experiment, including the “deception” aspect of the puzzle task. As mentioned previously, the current study focuses on the errors during sentence repetition rather than depletion effects, and therefore the number puzzle and results of the puzzle are not discussed further.

**Single-Talker Interference Task.** Single-talker interference procedures involve the participant hearing two talkers simultaneously, each speaking a different sentence. The participant then attempts to repeat one talker (the target) while ignoring the other (the distracter). The talkers used in the current study were both female; one is a native speaker of English (NS) and the other a non-native speaker (NNS). The stimuli and methods for the current experiment were first developed for earlier studies conducted by Dr. Miriam Krause (Krause, 2011). The program used to administer the experiment was designed using E-Prime software. The
experiment included instruction, familiarization, training, and experiment phases, described in greater detail below. Participants in the study completed the single-talker interference task in a sound-treated booth. They sat facing a computer, with a speaker on either side of the monitor. Mono sound files played from both speakers at approximately 70 dB; participants were offered the opportunity to increase or decrease the loudness of the stimuli during the instruction phase. Two participants requested the volume be turned down slightly.

**Instruction Phase.** The sentence repetition task procedure began with instructions provided simultaneously through text and audio via the computer screen and speakers. This provided an overview for participants so they knew what to expect during the experiment. It also reassured them they would first complete a training phase and could ask questions later. The researcher sat in the sound booth with the participant to answer any questions during the instruction, familiarization, and training sections.

**Familiarization.** The purpose of the familiarization phase was to introduce participants to the single-talker interference protocol. The target and distracter talkers used in this section were different from the ones used in the experimental section, but they were still both female, one NS and one NNS. First, an example sentence was presented from the target talker (NS) alone. Participants were instructed to attempt to repeat only the sentences spoken by that target talker when they heard two talkers at the same time. Ten trials were presented in this phase, with the experimenter providing nonspecific encouragement and explanation as the participant attempted to repeat the target sentences for each trial. At the end of the section, a 1-10 effort rating scale appeared on the screen with the question, “How much effort did it take to understand the sentences you just repeated?”
Training. The training section introduced the participants to each of the talkers in the experimental task and trained them to associate each talker with a colored cue, so later they would be able to focus attention on the talker that matched the visual cue. The target cues are pictured in Figures 1 and 2. First, participants were instructed to listen to and repeat five sentences spoken by the NS alone, with no distracter. A solid green face appeared on the screen to train the participant to associate the NS with that visual cue (Figure 1). Five sentences spoken by the NNS were then played for participants to repeat, accompanied by a purple face (Figure 2). Next, the participants listened to and repeated ten sentences in which the NS and NNS alternated pseudo-randomly, each talker presented with the matching colored target on the computer screen. Participants responded to the 1-10 effort rating scale again.

Then, to verify that the participant had learned to associate each talker with the correct color cue, a ten-sentence “quiz” was presented (five sentences for each talker) in a pseudo-random order. After hearing each sentence, participants were asked to choose which visual target, green or purple, represented that talker. All participants successfully matched both talkers to the appropriate visual cue 100% of the time, demonstrating that they could differentiate between the two talkers and could identify which talker was associated with which visual cue. Once the training section was complete, the researcher asked the participant if he or she had any
questions, reminded them that the next section of the experiment would involve hearing two talkers at the same time and repeating only one, and then exited the sound booth.

**Stimuli.** Sentences spoken by the NS and NNS in the single-talk interference task were from the IEEE corpus (IEEE, 1969). While these sentences are grammatically correct, they have low predictability, meaning that even if listeners hear the beginning of the sentence they are unlikely to be able to guess the end of the sentence. The sentences range from six to nine total words, each with five key words that are used to score accuracy of sentence repetition in this experiment. All sentences are included in Appendix C. In one trial, for example, the NNS spoke the sentence, “The NAG PULLED the FRAIL CART ALONG” while the NS said, “The BOY OWED his PAL THIRTY CENTS.” The capitalized words represent the five target words in each sentence, therefore the words NAG, PULLED, FRAIL, CART, and ALONG are the target words for the first sentence, and BOY, OWED, PAL, THIRTY, and CENTS are the target words for the latter sentence. The participant was asked to repeat the target words from only one of the sentences based upon the colored cue presented on the screen. All sentences began with the word “the,” and sentence pair lengths were adjusted so that both sentences began and ended at the same time.

**Sentence Repetition.** The experimental section of the procedure consisted of 60 single-talker interference trials in which the two talkers spoke different sentences at the same time while a visual cue for the target talker appeared on the screen. The cue was accompanied by the text instruction, “Listen and repeat.” The sentence, “Press the space bar when you are ready to continue,” also appeared at the bottom of the cue screen for each trial. Pressing the space bar began the next trial. At the end of the 60 trials, participants responded to the 1-10 effort rating scale again. Sentence pair stimuli were presented in the same order for each participant, but
which target cue was presented was randomly chosen by the computer for each trial. As a result, some participants had more trials with the NNS as the target while other participants had more NS target trials. E-Prime software recorded which target cue was presented during each trial for each participant. The twelve participants averaged 29.83 NS target trials (SD=1.267), and 30.17 NNS trials (SD=1.267).

The E-prime program automatically recorded each attempted sentence repetition as a separate audio file using a microphone connected to the experiment computer. After the 60 trials were completed, the effort rating scale appeared on the screen again for participants to rate the effort of the single-talker interference task.

**Standardized Tests.** Participants completed several standardized measures after the number puzzle task to assess working memory, decision speed, and verbal intelligence. *The Wechsler Test of Adult Reading* (Wechsler, 2001) provides an estimated verbal intelligence quotient (verbal IQ) score. A Listening Span task (Daneman & Carpenter, 1980) was used to test verbal working memory, and the Decision Speed subtest of the *Woodcock-Johnson III Test of Cognitive Abilities* (Woodcock, McGrew & Mather, 2001) was administered as a measure of non-verbal processing speed.

**Sentence Repetition Analysis**

In order to analyze participants’ sentence repetition accuracy the researcher listened to the audio recordings of participant responses and compared them to the written list of the target and distracter key words for each trial.

**Scoring.** Every key word (from the target or distracter) that was repeated during each trial was circled on a scoring sheet. If the participant repeated the root word, but changed or added one morpheme (e.g., target is “walks” but participant said “walked”), then the word was
still considered correct in accuracy calculations. Words that were spoken by the participant but were not spoken by either the target or distracter talker were not considered in the accuracy analysis, but are included in the error analysis, as discussed in the next section.

**Overall Accuracy.** Words that the participant repeated that were spoken by either the distracter talker or target talker were circled on a printed scoring sheet. Accuracy (target words repeated) and distracting (distracter words repeated) scores were given as a percent of representing all 60 trials of the single-talker interference task. During the study, participants were instructed to repeat the only the talker whose colored cue appeared on the screen, because this was the target talker. Repeated key words spoken by the target talker for each trial were considered accurate, and used to calculate percent of target words correct. This percent was found by dividing target words repeated by the 300 total possible target words. Key words spoken by the distracter talker for each trial were also counted, and the participant’s overall percent of distracter words repeated was calculated.

**Detailed Error Analysis of Words.** The researcher examined specific errors made during participants’ attempts to repeat the target sentences for each trial of the single-talker interference task. All repetitions were transcribed orthographically. If the word was unintelligible, any sounds that were clear were transcribed orthographically.

Categories of errors included: phonetically similar to a key word (e.g., “car” instead of the target word “cat”), semantically related (e.g., “The first worm gets eaten early,” instead of, “The first worm gets snapped early.”) Substituting the word eaten for snapped is appropriate for the sentence. Although words that contained one morpheme difference (i.e., indicating tense or plural, but same overall meaning) were counted correct in the overall accuracy measures, morphological errors were still noted for this detailed error analysis. If the participant used a
word such as “something” as a place holder for a word he or she was not able to repeat, this error was categorized as “filler.” Errors that included nonwords, unintelligible errors, and production of words that were not spoken by either talker and do not fit a specific category were identified as “other.” See Table 1 for further explanation and examples.

In addition to the primary error categories described above, morphological, phonetic, and semantic error categories also existed for words spoken by the distracter talker. If a participant said a word that fit into one of those categories, it was denoted with “x” on the data sheet. Some word errors fit into multiple categories. For the purposes of the analysis, errors qualifying for more than one category were tallied as what was judged by the researcher to be the most likely category based on the shared characteristics with the target word. The other, secondary category was noted with a “2” on the data sheet. After errors were categorized, the researcher analyzed the number of errors for participants in each category to answer the research questions. The total number of spoken words was also recorded.
Table 1. Error Types, Explanations, and Examples. Types of errors explained in the table include morphological, phonetic, semantic, filler, other, and spoken distracter word. “Other” error types included morphological, phonetic, and semantic variations of a distracter word. These are not listed, because the same criteria were used as for the target sentence.

<table>
<thead>
<tr>
<th>Type of error</th>
<th>Explanation/ criteria</th>
<th>Target word</th>
<th>Example error</th>
</tr>
</thead>
</table>
| Morphological          | One morpheme has been changed, but the root word remains the same.  
                          | SEEMS had                                                                 | “seemed”    |
| Phonetic               | 1. Spoken word begins with the same phoneme as the target word and has the same number of syllables  
                          | FARTHER BOY                                                                 | “feather”   |
|                        | 2. Shares two phonetic characteristics with the target word (e.g., rhymes with the target)  
                          | CONTENTS                                                                 | “temps”     |
| Semantic               | Grammatically fits the sentence and relates meaningfully to another word or words in the sentence.  
                          | The junk yard had a MOLDY smell.  
                          | The young kid jumped the rusty GATE.  
                          | “The junk yard had a BAD smell.”  
                          | “The young kid jumped the rusty FENCE.” |
| Filler                 | A word that acts as a place holder when the participant did not repeat the target word (something, someone, thing).  
                          | The FUR of cats… |
| Other                  | 1. A word that does not fit into any other category.  
                          | The empty FLASK stood…  
                          | “The empty CORN stood…” |
| Spoken distracter word | A word spoken by the distracting talker.  
                          | Target: The LONG JOURNEY HOME TOOK a YEAR.  
                          | Distracter: The SMALL RED NEON LAMP went OUT.  
                          | “The SMALL RED HOME TOOK a YEAR.” |
Reliability. Data were scored again for two portions of the experiment, including accuracy and error analysis. A graduate student who did not participate in the experiment coded both the recorded sentence repetition responses and errors for inter-rater reliability. The second coder listened to the recordings of three participants (25% of participants) selected randomly. She circled the target words on a new document with all trials (the same document used to score accuracy). Compared to the original scoring, the words circled by the second rater were 98.33%, 98.5%, and 98.33% the same for the three participants, respectively.

This second coder also reviewed and coded the same three participants’ errors for the error analysis portion of reliability. She was provided with the table above (Table 1) for examples, and received training from the experimenter. The second coder then followed the same procedure of typing an “x” in appropriate cells on the excel spreadsheet for each error, without having seen the original coding. Number of errors for each participant in each category was calculated and compared to determine inter-rater reliability. Errors were totaled and a Pearson product-moment correlation (PPMC) was used to compare the original errors with the second rater’s errors. It was found that the original ratings and second rater’s ratings were 96.3% the same \( r(26)=0.963; p<0.01 \). This correlation is significant at the 0.01 level in a two-tailed test. The author also re-coded these same errors for intra-rater reliability. It was found that the original error codes and the errors coded for the second time by the author were 95.7% the same \( r(26)=0.957; p<0.01 \). This correlation is significant at the 0.01 level in a two-tailed test. Reliability of categorization of different error types was also found. See Table 2 for results.
Table 2: Inter-rater and Intra-rater Reliability Results. Inter-rater and intra-rater reliability in percent errors categorized the same for all errors, as well as morphological, phonological, and semantic errors when compared to original categorization.

<table>
<thead>
<tr>
<th>Errors</th>
<th>Inter-rater reliability</th>
<th>Intra-rater reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>All errors</td>
<td>96.3</td>
<td>95.7</td>
</tr>
<tr>
<td>Morphological</td>
<td>95.0</td>
<td>90.8</td>
</tr>
<tr>
<td>Phonological</td>
<td>99.3</td>
<td>98.4</td>
</tr>
<tr>
<td>Semantic</td>
<td>93.7</td>
<td>99.4</td>
</tr>
</tbody>
</table>

Data analysis. Each participant’s accuracy data were entered into an Excel spreadsheet. Dependent variables analyzed were percent total target words correct, percent total distracter words repeated, percent NS target words correct, and percent NNS target words correct. SPSS software was used to conduct a repeated-measures Multivariate Analysis of Variance (MANOVA) to examine independent variables including nativeness (native speaker target vs. non-native speaker target), sex (male vs. female), and foreign language experience (more than 4 years of language education vs. less than 4 years). These performance scores along with standardized and cognitive test scores were analyzed using PPMC to observe any correlations among variables. Post-hoc tests were completed for variables with significant results.
RESULTS

Description of Participants’ Repetition Accuracy

Measures of repetition accuracy for each participant were examined relative to their standardized and cognitive test measures as well as factors including age, gender, and second language experience. Participants attempted to listen to and repeat the target talker, which was indicated by the NS or NNS (green or purple) visual cue presented on the computer screen. Repetition accuracy included percent total target words repeated, percent distracter words repeated, percent NS words correct, and percent NNS words correct. The mean percent of total target words repeated (out of 300 words) was 65.97% (SD=8.76, range 48% to 78%). Participants repeated a mean of 3.89% of total distracter words (SD= 2.26, range 0.33% to 8.0%).

Nativeness of Target Talker and Other Factors Affecting Accuracy

To examine factors affecting accuracy, a Repeated-measures Multivariate Analysis of Variance (MANOVA) was conducted with the factors of nativeness (NS target vs. NNS target), participant sex (male vs. female), and participant foreign language experience (more than 4 years of language education vs. less than 4 years).

There were 6 male and 6 female listeners included in the study. There was a significant main effect of sex on percent of target words correct [$F(1,8)=6.326; p=0.036; \text{Eta}^2=0.442$], with female listeners repeating a higher percent of total target words (mean=72.28%) compared to male listeners (mean=60.99%).

Foreign language experience was determined by the question in the initial screening form asking, “Do you speak or understand any languages other than English?” If participants answered “yes” to this question, they provided the foreign language and number of years’
experience with that language. Four participants answered “yes.” All of these participants indicated at least four years of foreign language experience (see Table 3). Two participants had four years of experience, and two participants had six years of experience. Two of these participants had 12 years of education, one had 17 years of education, and one had 18 years of education.

A significant interaction effect was found between nativeness of target speaker and participants’ foreign language experience \([F(1,8)=5.464; \ p=0.048; \ \text{Eta}^2=0.406]\). Participants attempted to repeat either the NS or the NNS talker within each sentence pair based on the random cue presented. The mean percent of NS target words repeated was 70.11% (SD=7.99, range 51.72% to 84%) and NNS target words repeated was 61.95% (SD=10.54, range 44% to 80%). The post-hoc t-test showed individuals with four or more years of foreign language experience were more accurate when repeating the NS target \([t(3)=7.628; \ p=0.005]\) than the NNS target. Participants who did not indicate that they spoke or understood a second language showed no effect of nativeness of the target speaker on their repetition accuracy \([t(7)=2.151; \ p=0.069]\). This interaction is shown in Figure 3.

Table 3: Participants’ Foreign Language Experience. This table shows participants’ foreign language experience information from the screening form, and includes gender and age. Only participants who indicated they had experience are included in this table.
Figure 3: Foreign Language Experience and Nativeness of Talker Interaction. Graph of interaction effect for participants grouped by foreign language experience. Those with more than four years of experience were more accurate at repeating the NS talker target than the NNS target, while those less than four years of experience showed no difference.

**Correlations Between Cognitive/Linguistic Tests and Accuracy**

To examine the relationship between sentence repetition accuracy and verbal IQ, working memory, and decision speed, a PPMC analysis was completed with the variables percent of target words correct, WTAR estimated verbal IQ, listening span score, and Woodcock-Johnson III Decision speed subtest seconds per item. No significant correlations were found between verbal IQ and accuracy, ($p>0.05$). Results indicated significant correlation between age and verbal IQ in a two tailed correlational analysis. [$r=0.599, p=0.039$]. See Table 4 for details.
regarding accuracy and test scores. The relationship between listening span and accuracy was also examined, and no significant correlation was found ($p>0.05$). Finally, no significant correlations were found ($p>0.05$) between decision speed and accuracy. These results suggest that estimated verbal IQ, working memory, and decision speed are not individual variables that relate to target repetition accuracy in the single talker interference task used in this experiment.

*Table 4: Accuracy, Standard Measures, and Age of Participants* The accuracy, standard measures, and age of the 12 participants included in this study. Data include percent total target words used (%) for Native Speaker (NS) and non-native speaker (NNS), predicted verbal IQ, decision speed time (seconds), decision speed number of items correct, working memory score (out of 42), and participants’ age (years).

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Total target words repeated</td>
<td>65.97</td>
<td>8.76</td>
</tr>
<tr>
<td>% Distracter words repeated</td>
<td>3.89</td>
<td>2.26</td>
</tr>
<tr>
<td>% NS target words correct</td>
<td>70.11</td>
<td>7.99</td>
</tr>
<tr>
<td>% NNS target words correct</td>
<td>61.95</td>
<td>10.54</td>
</tr>
<tr>
<td>Predicted verbal IQ</td>
<td>115.08</td>
<td>5.38</td>
</tr>
<tr>
<td>Decision speed time</td>
<td>168.67</td>
<td>19.97</td>
</tr>
<tr>
<td>Decision speed number correct</td>
<td>37.67</td>
<td>2.67</td>
</tr>
<tr>
<td>Working memory (Listening span)</td>
<td>39.42</td>
<td>2.23</td>
</tr>
<tr>
<td>Age</td>
<td>29.08</td>
<td>11.04</td>
</tr>
</tbody>
</table>

**Sentence Repetition Error Type Patterns: Phonetically and Semantically Related Errors**

The most common error type involved words that were phonetically similar to the target (mean=16.58 words per participant, range=8-35, $SD=8.23$). The second most common errors were words spoken by the distracter talker (mean=12.92 words per participant, range=1-28, $SD=8.74$). See Table 5 for error type data.
Table 5: Means, Ranges, and Standard Deviations of Error Analysis. Percent of error words produced by each participant that fall into each category listed by % (error type).

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>Range</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total words spoken</td>
<td>378.58</td>
<td>250-445</td>
<td>51.65</td>
</tr>
<tr>
<td>Words with errors</td>
<td>62</td>
<td>31-90</td>
<td>21.83</td>
</tr>
<tr>
<td>% words with errors</td>
<td>16.3</td>
<td>7.6-21.5</td>
<td>4.8</td>
</tr>
<tr>
<td>% phonetic errors</td>
<td>27.8</td>
<td>14.7-48.4</td>
<td>8.8</td>
</tr>
<tr>
<td>% semantic errors</td>
<td>15</td>
<td>5.6-36.7</td>
<td>8.18</td>
</tr>
<tr>
<td>% morphological errors</td>
<td>9.35</td>
<td>0-20.9</td>
<td>5.6</td>
</tr>
<tr>
<td>% other</td>
<td>15.3</td>
<td>6.1-23.2</td>
<td>4.96</td>
</tr>
<tr>
<td>% filler</td>
<td>8.8</td>
<td>0-27.5</td>
<td>9.01</td>
</tr>
<tr>
<td>% distracter spoken words</td>
<td>19.2</td>
<td>2.3-31.1</td>
<td>9.24</td>
</tr>
<tr>
<td>% distracter phonetic</td>
<td>3.2</td>
<td>0-7.5</td>
<td>2.63</td>
</tr>
<tr>
<td>% distracter morphological</td>
<td>1.3</td>
<td>0-5.6</td>
<td>1.7</td>
</tr>
<tr>
<td>% distracter semantic</td>
<td>0.2</td>
<td>0-2</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Results of t-tests comparing percent errors of two error types are shown in Table 6. The error types of phonetic, semantic, morphological, other, filler, and distracter words spoken were compared through separate t-tests. The distracter error categories (distracter morphological, distracter phonetic, and distracter semantic) were not included because these errors rarely occurred. Bonferroni correction was used to avoid Type I error. Because 15 t-tests were used to observe differences in error types, the chance increases that Type 1 error, or wrongly rejecting the null hypothesis, will occur. To account for this, the Bonferroni correction divides the significance level by the number of t-tests run to make it more difficult to reject the null hypothesis. Therefore, the significance level with this correction to determine error categories used significantly more by participants was $p \leq 0.0033$. Participants used phonetic errors significantly more than morphological, semantic, other, filler, and distracter spoken words. Participants used “other” errors significantly more than morphological and filler. Participants said words spoken by the distracter talker significantly more than morphological and filler. The most common secondary error (when an error could be categorized as two possible types) was
semantically related. Additionally, PPMC was used to determine any relationships between participants’ accuracy (percent target words correct) and error types. No significant correlations were found. These results will be addressed further in the discussion section.

*Table 6:* Results of *t*-tests Between All Error Types. Significant results before the Bonferroni Correction are shown. Significant results after the Bonferroni Correction are bolded.

<table>
<thead>
<tr>
<th>Error type and mean</th>
<th>Error type and mean</th>
<th><em>p</em> value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphological= 9.35%</td>
<td>Phonetic= 27.83%</td>
<td><em>p</em>=0.000004</td>
</tr>
<tr>
<td>Morphological= 9.35%</td>
<td>Other= 15.3%</td>
<td><em>p</em>=0.0117</td>
</tr>
<tr>
<td>Morphological= 9.35%</td>
<td>Distracter spoken= 19.15%</td>
<td><em>p</em>=0.0047</td>
</tr>
<tr>
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<td>Semantic= 14.98%</td>
<td><em>p</em>=0.0012</td>
</tr>
<tr>
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<td>Other= 15.3%</td>
<td><strong>p=0.0003</strong></td>
</tr>
<tr>
<td>Phonetic= 27.83%</td>
<td>Filler= 8.76%</td>
<td><strong>p=0.0003</strong></td>
</tr>
<tr>
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<td>Distracter spoken= 19.15%</td>
<td><em>p</em>=0.0279</td>
</tr>
<tr>
<td>Other= 15.3%</td>
<td>Filler= 8.76%</td>
<td><em>p</em>=0.0382</td>
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<tr>
<td>Filler= 8.76%</td>
<td>Distracter spoken= 19.15%</td>
<td><em>p= 0.0106</em>*</td>
</tr>
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</table>
DISCUSSION

Repetition Accuracy

Observing how participants perform on a single talker interference task provides insight into how individuals react to difficult listening situations in daily life. People often carry on conversations in noisy environments (e.g., restaurants, stores) and with distractions (e.g., television). One reason it is important to study how typical adults process speech in challenging situations is to help understand deficits in speech processing. For example, communicating in difficult listening situations becomes more challenging for individuals after a TBI. Studying how people with and without TBI perform in single-talker interference tasks will help clinicians determine expectations regarding how well people listen in distracting situations.

Previous research has focused on single talker interference with a variety of extraphonemic variables, but the current study is the first to examine the role of attention regulation by randomly switching the target talker and including a native speaker (NS) and non-native speaker (NNS). Brungart (2001) conducted single-talker interference task research with nonimpaired participants. In this study, the participants attempted to attend to the target and responded by selecting the colored number on a computer screen that was spoken by the target talker. Participants were between 70% and 90% accurate depending on the talker conditions in the current study. Aside from using single-word number stimuli, conditions included different sexes of talkers, spatial separation, signal to noise ratio. One factor that may add complexity to speech processing is accommodating to an unfamiliar accent. In the current study, participants repeated an average 65.97% of target words. It is not surprising this percent is lower than that of Brungart’s study, because participants were asked to repeat sentences in the current study rather than asked to recognize what was said by the target. In a previous study including different
participants and some unique procedures, participants correctly identified the target talker when given the two sentences from the trial in a forced choice task with a mean of 89.9% accuracy (Krause, Parlette, & Reif, 2014). This suggests participants are able to correctly identify the target from the distracter. Considering the added difficulty of recalling the unpredictable sentences, participants in the current study were not far off in their accuracy compared to the findings of Brungart’s study. Participants in the current study repeated few distracter words compared to target words, suggesting they were able to correctly identify and listen to the target talker despite the random order of visual cues. One preliminary study in which a participant with TBI completed a similar single-talker interference task found that he had much lower accuracy than a group of uninjured controls (Krause, Parlette, & Reif, 2014). Further research is needed with populations such as those with TBI to determine whether or not impairments in specific skills including executive functioning, attention, and memory affect the ability to attend to and repeat the target talker while blocking out the distracter.

**Nativeness of Target Talker and Other Factors Affecting Accuracy**

Previous research by Ji, Galvin, Chang, Xu, and Fu (2014) found that when listening to either a native speaker of English or a native speaker of Spanish speaking English in noise, participants with normal hearing found it easier to repeat the native English speaker. The study involved the participants rating the talkers on variables including intelligibility and accent, as well as recognizing spoken sentences. The non-native talkers had lived in the U.S. for 3-24 years. The normal hearing participants’ subjective rating scores for intelligibility were correlated with their performance (ability to recognize the correct sentence), but their accent ratings were not significantly correlated with accuracy. While nativeness of the target talker was only part of an interaction effect, it may be worth investigating whether accuracy in the single-talker
interference task would be disproportionately affected by accent relative to sentence repetition in quiet.

Somewhat counter-intuitively, individuals with foreign language experience were significantly more accurate at repeating the NS than participants who did not indicate experience with a foreign language; both groups were equally accurate for the NNS speaker. One possible explanation is that the individuals with foreign language experience were able to better focus their listening skills during this difficult listening task. While it is not known why the participants with foreign language experience had an advantage repeating the NS but not the NNS, one possible factor is that none of the participants specifically had experience with the NNS’s native language of Mandarin. Follow up research should investigate whether individuals with and without foreign language experience would perform differently with a less intelligible NNS as a target, and whether specific experience with the native language of the NNS would provide an advantage. Subjective ratings regarding the talker’s intelligibility and accent (as collected by Ji et al., 2014) would also provide information regarding whether individuals with foreign language experience perceive native and non-native speech differently compared to people without foreign language experience.

Another factor that affected repetition accuracy was participants’ gender; females repeated significantly more target words than male listeners. Females perform slightly, but not significantly better on a variety of verbal tasks, including vocabulary, reading comprehension, and essay writing (Hyde & Linn, 1988). In the current study, female participants repeated a significantly higher number of target words. It is possible that although estimated verbal IQ scores according to the WTAR did not differ significantly (female mean= 114.3, male mean=115.8), females in this study may possess higher verbal skills not recognized by the
WTAR compared to males, giving the females an advantage. Additionally, it should be noted once again that the two talkers recorded for the single talker interference task are female.

**Lack of Correlations Between Cognitive/Linguistic Tests and Accuracy**

It was thought that individuals with increased verbal abilities might be more successful at reintegrating words that were not heard or processed correctly due to interference; however, no significant correlation between accuracy in this single talker interference task and estimated verbal IQ was found. Several possible implications exist regarding verbal IQ and performance on this single-talker interference task. First, it is possible that an individual’s verbal IQ may not be an important component in successful listening and sentence repetition in this type of task. While the participants’ speech output was used as the accuracy measurement for the experiment (number of target words correctly repeated), participants were instructed to repeat the target talker, not generate their own verbal response based on verbal reasoning skills. Participants with higher accuracy scores repeated the target talker’s sentence, which does not involve choosing appropriate or sophisticated words, but listening carefully and repeating what was said. Additionally, the majority of the words used in the sentences were common occurring words. There were occasional low-frequency words such as “wharf” and “pennant,” but overall, the words used were one and two syllable words that tend to represent concrete concepts and were intended for speech repetition tasks. Because estimated verbal IQ was not correlated with accuracy, this suggests the task may not utilize verbal intelligence abilities, or utilizes verbal skills not represented by the estimated verbal IQ scores. It is also possible that a minimum verbal IQ score for successful performance on this task exists. Individuals with low verbal IQ might do poorly on the task but that all of the participants were above that hypothetical threshold. Further study including a broader range of verbal IQs would be useful to explore this question.
There was a significant correlation between age and verbal IQ; however, this may provide support that verbal IQ is not an important participant characteristic that determines success in the single-talker interference task. Older participants had a higher verbal IQ, but older participants did not have higher accuracy scores in the experiment, suggesting their verbal IQ did not help them in the study. On the other hand, other age-related factors, such as subclinical hearing loss, could negatively impact performance on the single talker interference task, counteracting any benefit of higher verbal IQ.

Decision speed also did not correlate to any measures of accuracy. As with verbal IQ, decision speed abilities may not be associated with performance in this single-talker interference task. It may be that because all participants received training, the task of choosing which of the two talkers to attend to became relatively automatic and therefore individuals with faster processing speed did not experience any advantage. While participants were not instructed to complete the listening task as quickly or possible, they had minimal time to decide which talker to listen to and which to block out when the visual cue was presented.

The listening span task (which tested verbal working memory) also did not correlate with accuracy. One factor to consider is that no participants experienced a TBI or any other issues that would negatively impact their working memory abilities. Because participants needed to remember and repeat only one sentence in the single-talker interference task, it is possible that, as posited for verbal IQ, a nonimpaired individual’s working memory abilities are sufficient for this task, and subtle differences among typical adults do not make a difference in their sentence repetition performance. Holding one sentence in working memory without any distractions (other than the second talker) may not have taxed nonimpaired participants’ working memory.
Finally, for all three cognitive measures (verbal IQ, decision speed, and listening span), there was not a great amount of variance among the 12 nonimpaired participants, making it less likely to find a significant correlation. Other variables that are not accounted for by standardized tests, including the amount of effort participants dedicated to the task or comfort with participating, may account for variations in accuracy in this task.

**Sentence Repetition Error Type Patterns**

Redintegration is a crucial process for successful listening because people encounter a variety of listening situations in which not all acoustic information is registered. In a single-talker interference task, it is likely that speech acoustic information will be degraded. Schweikert et al. (1999) found that a variety of factors affect the likelihood of the successful redintegration of speech, including the length of the inaudible or missing word, phonological characteristics of the word, and word frequency of the possible word choices. While their research focused on whether or not speech was successfully recalled or redintegrated, they did not report what types of errors individuals made when attempting to repeat speech. One of the goals of the current study was to observe what words participants produced when they were unable to understand the entire target sentence during the single-talker interference task.

Participants used phonetic sounds from the target talker most frequently compared to other categories of errors when unable to repeat the target word correctly, suggesting that they were often able to hear at least a portion of the relevant acoustic information. Participants also often chose words that not only shared phonetic characteristics with the target word, but also were semantically appropriate in the sentence. It can be assumed that nonimpaired participants are therefore able to consider both what sounds they heard and the meaning of the sentence when attempting to redintegrate a word. This process occurred very quickly, as they attempted to
repeat the sentence immediately following the presentation of each sentence pair. The ability to choose a word that both includes sounds from the target word and that carries appropriate meaning in the sentence is clearly beneficial to successful communication in day-to-day contexts. Understanding the abilities of nonimpaired adults in this type of task will be useful for future studies involving people who have difficulty with complex speech processing. For example, individuals with TBI may experience more difficulty simultaneously considering both phonological features of the missing word and the semantic context of the sentence.

Some participants used “something” in place of the word they were unable to repeat, while others did not use these filler words very often. This may have been used as a strategy to maintain the cadence of the target sentence; however, no significant correlation between accuracy and the “filler” error type was found, possibly because a small number of participants used a high number of fillers. Only two participants used fillers frequently (14 and 15 times, greater than 20% of each participant’s overall errors). The other 10 participants used 0-6 fillers. It may be that while some participants may have found it easier to repeat the sentence by keeping its cadence, it did not help them to repeat or redintegrate more words.

In some trials, participants were particularly prone to combining phonetic characteristics of both the target and distracter words. For example, in trial 18, the words “pencil” and “tin” were spoken simultaneously (one word by the NS and one by the NNS). In this trial, three participants said the correct target word, six participants said nothing, and three participants spoke a word with phonetic characteristics from both “tin” and “pencil” (either “tinsel” or “utensil”). This suggests the distracter talker did interfere with the target, and in some cases participants were unable to completely block out the distracter talker. It may be possible to create
a study in which the stimuli possess qualities that allow the researcher to observe the phonetic and semantic weight participants include in their response.

**Limitations**

This study included a small number of participants, making results less likely to generalize to the general population. Additionally, six participants (50%) completed or were in the process of completing a master’s degree. According to the United States Census Bureau, in 2011, 11% of the population 25 years and older had a master’s degree or higher (U.S. Census Bureau, 2011). Therefore, the number of participants with a graduate degree or pursuing a graduate degree does not represent the general population.

As discussed previously, because the population studied was nonimpaired and had not experienced TBI or known factors affecting cognition, standardized test scores may not have varied enough to produce significant correlations between test scores and performance. While the purpose of this study was to observe how nonimpaired individuals perform on the single-talker interference task and standard measures, involving individuals with TBI or other impairments may result in greater variance among participants. Comparing performance between nonimpaired and impaired individuals may indicate what cognitive processes or abilities are most important in difficult listening situations.

While this study observed participant errors in order to understand how listeners respond to and attempt to redintegrates speech in difficult listening situations, errors can not necessarily be interpreted as intentional strategies. The sentences in the experiment were overlapping, and the milliseconds between sentences spoken by the distracter rarely, if ever, lined up exactly with an entire word spoken by the target. While this has not been tested specifically, it is assumed that interference occurs for all target sentences, and participants must ignore the distracter talker
while listening to the target talker. For words that participants repeated without error, there is no way to know which were correct due to successful redintegration despite interference and difficulty blocking out the target talker, versus which words participants repeated with confidence because they successfully ignored the distracter talker.

**Future research**

As previously mentioned, further research should include more detailed methods to observe how participants respond and cope in the single-talker interference task, and what strategies (deliberate or automatic) they use. One way to accomplish this is to combine quantitative methods similar to those in this study with qualitative interviews with participants asking what they believe they are actively doing during the task. Additionally, a more in depth analysis of the characteristics of words in error (e.g., frequency weighted neighborhood density, frequency of words’ occurrence, length of words) may provide further understanding as to how people redintegrate speech. Participants could be instructed to attempt to specifically use a strategy while repeating (e.g., “say a word that fits into the sentence,” or “really listen to the sounds you hear to come up with a word”) to see if a particular strategy increases repetition accuracy.

Female participants’ superior accuracy in repeating more target words compared to males in this study is another area to examine in greater detail. Another single-talker interference task could include some trials with two males speaking, other trials with two females speaking, and others with one male and one female, which are easier overall (Brungart, 2001). Larger participant groups would allow analyses of interactions with factors such as age, precise hearing acuity, and verbal abilities. This would provide better understanding regarding how males and females perform in this type of complex speech processing task.
A crucial area for future research is the study of impaired populations. This may include the comparison of accuracy as well as error types between nonimpaired individuals and those with TBI. Although the cognitive tests used in this study did not reveal significant correlations, these measures should still be included if testing individuals with TBI because they may experience deficits in the areas of attention, memory, and decision speed. Correlating their scores with their accuracy on the single-talker interference task may reveal specific skills that are necessary for successful performance in a single-talker interference task, as well as daily difficult listening situations. Because many individuals with TBI report experiencing difficulty attending to conversations, particularly in distracting situations, finding ways to help them attend to a specific talker would be quite beneficial. Discovering effective strategies these individuals could use in their daily lives when speech input is not clearly understood would be useful and functional.

**Conclusions**

All individuals experience situations in which they miss some speech information because of various types of interference and must make an educated guess as to what was said. Individuals with impairments in attention and memory (among other cognitive skills) experience increased difficulty in successfully overcoming this interference in complex listening situations. This study observed how nonimpaired adults perform and respond in a single-talker interference task, which is designed to model real life difficult listening situations.

Participants were able to repeat 65.97% of target words on average while only repeating 3.89% of distracter words, suggesting that they successfully identified and attended to the target while blocking out the distracter. Females were more accurate than males at repeating the target talker. It was also found that participants with foreign language experience had an advantage,
specifically when repeating the NS. These findings provide a foundation for understanding performance expectations for nonimpaired adults and will offer a basis for comparison in future research involving individuals with impairments (e.g., TBI, SLI, cochlear implants).

This study was the first to observe not only how accurate participants are at repeating a target talker in a single-talker interference task with a non-native talker, but also what specific errors participants produce when attempting to repeat the target. This new perspective of redintegration revealed that participants in this situation relied on phonetic information from the target talker most heavily, while often simultaneously choosing words that were somewhat semantically appropriate. Future research that observes redintegration more specifically, as well as what automatic or metacognitive strategies aid in success of repetition, may improve therapy techniques for populations who struggle in difficult listening situations.
REFERENCES


Processing in a Single-Talker Interference Task. Unpublished dissertation,
University of Minnesota, Minneapolis, Minnesota.


APPENDIX A. WELLNESS SURVEY

Participant: _____________

Current time: _____________

1. What time did you wake up this morning? _______________

2. How many hours did you sleep last night? _______________

3. How much caffeine have you consumed today? (e.g., 2 cups of coffee) _______________
   Is this amount of caffeine normal for you? Circle: Yes No

4. How healthy are you today? (1 = very ill, 5 = very healthy)
   _____________________________
   1 2 3 4 5

5. How stressed do you feel at this time? (1 = no stress, 5 = maximum stress)
   _____________________________
   1 2 3 4 5
## APPENDIX B. WELLNESS SURVEY RESULTS

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<th>Participant</th>
<th>Hours sleep</th>
<th>Time since waking (hours)</th>
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<th>Healthiness (1-5)</th>
<th>Stress (1-5)</th>
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APPENDIX C. HSRB APPROVAL

DATE: August 4, 2014

TO: Miriam Krause, Ph.D.
FROM: Bowling Green State University Human Subjects Review Board

PROJECT TITLE: [300497-19] Speech Processing and Self-Regulatory Depletion in Adults With and Without Brain Injury

SUBMISSION TYPE: Revision

ACTION: APPROVED

APPROVAL DATE: August 4, 2014
EXPIRATION DATE: April 30, 2015

REVIEW TYPE: Expedited Review

REVIEW CATEGORY: Full Board review category

Thank you for your submission of Revision materials for this project. The Bowling Green State University Human Subjects Review Board has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

Modifications Approved:

1. New second task:

   - Use a puzzle persistence task as a measure of self-regulation depletion. The puzzle persistence task has been used effectively in previous studies of self-regulation depletion (e.g. Schmeichel & Vohs, 2009), and the response sheet is attached to this application. Each participant would still only complete one of these measures (either the writing task or the puzzle persistence task). This change requires modification of wording in the screening and consent forms, which previously referred only to the writing task. Updated versions of these forms.

2. Participants will complete a brief "Wellness Survey" the day of the experiment. The purpose of this survey is to collect data regarding factors such as sleep, caffeine intake, current illness, and stress level to observe whether or not they influence performance on the experimental tasks. No
personal identifying information (including the participant's name) will be written on the sheet, only the participant's experiment ID.

3. Elimination of foreign language experience as exclusion criterion: In previous phases of data collection, participants with more than four college semesters of foreign language experience have been excluded from this study. This exclusion based on foreign language experience was not based on any established research, but was instituted as a precaution. However, rather than continue to exclude otherwise appropriate participants from the study we propose to include them and then analyze whether language experience is actually a factor in sentence repetition accuracy.

The final approved version of the consent document(s) is available as a published Board Document in the Review Details page. You must use the approved version of the consent document when obtaining consent from participants. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that you are responsible to conduct the study as approved by the HSRB. If you seek to make any changes in your project activities or procedures, those modifications must be approved by this committee prior to initiation. Please use the modification request form for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. All NON-COMPLIANCE issues or COMPLAINTS regarding this project must also be reported promptly to this office.

This approval expires on April 30, 2015. You will receive a continuing review notice before your project expires. If you wish to continue your work after the expiration date, your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date.

Good luck with your work. If you have any questions, please contact the Office of Research Compliance at 419-372-7716 or hsrb@bgsu.edu. Please include your project title and reference number in all correspondence regarding this project.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Bowling Green State University Human Subjects Review Board's records.
APPENDIX D. CONSENT FORM

Two Studies Comparing Adults With and Without Traumatic Brain Injury

You are invited to be in two research studies about communication in people with and without traumatic brain injury (TBI). You were selected as a possible participant because you responded to a request for participants. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

The studies are being conducted by Miriam Krause, Ph.D., an adjunct professor in the Department of Communication Sciences and Disorders at Bowling Green State University, and her graduate students.

Background Information

The purpose of the Understanding Speech Study is to learn about how people with and without TBI understand speech in challenging situations. The purpose of the Writing/Number Study is to learn about how people with and without TBI are able to complete a challenging written task.

Procedures

The studies take place in the Health Center Building at Bowling Green State University. If you agree to participate, we would ask you to do both studies.

In the Understanding Speech Study, the main part of the experiment involves listening to sentences and repeating back all or part of the sentences based on how much you understand. These sentences will be played with other sentences overlapping them, which may make them harder to understand. In addition to repeating the sentences, you will be asked, “How much effort did it take to understand the sentences you just heard?” using a scale where 1 = absolutely no effort and 10 = extreme effort. Your responses will be audio recorded so the researcher can listen to them again later.

In the Writing/Number Study, the main part of the experiment involves either writing a story or completing a number puzzle.

As a second part of both studies, you will take several types of standardized assessments that are designed to evaluate things like vocabulary, processing speed, and short-term memory. You will only do each test one time.

Your participation in the studies will be done on one day, in a 60-90 minute appointment, including several breaks.

If you have had a TBI, we will ask you to sign a HIPAA form to allow us to view your medical records. The purpose of this is to confirm your diagnosis of brain injury, including the type and severity of injury.

Risks of Being in the Studies

The studies have minimal risks to you. First, you may become bored or frustrated with the testing; second, the testing may be tiring. Some people may also feel uncomfortable discussing the history or effects of brain injury. If you become tired or frustrated, you can take a break at any time.

Benefits of Being in the Studies
The studies will not benefit you directly. The knowledge they provide will contribute to our understanding of the effects of TBI.

**Compensation**

To thank you for participating in these studies, you will receive a $10 gift card. If you were recruited through the Psychology Department Sona system, you may choose to receive course credit instead of the $10.

**Confidentiality**

The records of these studies will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify a participant. Research records will be stored in a locked filing cabinet in Dr. Krause’s lab and only researchers involved with this study will have access to the records.

**Voluntary Participation and Ability to Withdraw from the Studies**

Your participation in these studies is completely voluntary, and you are free to withdraw consent and to stop participating in the project at any time. Your decision whether or not to participate will not affect your current or future relations with Bowling Green State University or any other organization. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

**Contacts and Questions**

The researcher conducting this study is: Miriam Krause, Ph.D., CCC-SLP. You may ask any questions you have now. If you have questions later, please contact Dr. Krause at the Communication Sciences and Disorders Department, 419-372-2515 or miriamk@bgsu.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), you can contact the Human Subjects Review Board at 419-372-7716 or hsrb@bgsu.edu.

*You will be given a copy of this information to keep for your records.*

**Statement of Consent**

I have read the above information. I have asked any questions I have, and have received answers. I consent to participate in the study.

Signature: ___________________________________________ Date: __________________

Signature of Investigator: _____________________________ Date: __________________

☐ I am interested in being contacted about participating in future studies.

☐ I am NOT interested in being contacted about participating in future studies.
Two Studies Comparing Adults With and Without Traumatic Brain Injury

HIPAA (Health Insurance Portability and Accountability Act) Requirements

For participants with history of traumatic brain injury (TBI)

1. You are being asked to sign this form so that your protected health information, including your name and date of birth, can be used to verify your TBI history with your health care provider (doctor or hospital). **No other protected health information will be used.**

2. By signing this form, you are giving authorization for (Name of hospital or doctor)_________________________ to share information about your medical history with Dr. Krause. Only Dr. Krause and researchers working on this project will have access to your information.

3. This authorization does not have an expiration date. The information will be requested once and, if you have given permission for us to contact you about other studies, we will keep the information in a locked filing cabinet for future reference.

4. However, you may revoke your authorization at any time. You can do this by informing Dr. Krause, in writing, and she will confirm in writing that you have revoked authorization to access your protected health information. At this time your information will be disposed of securely (shredded).

5. You should be aware that it is possible that disclosed information may be accidentally re-disclosed and no longer protected. Your information will be kept in a locked filing cabinet, but re-disclosure due to unforeseen circumstances is a possibility.

I have read and have been informed about this form, and I give authorization for the use of my protected health information for this research study.

Signature:__________________________________________ Date: __________________

Printed Name:__________________________________________

Date of Birth: ____________________________
APPENDIX E. IEEE SENTENCES

Speaker 2: The FIRST WORM GETS SNAPPED EARLY.
Speaker 1: The STRAW NEST HOUSED FIVE ROBINS.
Speaker 2: The BRASS TUBE CIRCLED the HIGH WALL.
Speaker 1: The BLIND MAN COUNTED his OLD COINS.
Speaker 2: The DARK POT HUNG in the FRONT CLOSET.
Speaker 1: The GOLD RING FITS only a PIERCED EAR.
Speaker 2: The FLINT SPUTTERED and LIT a PINE TORCH.
Speaker 1: The COLD DRIZZLE will HALT the BOND DRIVE.
Speaker 2: The STORE WALLS were LINED with COLORED FROCKS.
Speaker 1: The BLIND MAN COUNTED his OLD COINS.
Speaker 2: The BRASS TUBE CIRCLED the HIGH WALL.
Speaker 1: The STRAW NEST HOUSED FIVE ROBINS.
Speaker 2: The FIRST WORM GETS SNAPPED EARLY.
Speaker 1: The GOLD RING FITS only a PIERCED EAR.
Speaker 2: The FLINT SPUTTERED and LIT a PINE TORCH.
Speaker 1: The COLD DRIZZLE will HALT the BOND DRIVE.
Speaker 2: The STORE WALLS were LINED with COLORED FROCKS.
APPENDIX E. CONTINUED

Speaker 2 The CLOTHES DRIED on a THIN WOODEN RACK.
Speaker 1 The HITCH BETWEEN the HORSE and CART BROKE.
Speaker 2 The YOUTH DROVE with ZEST, but LITTLE SKILL.
Speaker 1 The FACTS DON'T ALWAYS SHOW who is RIGHT.
Speaker 2 The BANK PRESSED FOR PAYMENT of the DEBT.
Speaker 1 The MAIL COMES in THREE BATCHES per DAY.
Speaker 2 The YOUTH DROVE with ZEST, but LITTLE SKILL.
Speaker 1 The FACTS DON'T ALWAYS SHOW who is RIGHT.
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APPENDIX E. CONTINUED

Speaker 1 The NIGHT SHIFT men RATE EXTRA PAY.
Speaker 1 The SUN CAME up to LIGHT the EASTERN SKY.
Speaker 2 The WRECK OCCURRED by the BANK on MAIN STREET.
Speaker 1 The SLAB was HEWN from HEAVY BLOCKS of SLATE.
Speaker 2 The SHELVES were BARE of BOTH JAM or CRACKERS.
Speaker 1 The SLAB was HEWN from HEAVY BLOCKS of SLATE.
Speaker 2 The JUICE of LEMONS MAKES FINE PUNCH.
Speaker 1 The BILL was PAID EVERY THIRD WEEK.
Speaker 2 The RED PAPER NED the DIM STAGE.
Speaker 2 The POOR BOY MISSED the BOAT AGAIN.
Speaker 2 The SOFT CUSHION BROKE the MAN'S FALL.
Speaker 1 The FRIENDLY GANG LEFT the DRUG STORE.
Speaker 1 The WIDE ROAD SHIMMED in the HOT SUN.
Speaker 2 The BIRCH CANOE SLID on the SMOOTH PLANKS.
Speaker 2 The YOUNG GIRL GAVE no CLEAR RESPONSE.
Speaker 1 The LEASE RAN OUT in SIXTEEN WEEKS.
Speaker 1 The BOY was THERE WHEN the SUN ROSE.
Speaker 2 The BOX was N BESIDE the PARKED TRUCK.
Speaker 2 The STRAY CAT GAVE BIRTH to KITTENS.
Speaker 1 The SLUSH LAY DEEP ALONG the STREET.
Speaker 1 The URGE to WRITE SHORT STORIES is RARE.
Speaker 2 The HOGS were FED CHOPPED CORN and GARBAGE.
Speaker 2 The FROSTY AIR PASSED THROUGH the COAT.
Speaker 1 The TINY GIRL TOOK OFF her HAT.
Speaker 1 The IDEA is to SEW BOTH EDGES STRAIGHT.
APPENDIX E. CONTINUED

Speaker 2  The GIRL at the BOOTH SOLD FIFTY BONDS.
Speaker 2  The WAGON MOVED on WELL OILED WHEELS.
Speaker 1  The LAWYER TRIED to LOSE HIS CASE.
Speaker 1  The TWO MET WHILE PLAYING on the SAND.
Speaker 2  The SALT BREEZE CAME ACROSS from the SEA.
Speaker 2  The NAVY ATTACKED the BIG TASK FORCE.
Speaker 1  The PIPE BEGAN to RUST WHILE NEW.
Speaker 1  The WALLED TOWN was SEIZED WITHOUT a FIGHT.
Speaker 2  The SWAN DIVE was FAR SHORT of PERFECT.
Speaker 1  The PLAY SEEMS DULL and QUITE STUPID.
Speaker 1  The CLOCK STRUCK to MARK the THIRD PERIOD.
Speaker 2  The COLT REARED and THREW the TALL RIDER.
Speaker 2  The HOG CRAWLED UNDER the HIGH FENCE.
Speaker 1  The PENNANT WAVED WHEN the WIND BLEW.
Speaker 1  The CEMENT had DRIED WHEN he MOVED IT.
Speaker 2  The WRIST was BADLY STRAINED and HUNG LIMP.
Speaker 1  The CUP CRACKED and SPILLED ITS CONTENTS.
Speaker 1  The LARGE HOUSE had HOT WATER TAPS.
Speaker 2  The YOUNG KID JUMPED the RUSTY GATE.
Speaker 1  The DOCTOR CURED HIM with THESE PILLS.
Speaker 1  The INK STAIN DRIED on the FINISHED PAGE.
Speaker 2  The LAZY COW LAY in the COOL GRASS.
Speaker 2  The JUST CLAIM GOT the RIGHT VERDICT.
Speaker 1  The CHILD ALMOST HURT the SMALL DOG.
Speaker 1  The THAW CAME EARLY and FREED the STREAM.
Speaker 2  The CROOKED MAZE FAILED to FOOL the MOUSE.
Speaker 2  The  TONGS  LAY  BESIDE  the  ICE  PAIL.
Speaker 1  The  RUDE  LAUGH  FILLED  the  EMPTY  ROOM.
Speaker 1  The  PAPER  BOX  is  FULL  of  THUMB  TACKS.
Speaker 2  The  FRUIT  PEEL  was  CUT  in  THICK  SLICES.
Speaker 2  The  BIRCH  LOOKED  STARK  WHITE  and  LONESOME.
Speaker 1  The  PLUSH  CHAIR  LEANED  AGAINST  the  WALL.
Speaker 1  The  TREE  TOP  WAVED  in  a  GRACEFUL  WAY.
Speaker 2  The  HEART  BEAT  STRONGLY  and  with  FIRM  STROKES.
Speaker 2  The  PRINCE  ORDERED  his  HEAD  CHOPPED  OFF.
Speaker 1  The  PURPLE  TIE  was  TEN  YEARS  OLD.
Speaker 1  The  MAP  HAD  an  X  that  MEANT  NOTHING.
Speaker 2  The  HAT  BRIM  was  WIDE  and  TOO  DROOPY.
Speaker 2  The  RED  TAPE  BOUND  the  SMUGGLE  D  FOOD.
Speaker 1  The  JUNK  YARD  HAD  a  MOLDY  SMELL.
Speaker 1  The  NEW  GIRL  was  FIRED  TODAY  at  NOON.
Speaker 2  The  SLANG  WORD  for  RAW  WHISKEY  is  BOOZE.
Speaker 2  The  CLAN  GATHERED  on  EACH  DULL  NIGHT.
Speaker 1  The  STALE  SMELL  of  OLD  BEER  LINGERS.
Speaker 1  The  SHAKY  BARN  FELL  with  a  LOUD  CRASH.
Speaker 2  The  EMPTY  FLASK  STOOD  on  the  TIN  TRAY.
Speaker 2  The  NEWS  STRUCK  DOUBT  into  RESTLESS  MINDS.
Speaker 1  The  CHILD  CRAWLED  INTO  the  DENSE  GRASS.
Speaker 1  The  LAKE  SPARKLED  in  The  RED  HOT  SUN.
Speaker 2  The  OFFICE  PAINT  was  A  DULL,  SAD  TAN.
Speaker 2  The  BOY  OWED  his  PAL  THIRTY  CENTS.
Speaker 1  The  NAG  PULLED  the  FRAIL  CART  ALONG.
APPENDIX E. CONTINUED

Speaker 1 The FLY MADE its WAY ALONG the WALL.
Speaker 2 The HOSTESS TAUGHT the NEW MAID to SERVE.
Speaker 2 The WALL PHONE RANG LOUD and OFTEN.
Speaker 1 The MUSIC PLAYED ON WHILE they TALKED.
Speaker 1 The FIGHT will END in JUST SIX MINUTES.
Speaker 2 The DOORKNOB was MADE of BRIGHT CLEAN BRASS.
Speaker 2 The LITTLE TALES THEY TELL are FALSE.
Speaker 1 The BLACK TRUNK FELL FROM the LANDING.
Speaker 1 The BEETLE DRONED in the HOT JUNE SUN.
Speaker 2 The LAMP SHONE with a STEADY GREEN FLAME.
Speaker 2 The SMALL RED NEON LAMP went OUT.
Speaker 1 The LONG JOURNEY HOME TOOK a YEAR.
Speaker 1 The KITTEN CHASED the DOG DOWN the STREET.
Speaker 2 The ANCIENT COIN was QUITE DULL and WORN.
Speaker 2 The FAN WHIRLED its ROUND BLADES SOFTLY.
Speaker 1 The RAM SCARED the SCHOOL CHILDREN OFF.