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COGNITIVE CONSEQUENCES OF DEGRADED SPEECH: THE EFFECT OF BACKGROUND NOISE, NOISE-VOCODED SPEECH AND LOW-PASS FILTERING ON SHORT STORY RECALL

By:

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A Capstone Project
submitted in partial fulfillment of the
requirements for the degree of:

Doctor of Audiology

Washington University School of Medicine
Program in Audiology and Communication Sciences

May 15, 2015

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Abstract: Recall accuracy for speech-degraded short stories was assessed in young adults with normal hearing sensitivity. Stories were presented in the clear, or in noise vocoded, low-pass filtered, or background noise conditions of varying difficulty. Propositional scoring was used to determine the accuracy of participants' recall. No significant effect on short story recall accuracy was observed for the degraded listening conditions. These results suggest that young adult listeners may be less susceptible to the extra cognitive challenge associated with degraded speech than might be predicted by the effortfulness hypothesis.

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ACKNOWLEDGMENTS

I would like to thank Dr. Jonathan Peelle for his insight, expertise, willingness to be bothered a lot, and unfailing patience. Taking young researchers under your wing is not something that is required of you, but you accepted the challenge with great skill and alacrity. I am eternally grateful for the wisdom you have shared and the assistance you have given.

Thank you to Dr. Lisa Davidson who let me take advantage of her wealth of knowledge on listening and cognition. Your insight is invaluable.

Thank you to Carol Iskiwitch who has been a wonderful partner in arms throughout this whole process. I very much appreciate your assistance scoring, transcribing, rallying the undergrad troops, recording and preparing stimuli, and generally keeping things organized.

Thank you to Dr. Matthew Winn who allowed me the use of a few of his Praat scripts and who also makes for a wonderful sounding board when I am pondering study methods and strange results.

Finally, I would like to express my great gratitude to all the undergraduate students working in Dr. Peelle's lab who have assisted me in the editing of my stimuli and transcription of participant responses. I honestly do not know if this study would have come together without your help.

Research reported in this publication was approved by Washington University's Institutional Review Board (201310095; Approved: 2/10/2014)

Research reported in this publication was supported by Washington University in Saint Louis Department of Otolaryngology. The content is solely the responsibility of the authors and does not necessarily represent the official views of Washington University.

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ABBREVIATIONS

ANOVA	Analysis of Variance
BN	Background noise
fMRI	Functional magnetic resonance imaging
LPF	Low-pass filtered
NV	Noise-vocoded
PTA	Pure tone average
RMS	Root mean square
SNR	Signal-to-noise ratio
SRT	Speech reception threshold

INTRODUCTION

Outside of the test booth, speech is rarely encountered in a manner that allows for perfect intelligibility for the listener. The prevalence of background noise, the imperfect speech patterns of the speaker in connected discourse, and the presence of distortion in the signal as well as within the listener's auditory system may all impact how accurately and efficiently the listener perceives a signal. The accuracy of the representation within a listener's auditory system is often gauged in the clinic through the use of word and sentence reception tasks wherein a patient must repeat back verbatim a word or sentence that was just played for them. Such tasks present a minimal short-term memory load and seek to assess how accurately the speech is being represented in the auditory system. When the speech is presented with some form of environmental degradation or a hearing loss is present, the task may become more difficult for the listener, such that intelligibility suffers. In recent decades, however, it has been suggested that some cognitive effects may be present when a signal is degraded in some fashion, even if speech intelligibility is not adversely affected. It has been postulated that the greater effort needed for one to perceive and process degraded speech takes away from cognitive resources a listener has available to spend on other cognitive tasks, such as working memory storage and retrieval. This theory, coined the "effortfulness hypothesis" by Rabbitt (1968, 1990), has been explored in various populations and with various different assessment methods.

When Rabbitt (1968) first explored the effects of effortful listening on memory, he enlisted normal hearing participants to perform several tasks probing how well they were able to hold lists of digits and details from prose passages played in short term memory when played in the presence of background noise. The lists of digits were presented either in a clear condition or in a condition in which the latter half of the list was presented in pulse-modulated white noise.

Conditions were created for the prose passage task in a similar fashion, wherein the passage was presented in either a completely clear condition or a condition in which the first half of the passage was presented without background noise and the latter half was presented in white noise. The study found that participants were less accurate at recalling digits in the first half of a digit list when the second half was presented in noise. Although participants were able to repeat back the digits accurately, Rabbitt found their ability to recall the list was impeded when noise was introduced into the signal. The noise produced a similar interference effect when participants answered questions about the content of prose passages presented half in noise, with participants demonstrating poorer recall on details in the clear first half of the story and better recall of details in the noisy second half of the story. It has since been postulated that background noise disrupts the entry of the earlier speech information into a "memory buffer," thus weakening the associative links between the words and making them more difficult to recall (Piquado, Cousins, Wingfield, and Miller, 2010).

Rabbitt theorized that effortful listening affected memory storage by interrupting the listener's rehearsal, elaborative encoding, and deep processing, levels of processing proposed by Craik and Lockhart (1972). These levels of processing were based on the concept that the encoding of a signal in memory is reliant upon what level of processing it achieves, starting with recognition of the physical characteristics of the signal (loudness, pitch, etc.) and moving onto more top-down variables such as contextual relevance, meaningfulness, and recent experience. The deeper the processing level – that is, the more meaning that can be attributed to the incoming signal – the more likely it is that the information will be stored in memory for later recall (Craik, 2002; Craik and Lockhart, 1972). It has also been proposed that the increased effort required in the processing of degraded speech stems from the requirement that the listener utilize top-down processing, such as the use of context or prior knowledge, in order to recover the information that was not gleaned from the acoustic signal (Pichora-Fuller, Schneider, & Daneman, 1995). In contrast to the theory suggested by Rabbitt, this theory implies that the deleterious effects of degraded speech on short term recall is a consequence of top-down and bottom-up processes occurring concurrently, as opposed to the degraded speech simply failing to activate the higher order processing required for proper memory encoding. More current models have attempted to explain the disruptive effect of a degraded word on the recall of a list of clear words. These models support the idea that degraded speech increases one's reliance on verbal short-term memory, which is, in turn, necessary for encoding auditory input to memory (Cousins et al., 2013; Miller and Wingfield, 2010; Piquado et al., 2010).

Neural correlates of effortful listening have also been explored using functional brain imaging techniques. Using functional magnetic resonance imaging (fMRI), it has been shown that certain areas of the brain are responsive to a degraded speech signal and show increased activation when processing degraded speech. When neural activation for clear speech was compared to activation patterns for speech degraded in various fashions, a left-lateralized frontal and temporal lobe system emerged that demonstrated increased activation with degraded speech (Davis and Johnsrude, 2003). Increased activity in these regions is consistent with the idea that as processing demands become more complex, a small, centralized area of activation within the auditory cortex, known as the core region, spreads to more distal sections of the auditory cortex, known as the belt and parabelt regions. As the activation of these more distal areas expands, areas of the premotor cortex and areas of the inferior frontal gyrus will activate reciprocally, perhaps operating as a modulating force for these lower-level auditory areas in the auditory cortex and assisting in the recovery of meaning from the degraded speech signal (Davis and

Johnsrude, 2003; Kaas and Hackett, 2000). Further research supports the finding that a degraded speech signal will recruit the temporal lobe bilaterally and portions of the left frontal lobe (Adank, Davis, & Hagoort, 2012; Hervais-Adelman, Carlyon, Johnsrude, & Davis, 2012; Ramezani, Abolmaesumi, Marble, Chang, & Johnsrude, 2014) These left frontal lobe regions, including the anterior insula and the inferior frontal gyrus, are thought to be involved in the processing of higher levels of speech and cognition, including semantics, syntax, attention, and performance monitoring (Hagoort, Hald, Bastiaansen, & Petersson 2004; Rodd, Davis, & Johnsrude, 2005). Imaging studies therefore appear to support the concept that the perception of degraded speech enlists a higher amount of cognitive resources as evidenced by the activation of cortical regions outside those located in the temporal lobe and primary auditory cortex. Additionally, the activation of both higher order processing centers and lower level sensory processing centers appears to support the theory suggested by Pichora-Fuller et al. (1995) which implicated concurrent top-down and bottom-up processing in the effortful processing of degraded speech.

The evidence in support of the effortfulness hypothesis present at the neurological level is further supplemented by evidence from behavioral research. Behavioral measures of listening effort have aimed to assess this concept through various methods, including subjective reports of listening effort, participant reaction time to a secondary task, participant recall of word or digit lists, or some combination of these tasks (Hicks and Tharpe, 2002; Larsby, Hällgren, Lyxell, & Arlinger, 2005; McCoy et al., 2005; McFadden and Pittman, 2008; McCreery and Stelmachowicz, 2013; Pichora-Fuller et al., 1995; Rakerd, Seitz, & Whearty, 1995; Stewart and Wingfield, 2009; Surprenant, 1999, 2007; Tun, McCoy, & Wingfield 2009). In all cases, the auditory system is taxed during the comprehension of degraded speech and effort is assessed through performance on a cognitive task.

Investigations into effortful listening often focus on a population that is particularly vulnerable to the listening difficulties: individuals with hearing loss. For these listeners, speech degradation is inherent in their auditory system, allowing for the exploration of listening effort without artificial signal degradation. Increases in listening effort among listeners with hearing loss have been documented across the lifespan (Hicks and Tharpe, 2002; McCoy et al., 2005; McFadden and Pittman, 2008; Rakerd et al., 1995; Stewart and Wingfield, 2009; Tun et al., 2009). McCoy et al. (2005), for example, recruited older adults with good hearing relative to their age as well as presbycusic older adults with a mild to moderate hearing loss. Participants were then presented lists of words with varying numbers of words in each list at a suprathreshold level and were asked to recall the final three words of the list. While all participants demonstrated near perfect identification of the final word, the hearing loss group identified significantly fewer of the non-final words. This suggests that hearing loss alones increases cognitive load to such an extent that recall of clear speech is negatively impacted. Similarly, Hicks and Tharpe (2002) noted a decrease in reaction times in a secondary non-auditory task among children ages 6-11 with hearing loss when compared to normal hearing age-matched peers. The children were asked to press a button whenever a light came on while simultaneously repeating back words. Reaction times for the button press were significantly slower for children with hearing loss compared to the control group, although speech recognition scores did not vary between groups, suggesting children are not immune to the deleterious cognitive effects of difficult listening situations.

Complementing studies in listeners with hearing loss, presenting speech in the presence of background noise is a favored method for creating a challenging listening situation and has been examined in numerous publications (Larsby et al., 2005; McCreery and Stelmachowicz, 2013; Pichora-Fuller et al., 1995; Surprenant, 1999, 2007). Pichora-Fuller et al. (1995), specifically, recruited young normal hearing adults, older near-normal hearing adults, and older presbycusic adults to determine each group's ability to identify the final word in lists of sentences was examined. The sentences varied in final word predictability and were presented in the presence of 8-talker babble. The authors examined speech intelligibility by determining how well the sentence final words could be identified at various signal-to-noise ratios (SNRs). Working memory retention was then assessed by asking participants to recall the sentence-final words from blocks of 5 to 8 sentences. Participants in the study demonstrated greater difficulty with low context sentences in more challenging SNRs, suggesting that a harder listening situation forces greater reliance on context clues and thus exhibits greater effort. Consequently, all groups demonstrated poorer recall of the sentence final words at more challenging SNRs. The older adults, however, regardless of hearing status, demonstrated poorer recall at all SNRs compared to the younger adults, even though the words were perceived correctly in the intelligibility task.

While studies exploring the effortfulness hypothesis vary in regards to how cognitive load is assessed, results of these studies suggest speech degradation yields a decrement in recall performance similar to the findings of Pichora-Fuller et al. (1995). The recall of nonsense syllables by young and older adults when presented in background noise, for example, suffered in a similar manner (Surprenant, 1999, 2007). Larsby et al. (2005) additionally notes that performance accuracy on non-recall cognitive tasks declines in the presence of background noise and yields higher subjective scores of perceived effort, especially for participants with hearing loss. McCreery and Stelmachowicz (2012) examined the word recall of normal hearing children ages 6-12 years old who were presented low-pass filtered stimuli, as well as stimuli presented in the presence of background noise. In the more challenging listening situations, the length of the children's response times increased, and the accuracy of recall decreased, demonstrating results similar to the hearing impaired children examined by Hicks and Tharpe (2002).

These results of these studies not only provide convincing evidence in favor of the effortfulness hypothesis, but also suggest that effortful listening situations tax auditory and cognitive systems across a variety of populations. Although specific populations such as older adults and individuals with hearing loss may exhibit increased susceptibility to situations that induce effortful listening, prior research has demonstrated a clear effect of adverse listening situations on the ability to perform cognitive tasks among individuals across the lifespan. Young adults with normal hearing are not immune to such effects. The results of these studies also support the idea that regardless of where the degradation lies, in the damaged structures of the listener's auditory system or in the signal itself, cognitive demand and listening effort increase as intelligibility decreases.

Many studies exploring the effects of effortful listening on cognitive tasks have used test paradigms involving the perception and recall of single word lists or single sentences. The words in these tasks are typically unrelated and their recall requires little transformation or processing of the information. This type of task is not representative of realistic listening situations. In such situations, information is typically presented through connected discourse.

Connected discourse offers the listener some inherent advantages and disadvantages. Within connected discourse, salient points are often redundant such that should a listener miss a detail upon first hearing, they have the opportunity to pick it up on a subsequent repetition. However, should the listener miss a detail, they may miss information presented immediately afterward while attempting to decipher prior details. Natural connected discourse does not typically afford the listener extensive processing periods, which may increase cognitive effort when the discourse is presented in adverse listening conditions. However, the effects of these adverse listening conditions on discourse recall have not been extensively explored. Negative effects on discourse recall among young and older adults have been noted when speech in the presented passages was time compressed (Wingfield, Tun, Koh, & Rosen,1999). Piquado, Benichov, Brownell, & Wingfield (2012) examined the effect continuous versus self-paced discourse had upon the accuracy of discourse recall among young normal hearing adults and young adults with a mild to moderate hearing loss. Recall performance suffered in the continuous condition among participants with hearing loss but recovered to levels similar to those of normal hearing participants when participants were allowed to better set the pace of the speech. These data support the notion that listening to continuous discourse in adverse listening conditions may increase cognitive effort due to the lack of processing time available for the listener.

There are additional factors to be examined in regards to their impact on effortful listening. Within the current literature evaluating the effects of effortful listening on cognitive tasks, adding background noise is the most common approach to creating an adverse listening situation. However, it is possible to degrade speech in any number of ways, including noise vocoding (Shannon, Zeng, Kamath, Wygonski, & Ekelid, 1995) or spectral filtering. Each of these methods deprive the speech signal of different elements that may be useful to the listener when attempting to analyze the incoming auditory information. Noise vocoding, for example, will degrade the spectral resolution of a signal, forcing a listener to rely more heavily upon temporal information to decipher it. Low-pass spectral filtering may entirely eliminate some high frequency speech sounds and redundant speech cues that make clear speech effortless to understand. It has not, to this point, been extensively explored whether the type of degradation plays a role in the creation of an effortful listening situation and one's subsequent performance on cognitive tasks.

One challenge associated with using discourse recall as a measure of listening effort is that the evaluation of discourse recall is not quite as straightforward as the evaluation of word list recall. One particular method of evaluating a one's recall of prose passages that has gained recognition and acceptance involves the deconstruction of a passage into a hierarchy of details that allows researchers to assess the quantity of the details recalled as well as the overall importance of those details to the integrity of the prose. This system calls for the break down of the prose passage into propositions, or "idea units" that represent a single idea presented in the passage (Kintsch, 1988; Kintsch and van Dijk, 1978; Turner and Green, 1978). These propositions are placed into a hierarchy wherein the main ideas of a clause are placed at a higher level than the supporting or modifying details. This process of breaking down the passages allows the researcher to assess how much of each level of detail a listener is able to recall from the passages.

In the current study, we seek to provide a more naturalistic assessment of the effortfulness hypothesis through the evaluation of discourse recall. In order to create an adverse listening situation, the discourse was degraded to varying extents through the implementation of noise vocoding, low-pass filtering, and background noise. We used propositional recall scoring to determine whether, and to what extent, working memory encoding was interrupted by effortful listening conditions and whether this depended on the specific form of acoustic degradation used. Measures of cognitive and audiologic function were additionally performed to determine their impact on discourse recall.

METHODS

Participants

Recruitment, informed consent, and protocol for this study were approved by the Institutional Review Board and Human Studies Committee at Washington University in St. Louis School of Medicine. Four young adult male and 8 young adult females were recruited from Washington University in St. Louis and surrounding areas through word of mouth. Data from one participant was discarded due to tester error; data from a second was discarded due to the participant having difficulty with task instructions. The final study sample therefore consisted of 4 young adult males and 6 young adult females for a total sample size of 10. Participants ranged in age from 22 to 27 years with a mean age of 24.1 (SD = 1.52 years). All participants were right-handed native speakers of English and reported good overall health and hearing. All participants denied having ever been diagnosed with a hearing impairment. Testing consisted of one approximately 2 hour test session and all participants were compensated at $15 per hour at the end of the test session.

All audiometric testing, as well as any testing requiring the presentation of auditory stimuli during the study, was performed on a calibrated GSI-61 audiometer in a sound treated booth under TDH-50 headphones. Speech reception threshold (SRT) testing was performed along with air conduction pure tone thresholds for 0.25, 0.5, 1, 2, 3, 4, 6, and 8 kHz for the left and right ears. The average SRT for both ears was 4.25 dB HL (SD = 2.45) and none of the pure tone thresholds exceeded 25 dB HL at any of the test frequencies. The pure tone average (PTA) in the right ear ranged from -3.33 to 8.33 dB HL (SD = 3.93). PTA in the left ear ranged from -1.67 to 8.33 dB HL (SD = 3.06). Refer to Figure 1 for average right and left ear thresholds at all test frequencies. Prior to testing, the participants were administered the Shipley Vocabulary Test (Zachary, 1986), a multiple-choice assessment wherein participants must select synonyms for a list of 20 words. The average score on the vocabulary assessment was 15.2 synonyms correctly identified out of 20 (Range = 10-18; SD = 2.30).

Reading Span

An assessment of non-auditory working memory function was obtained through administration of the Daneman and Carpenter reading span task (Daneman and Carpenter, 1980). The reading span task assesses a participant's ability to hold words in working memory while processing competing linguistic information. The task was presented through the E-Prime Software Suite installed on a Lenovo ThinkPad laptop. Participants were presented sentence lists in blocks of one, two, three, four, or five sentences. Following the presentation of each sentence, the participant was asked to determine whether or not the sentence made logical sense. They were informed that this decision should be made as quickly as possible and should be indicated by pressing a key on the laptop for "yes" and a different key for "no." At the end of the sentence block, a screen appeared that prompted the participant to recall out loud the final word of each sentence seen in that sentence block. Participant accuracy was scored while the task was being performed. A total of 45 sentences were shown with three blocks of each sentence length (i.e. three blocks of one sentence lists, three blocks of two sentence lists, etc.). The length of sentence blocks increased sequentially, beginning with one-sentence blocks and finishing with five-sentence blocks. Reading span was determined as the sentence list length where the participant recalled two of the three sentence list blocks with 100% accuracy.

Pseudo-Word Listening Span

A pseudo-word listening span task (Szenkovits, Peelle, Norris, & Davis, 2012) was performed on participants in order to assess verbal short-term memory. The use of pseudo-words allows auditory memory alone to be assessed without the activation of higher order processing functions that are activated upon the perception of a known word (i.e., lexical and semantic processing). The stimuli used were novel words that involved combinations of phonemes frequently found together in the English language, such that the phoneme combinations were familiar to English listeners but devoid of any meaning ("rin," "toop," "charss," for example). A total of 23 words were concatenated into four lists of lists of two, three, four, or five words. The length of word blocks increased sequentially, beginning with two-word blocks and finishing with five-word blocks. The word lists were recorded by a female talker and presented via the E-Prime Software Suite loaded onto the Lenovo ThinkPad laptop. The audio output of the laptop was routed through the GSI-61 audiometer. Output was calibrated using the VU meter on the audiometer such that the stimulus words peaked at approximately 0 dB. The task was performed in a sound treated booth and presented binaurally at 40 dB above the SRT measured in each individual ear. The participants were instructed that they would hear lists of words that may sound like English words but are not words of English. They were instructed to repeat back the words they heard following presentation of the word list. Participant accuracy was scored while the task was being performed. Pseudo-word span was selected as the list length where the participant recalled three of the four list blocks with 100% accuracy.

Creation of Sentence and Story Stimuli

Novel sentences and connected discourse stimuli were created for this study. Sentence stimuli presented in all forms and levels of speech degradation were necessary in order to ensure the degradation allowed for sufficient intelligibility. Because the purpose of the various forms and levels of degradation is to provide a difficult listening situation and not an impossible one, a verification of sentence intelligibility was essential in order to confirm that effects seen on connected discourse recall were not due to inability to decode acoustic information. As such, sentences and connected discourse, hereafter referred to as "stories," were created at all levels in all three types of degradation.

Eleven fiction and eleven non-fiction stories were created for this study (see appendix A for the full stories). Stories ranged in length from 141 to 161 words, with an average length of 150.1 words (SD = 5.03 words). One fiction and one non-fiction story was selected randomly to be presented as practice stories to be presented to the participant prior to the presentation of the test materials. The remaining ten fiction and ten non-fiction stories were presented in the various test conditions. None of the stories were related and spanned a wide variety of topics. The fictional stories were typically descriptive narrative stories, while the non-fiction stories were heavier with concrete details such as numerical figures and specific dates. Stories were edited numerous times by various research personnel to the ensure phrasing of all the stories was natural and unobtrusive to the flow of the narrative. Forty syntactically simple eight-word sentences were also created for the measure of intelligibility (see appendix B for the full sentence list).

All stimuli were recorded by a single female speaker. Stories ranged in recording length from 53 to 70 seconds, with an average length of 59.14 seconds (SD = 4.44 seconds). Root mean square (RMS) equalization was performed on all sentence stimuli using the MATLAB software prior to any acoustic manipulations. Ten different conditions of sentence and story stimuli were created from these recordings: a clear condition, three levels of noise vocoding, three levels of low-pass filtering, and the addition of three levels of background noise. The addition of background noise and the noise vocoding of the stimuli was accomplished using MATLAB software. Low-pass filtering was accomplished using the Praat software. Noise vocoded (NV) speech was presented at 32, 16, and 8 channels. Low-pass filtered (LPF) speech was presented with cutoff frequencies of 3000, 2200, and 1500 Hz. Speech with competing noise was presented in speech shaped noise at SNRs of +10, +5, and 0 dB. Sentence stimuli were once again RMS equalized following each of these acoustic manipulations. The manipulations were selected to provide a gradient of listening difficulty for the participants such that the effects of each level of degradation may be monitored for effects upon discourse recall. The lowest, mid, and highest difficulty conditions for each of the three acoustic manipulations were judged by the authors to be of equivalent difficulty, such that the "easiest" SNR for the BN stimuli (the +10 SNR condition) was equivalent in listening difficulty to the "easiest" number of channels for NV stimuli (the 32 channel condition) and the "easiest" cut-off frequency for LPF stimuli (the 3000 Hz condition), and so on.

Sentence Intelligibility

The sentence stimuli were presented to the participant using a Lenovo ThinkPad laptop coupled to the GSI-61 audiometer. The sound files for each individual sentence and story was played from Windows Media Player and was calibrated prior to their presentation with a custom-made 1000 Hz calibration tone set to 0 dB on the VU meter of the audiometer. All sentences were presented binaurally at 40 dB above the SRT measured in each individual ear. Participants were asked to listen to the entire sentence and repeat back exactly what they heard. They were advised in advance that some of the sentences might be clear, while some may be difficult to understand. Participant accuracy was scored while the task was being performed.

Four sentences were presented in each of the ten test conditions for a total of 40 sentences. The sentences were organized into four-sentence blocks such that the same four sentences were always presented in the same test condition. The order of the sentence blocks was randomized for each participant. The types of degradation were also organized into blocks, such that the sentences were always presented in the lowest level of difficulty for that degradation first in the block and the highest level of difficulty last. The sentences in the NV block, for example, were always presented at 32 channels first and 8 channels last. Although the first four-sentence block was always presented in the clear condition, the presentation of the three degraded speech blocks was randomized across participants. The randomization of the sentence blocks and the degradation blocks ensured none of the participants received the same order of sentences in the same order of degradation.

Story Recall

The set-up for the presentation of the story stimuli was identical to that used for the sentence stimuli. Participants were informed that they would hear twenty stories total, each approximately one minute in length. They were told that some of the stories may be clear and easy to understand and other may be difficult to understand, similar to the sentences they had heard prior. They were asked to listen to the entire story and then try to recall as many of the details of the story as they could, starting from the beginning of the story and working their way toward the end. Upon completion, the participants were instructed to indicate that they were finished recalling what they could of the stories. All participant responses were recorded using the Audacity computer program and transcribed at a later point (transcribers were blind to the order of test conditions).

Prior to the presentation of the test stories, the participant was presented a single practice story in order to ensure the task was understood. If the participant performed the recall task acceptably, the second practice story was omitted. Presentation and randomization of the test story stimuli was completed in a manner similar to that of the sentence stimuli. Participants were presented a block of two stories, one fiction and one non-fiction, in each of the ten test conditions. The same two stories were always presented together within one degradation block, such that each particular fiction story was always presented with one particular non-fiction story. These fiction-non-fiction story pairs, or story blocks, were randomly selected and the fiction story was always presented first in each test condition. The order of the story blocks was randomized across participants. The individual degradation blocks were arranged identically to the degradation blocks described for sentence presentation; for each type of degradation, story blocks were presented in the "easiest" condition first, and the most difficult condition last. The presentation of these degradation blocks differs from the presentation described for the sentences in that the clear, non-degraded stories were not always presented first. The presentation of all of the degradation blocks (clear speech, NV speech, LPF speech, and BN speech) was randomized across participants, ensuring that none of the participants received that same order of stories in the same order of degradation.

Story Scoring

Score sheets for all 20 test stories were created prior to the start of participant testing. Stories were broken down into their propositional components and tiered spreadsheets were created to track the proposition levels. These score sheets were based off of the method of propositional scoring developed by Kintsch (1988) and Kintsch and van Dijk (1978), as described in detail by Turner and Green (1978). Stories were broken down by sentence and each sentence was further broken down into component propositions with six levels of propositions possible. The main idea of the sentence, devoid of any qualifying or clarifying details, was placed in the first proposition level and all modifying details were placed into lower levels based on their relationship to higher-level details (refer to Figure 2 for examples).

Participant recall was scored by one scorer who was unfamiliar with the presentation order of the stimuli for the participants. One point was awarded a participant for each proposition accurately recalled, with partial credit awarded when deemed appropriate. If a participant, for example, recalled a date in a story as "July 10th" when the actual date was "July 7th," they would receive partial credit for correctly recalling the month. Points were additionally rewarded to isolated lower-level details, regardless of whether higher-level propositions were recalled.

RESULTS

Reading Span and Pseudo-Word Listening Span

For both reading span and pseudo-word listening span, a span ranging from 1 to 5 was possible. For reading span, the average word span was 3.6 words (Range = 1-5, SD = 1.27). For the listening span task, the average pseudo-word span was 3.2 words (Range = 3-4, SD = 0.42).

Sentences

Scores on sentence repetition and on story recall were averaged within each condition. Proportion of sentences correctly repeated did not vary significantly across conditions, as shown in Table 1. Slight decreases in performance were noted in the 8-channel NV condition.

Stories

In order to determine whether any interaction existed between the type of degradation and the level of degradation difficulty, we performed a 3x3 repeated measures analysis of variance (ANOVA) with degradation type (BN, LPF, and NV) and level of difficulty (easiest, medium, hardest) as within-subject factors. Results for story recall are show in Figure 3. No significant interaction was seen with degradation type, $F(2,18) = 0.82$, $p = 0.46$, or level of difficulty, $F(2,18) = 0.52$, $p = 0.60$. Marginal significance was found in degradation type and level of difficulty interaction ($F(4,36) = 2.57$, $p = 0.054$).

To investigate the relationship between individual differences in auditory, cognitive, and memory performance, we performed Pearson correlations across these variables, shown in Table 2. Of note are the significant positive correlations between the PTA of the right ear and recall performance for both the average clear and average degraded speech recall, illustrated in Figure 4. A similar trend was not noted with the left ear PTA.

DISCUSSION

The effortfulness hypothesis has been supported by the results of numerous prior studies, indicating recall for words and sentences suffers when presented in an adverse listening situations or when presented to listeners with hearing loss (Hicks and Tharpe, 2002; Larsby et al., 2005; McCoy et al., 2005; McCreery and Stelmachowicz, 2013; McFadden and Pittman, 2008; Pichora-Fuller et al., 1995; Rakerd et al., 1995; Stewart and Wingfield, 2009; Surprenant, 1999, 2007; Tun et al., 2009). Only a limited amount of research has, however, been undertaken to examine the effects of a degraded speech signal on the recall of connected discourse (Piquado et al., 2012; Wingfield et al., 1999). Prior research demonstrates a decrease in recall performance as the listening situation increases in difficulty, as might be expected predicted by the effortfulness hypothesis. In the current study, we examined the impact of acoustic challenge on discourse recall in young adults with normal hearing. We did not find a significant impact of speech degradation was not noted in any of the degradation types or difficulties and as such, the data with the current sample size do not appear to follow the trends predicted by the effortfulness hypothesis. Furthermore, no interaction was seen between any of the cognitive assessments and discourse recall. Below we expand on our findings and their implications for the effortfulness hypothesis.

One inherent challenge in using discourse recall is that recall data are complex and reflect the interaction of a wide variety of cognitive and auditory factors. At a linguistic level, the incoming speech is analyzed at an acoustical level and lexical, syntactical, and semantic analyses are performed. Working memory processes are activated in order to retain the information being presented and are mediated by attention and other top-down processes (Wild et al., 2012). Discourse recall is an active process that involves not only the storage of information in memory but also the manipulation of that stored information in order to integrate previously presented information with information presently being presented (Just and Carpenter, 1980; Pichora-Fuller et al., 1995). As such, a number of variables that are difficult to control for will be inherently present when assessing discourse recall. A participant's prior knowledge of or personal feeling towards a certain topic, for example, could influence their ability to recall the details of a story. While the stories in the current study spanned a wide array of topics and were both fiction and non-fiction, some prior knowledge is inevitable when presenting meaningful discourse and represents a confounding factor in the accuracy of participant recall.

It must also be considered that the levels of degradation the stimuli were presented in may not have sufficiently taxed the auditory and cognitive systems of this group of young adults.

The intelligibility of sentences did not vary significantly between each of the listening conditions, indicating the majority of speech was still identifiable regardless of degradation type or degree of difficulty. Therefore, it is reasonable to suggest that perhaps reduced recall was not observed in this study because the listening situations were not challenging enough for the participants. The only condition where intelligibility appeared to suffer, albeit not to significant levels, was the 8-channel NV condition (mean proportion of sentence correctly repeated = 0.93, SD = 0.04). Because this was some of the participants' first experience with vocoded speech, it was not entirely unexpected that some difficulties might occur when listening to the sentences in the NV conditions. However, several studies have demonstrated that speech recognition does not suffer significantly until 4 to 6 channels are used, which indicates that perhaps a lower number of channels could be used in future studies in order to determine whether recall suffers with an even more difficult listening situation (Dorman, Loizou, & Rainey, 1997; Dorman & Loizou, 1998; Hill, McRae, & McClellan, 1968; Shannon et al., 1995). Regardless of whether the degradation was difficult enough to impact the accuracy of recall, it is possible that the cognitive effects of the degradation were too subtle to be measured using the methods utilized in this study. Young adults may have enough cognitive capacity to compensate for the difficulties of the degraded speech, preventing any measurable consequences on recall.

It certainly should be noted that the results are limited in their predictive power by the small sample size. Indeed, the interaction of degradation type and the level of difficulty approached significance ($p = 0.054$). A larger sample size could assist in parsing out whether the combination of degradation type and difficulty does in fact interact significantly with discourse recall. Additionally recall in the 8 channel NV condition was slightly diminished compared to the others and could have been exerting a force on the type and difficulty interaction that could be better clarified with a larger data sample.

Within this small sample, an unexpected positive relationship emerged between PTA in the right ear and accuracy of discourse recall, such that listeners with poorer hearing showed better recall performance. This finding is not supported by any of the current literature, which indicates a recall disadvantage to listeners with hearing loss (Hicks and Tharpe, 2002; Larsby et al., 2005; McCoy et al., 2005; McFadden and Pittman, 2008; Piquado et al., 2012; Rakerd et al., 1995; Stewart and Wingfield, 2009; Tun et al., 2009). This fact, in conjunction with a small sample size, suggests that this finding must be interpreted with caution. Further evidence of the trend would need to be identified before a feasible explanation could be explored.

In addition to the implementation of more difficult levels of degradation, new ways of evaluating the accuracy of the effortfulness hypothesis within the context of discourse recall need to be explored. While no trend was found for overall recall of the stories, recall within each individual proposition level should be explored to determine whether speech degradation exerted an influence on the recall accuracy of a certain level of detail within the stories. The length of time it takes for a participant to recall all possible details from a short story could additionally be explored as a metric for listening effort. A longer time for recall could potentially indicate the participant is having greater difficulty accessing the stored information for recall. Also, an assessment of recall organization could lend some insight into listening and recall effort. It was subjectively observed during this study that participants appeared to recall details of stories in a more disorganized fashion in the more difficult listening conditions. An analysis of how likely the participant was to present the details of the story in the order they appeared could be a useful tool for examining how organized the story representation was in the listener’s memory.

In addition to these future directions, an exploration of the impact of degraded speech on short story recall in populations with reduced cognitive resources may help to determine whether the cognitive resources of young adults in this study helped them to overcome the difficulties of listening to degraded speech. An investigation of brain regions activated during degraded speech listening and story recall could also be useful in determining whether the speech degradation is engaging a greater number of cognitive centers compared to clear speech.

CONCLUSIONS

In this study, short stories were presented to listeners in three different degraded listening conditions. Stories were presented at three different difficulty levels within each degradation type and the participants' ability to recall details from the short stories was assessed using a propositional scoring method. Short story recall was not significantly affected by any of the types or difficulty levels of degradation, suggesting these speech manipulations did not significantly impact how accurately details of the discourse were committed to memory. Additionally, reading span and pseudo-word listening span measures did not correlate with recall accuracy, while the pure-tone average in the right ear did demonstrate a significant correlation. Although our results did not demonstrate that degraded speech causes a detrimental effect on discourse recall as might have been predicted by the effortfulness hypothesis, further analysis of the data and a larger sample size will help better elucidate and verify the findings of this study.

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Table 1: Sentence Repetition Accuracy

	Clear	*10 dB SNR (BN)*	*5 dB SNR (BN)*	*0 dB SNR (BN)*	*32 Channels (NV)*	*16 Channels (NV)*	*8 Channels (NV)*	*3000 Hz (LPF)*	*2200 Hz (LPF)*	*1500 Hz (LPF)*
Mean	1.00	1.00	0.99	0.99	1.00	1.00	0.93	0.99	0.99	0.96
SD	0.00	0.00	0.01	0.03	0.00	0.00	0.04	0.02	0.01	0.06

Table 2: Pearson Correlation Coefficients for Cognitive, Audiologic, and Story Recall Tasks

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1. SRT (L)	--	0.371	0.149	0.307	-0.062	0.093	0.497	0.464
2. SRT (R)		--	0.831**	0.715*	0.250	0.250	0.578	0.561
3. PTA (L)			--	0.774**	-0.115	0.029	0.456	0.552
4. PTA (R)				--	-0.045	-0.156	0.734*	0.757*
5. Reading Span					--	0.375	0.262	0.042
6. Pseudo-Word Span						--	0.115	0.333
7. Clear							--	0.841**
8. Degraded All								--

** = Correlation is significant at the 0.01 level * = Correlation is significant at the 0.05 level

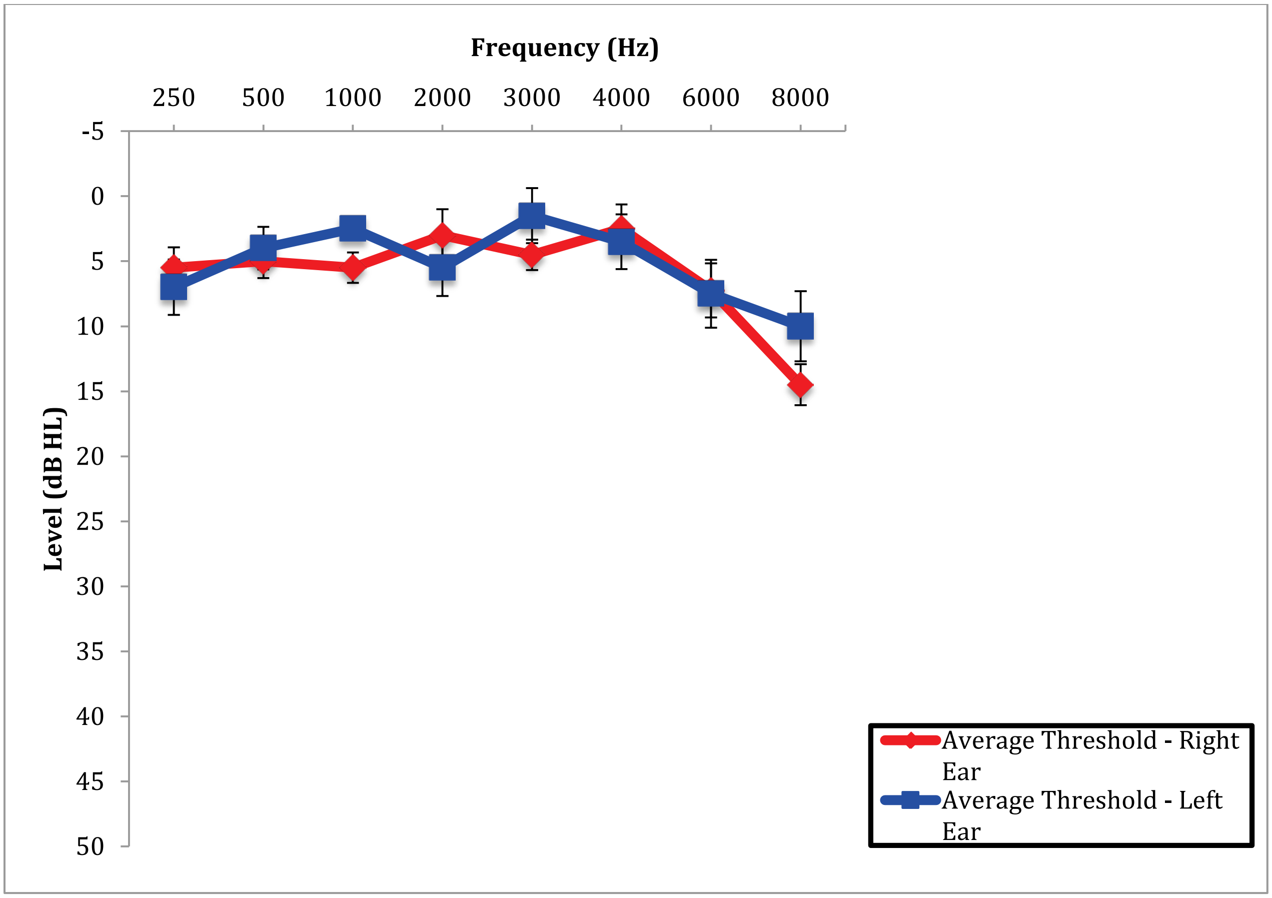


Figure 1: Average air conduction pure-tone thresholds in the right and left ears. Error bars represent the standard error.

Sentence 1: "Because of the discovery of many other similarly small planets around the solar system, they decided to lower Pluto's status in 2006 to a dwarf planet."

Level	
1	They (astronomers) decided
2	decided to lower Pluto
3	Pluto's status
3	to a dwarf planet
2	in 2006
2	Because of a discovery
3	discovery of planets
4	other planets
4	small planets
5	similarly small
4	around the solar system

Sentence 2: "Grieved by the death of her favorite human, Hera placed Aquarius' spirit in the stars where his beauty could be admired for the rest of time."

Level	
1	Hera placed Aquarius
2	Aquarius' spirit
2	in the stars
3	where he could be admired
4	his beauty could be admired
5	for the rest of time
2	(because) she was grieved
3	by the death
4	of her human
5	favorite human

Figure 2: Examples of the break down of story sentences into component propositions. Propositions were ranked hierarchically and put into "levels" depending upon their relation to the proposition in the level above them. Lower ranked propositions (i.e. a level 3 or 4 proposition) modify higher ranked propositions (i.e. a level 1 or 2 proposition). Both sentences were taken from novel stories presented to participants during the story recall task.

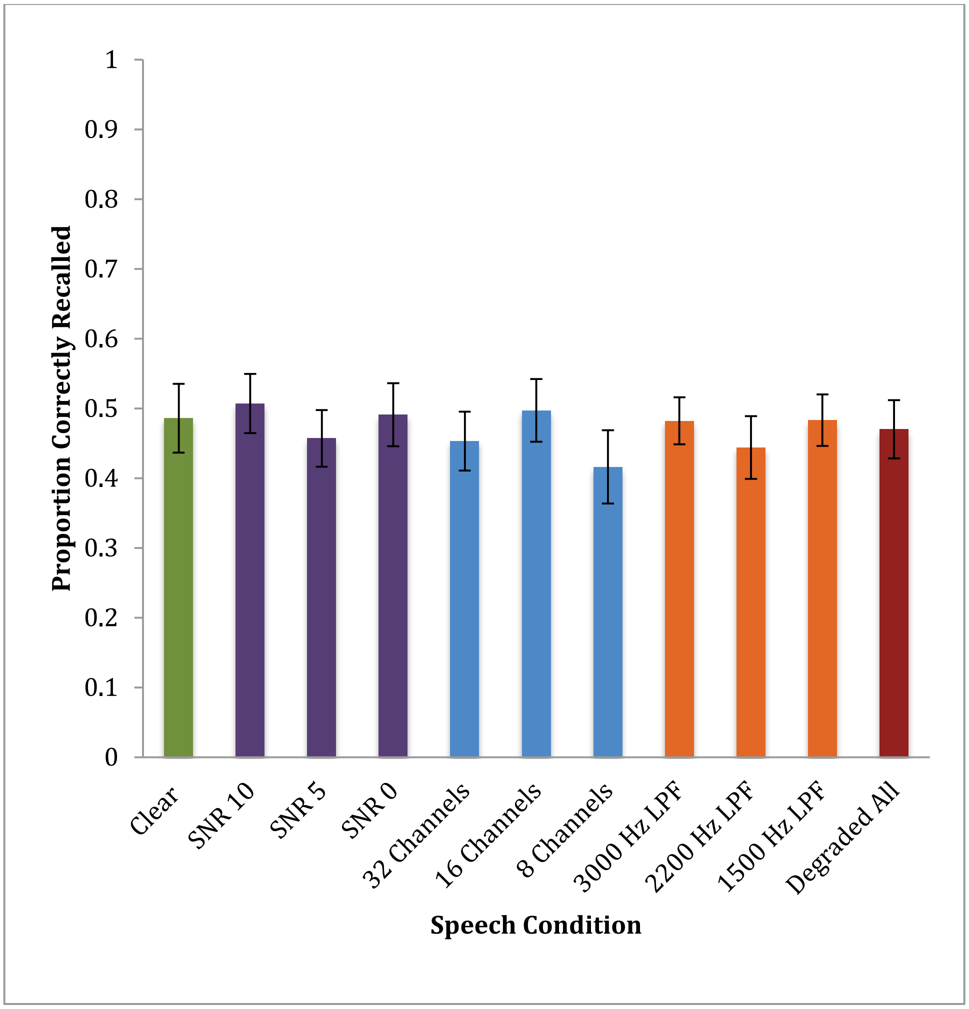
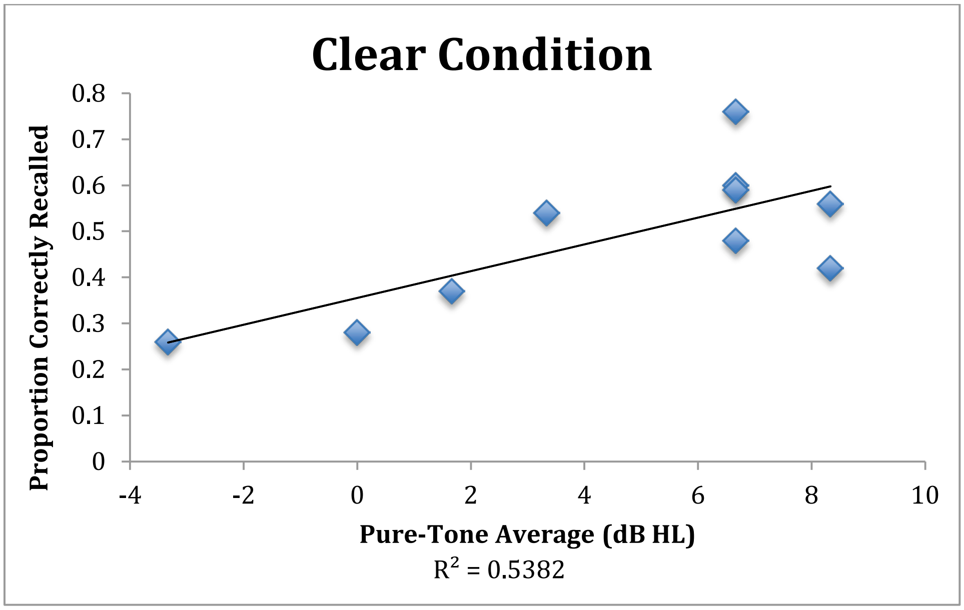


Figure 3: Average proportion of stories correctly recalled across all listening conditions. "Degraded All" indicates the average proportion of stories correctly recalled across all the degraded listening conditions. No significant differences were found between any of the listening conditions. Error bars represent the standard error.

a)



b)

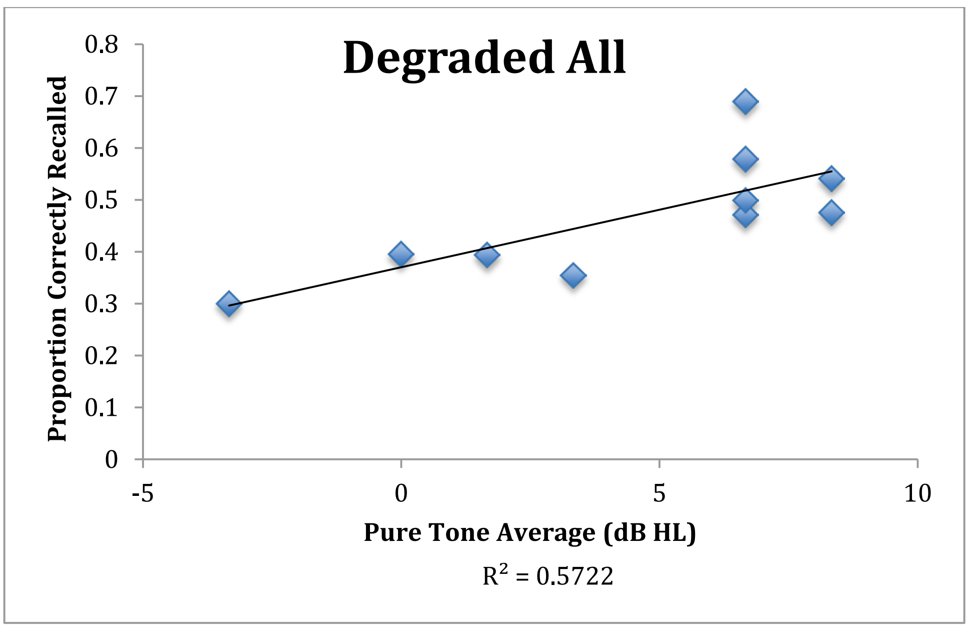


Figure 4: Pure tone averages for the right ear of all ten participants plotted against the average proportion of stories correctly recalled in the clear listening condition (a) and in all degraded listening conditions (b). Pearson correlation coefficient for the clear listening condition = 0.734. Pearson correlation coefficient for the degraded all condition = 0.757. Both are significant at the 0.05 level.

APPENDIX A

NON-FICTION

1. Lucy the Chimp
Lucy was a chimpanzee who, as a baby, was taken from her birth mother and given to human parents. The Temerlins, Lucy's foster parents, loved her and raised her like a human child. Lucy thrived at first, learning a number of human habits by imitating her parents. She learned rudimentary American Sign Language as a way of communicating, she ate all her meals at the dinner table, and she even understood human emotions. For example, Lucy comforted her foster mother whenever she was feeling sad. Unfortunately, when Lucy was twelve years old, she grew too strong and destructive for her suburban home. The Temerlins could no longer keep her, so they sent her to a rehabilitation center, hoping that she could assimilate to life with other chimps. It was very hard for Lucy, but eventually she was able to adapt to the new lifestyle.

2. Life on Mars
Mars, also known as the "Red Planet" because of its abundance of iron oxide, is the fourth planet from the sun in our solar system. Many people have wondered about the existence of life on Mars, with all speculation surrounding the idea that water is the key ingredient for life. While scientists believe that billions of years ago Mars once contained flowing water, and current research has found ice near the surface as well as near the polar caps, now Mars' temperature is too low and its atmosphere is too thin to ever contain water for a long period of time. Though still uncertain, some scientists believe that it's possible for water to exist during the warmer seasons of Mars' orbital rotation. Scientists have sent *Opportunity,* a NASA rover, to the planet's surface to gather data and perform experiments with the hope that it will one day find more answers.

3. Tigers: An Endangered Species
Tiger poaching has become a dangerous threat to the population of tigers over the last century. In illegal markets, every part of the tiger is in high demand. This includes tiger bones, which have been used as remedies in Chinese traditional medicine for centuries; tiger claws and teeth, which are symbols of good luck; and even tiger skin, which has been a symbol of status in many different cultures. As of 2013, scientists estimate there is a total of 3200 tigers left in the world, with the species on the brink of extinction. Three subspecies, the Bali, Javan, and Caspian tigers, have already gone extinct. Many dedicated environmental groups have fought fiercely to change the way humans treat these animals in the wild. The goal of these efforts is to double the population of tigers by halting all illegal poaching, as well as protecting and managing the wild cats' endangered habitats. (151)

4. The Ferris Wheel
The original Ferris Wheel was opened to the public in 1893 at the Chicago World's Fair. George Washington Gale Ferris Jr., against all odds, designed the fully functional wheel that became the largest attraction at the fair. The project took months to complete even with several different firms working at the same time, and was especially delayed due to the severe winter at the time. This particular ride was not like ordinary Ferris wheels seen today. It was 264 feet high, with 36 cars each weighing 26,000 pounds and fitting up to 60 people. It took one car twenty minutes to complete the two revolutions. As expected, the visitors at the fair were terrified of the new invention, but at the same time excited to give it a try. The Ferris Wheel proved to be an enormous success and ran smoothly until the end of the exposition.

5. Pluto
In 1906, the astronomer Percival Lowell believed that there was a ninth planet blocking Uranus' orbit, and set off to find his 'Planet X'. Finally, in 1930, years after Lowell's death, the planet Pluto was officially discovered. After many suggestions from around the world, Pluto was named by Venetia Burney, an eleven-year-old girl interested in mythology. Pluto is a name for the underworld and represents the planet's dark and cold characteristics. It also honors Percival Lowell by using his two initials. Pluto's lengthy orbit is 248 Earth years, and it also has a much more erratic elliptical than the other planets. Pluto's mass is roughly 1/6 of that of Earth, much smaller than previously thought. In the 1970s, astronomers began to question Pluto's status as a planet. Because of the discovery of many other similarly small planets around the solar system, they decided to lower Pluto's status in 2006 to a dwarf planet.

6. Fireflies
Fireflies, also known as lightning bugs, are tiny little beetles that light up in the dark. They appear mostly during the summer in tropical places all over the world because they are attracted to warm, moist environments. Fireflies have the ability to produce light from a light organ in their abdomen that combines oxygen and luciferin to create a glow that gives off almost no heat at all; however, scientists do not yet fully understand the purpose of the glowing. They believe that the blinking patterns play a role in the mating selection process, but cannot figure out how the pattern works. In addition, the blinking light may serve as a safety precaution from predators. On warm summer nights, catching fireflies is a fun family activity. Once caught, these remarkable little bugs can survive in jars with air holes and grass for a couple days at a time.

7. Coca-Cola
A young pharmacist named John Pemberton created the first cup of Coca-Cola in 1886. It was sold at a nearby pharmacy for five cents a glass, selling about ten glasses a day. Now, of course, Coca-Cola is one of the largest brands worldwide. Coca-Cola was named after its two main ingredients: cocaine and caffeine. The caffeine used to produce the soda came from the Kola nut, which can be found in the Kola trees in Africa. In 1903, significant amounts of cocaine were supposedly removed from the drink, switching from fresh leaves to "spent" leaves which only left traces of cocaine. Coca-Cola still uses extracts from the Coca plant, but they no longer use cocaine. Coca-Cola has kept the official formula of their added flavors a secret since the beginning of the company. It is rumored that only two executives know the formula, each possessing half of the mysterious recipe.

8. Disneyland
The first Disneyland was first opened on July 17th, 1955 in Anaheim, California. It was built in response to the multitude of letters Walt Disney received from fans asking to visit Walt Disney Studios. Walt believed that a working studio would not offer much to visitors in terms of amusement, so he set about to create a theme park that would entertain fans of Disney. Walt was invested in this project, even basing a section of the park, "Main Street U.S.A.," on his hometown of Marceline, Missouri. Unfortunately, during a preview event for invited guests before opening day, the park was plagued with issues, the worst being that the temperature was an unusually high 101 degrees fahrenheit and a plumber's strike caused drinking fountains to run dry. This, however, did not stop Disneyland California from becoming one of the most popular amusement parks in the world, inspiring the construction of four other Disney themed parks around the world.

9. Budweiser Clydesdales

When one thinks of the beer company Anheuser-Busch, the image of a group of large horses pulling a red wagon often comes to mind. These horses are the Budweiser Clydesdales and they have been an iconic image for the brewing company since 1933. To celebrate the repeal of Prohibition, August Busch Jr. bought his father August Sr. (the the president of Anheuser-Busch) a hitch of clydesdales. August Sr. realized the promotional potential of the horses and turned them into a symbol of his company. Since then, the Budweiser Clydesdales have appeared in dozens of television ads for the company, with the horses appearing in Super Bowl ads every year since 1986. There are three teams of eight Budweiser Clydesdales who travel around the world, one based in St. Louis, Missouri, one in Merrimack, New Hampshire, and one in Fort Collins, Colorado. Each team is also accompanied by an obedience trained Dalmatian, who rides in the modified Studebaker wagons the horses pull.

10. Redcoats
Anyone familiar with the American Revolution would be able to recognize the uniforms worn by the British during that war. British soldiers carried a highly distinguishable shade of red on their uniforms during the 18th century, when the war took place. This red coloring has its origins in the English Civil War, about a century before. Specifically, in the year 1645, the Parliament of England instituted a new national army, called the New Model Army, which wore coats of Venetian Red. This practice of dressing British foot soldiers in red continued until 1902, when Khaki was adopted. Historians have theorized on why the color red was chosen, with many pointing to the cheap cost of red dye as a possible explanation. Also, conspicuous colors such as red could actually prove an asset on the battlefield given that smoke from rifles often obscured one's vision, making it hard to distinguish friend from foe.

FICTION

1. The Weatherman and the Tornado
The weatherman raced towards the tornado in his heavy-duty weather truck. While everyone else was driving away from the monstrous funnel-shaped cloud that was rotating air at 200 miles per hour, Lucas raced on, determined to get his data. With the United States averaging 1000 tornadoes a year, Lucas knew that his recordings could help future scientists predict tornadoes and in turn save lives. Lucas could hear tornado sirens blaring in the distance, and he could see debris flying all around him. Once finally directly in the path of the tornado, he drilled his 50-pound sensors into the ground hoping they would survive to detect the speed and direction of the tornado's wind. He jumped back into the truck and sped off in the opposite direction, feeling a little bit scared for his life but mostly ecstatic from his successful work.

2. The Beetle and the Venus Flytrap
Ella and Brad, two curious little beetles, were crawling through the forest when they spotted a Venus flytrap. Ella, being the more reserved and logical of the two, warned Brad that those kinds of plants were dangerous to all sorts of bugs, including beetles. Ella knew that Venus flytraps were capable of shutting after detecting movement, and if caught, a bug would not be able to escape its fierce grip. Brad, however, was too confident to think that a plant could hurt a quick beetle like him. He flew up to the plant to inspect it, and laughed when he realized the plant stood still. But when Brad got too close and the wind rustled the hairs on the Venus flytrap, it instantly shut and knocked Brad onto his side. Shocked, Brad returned to Ella and thanked her for warning him about the plant's vicious nature.

3. The Scuba Diver
Suzy pulled the facemask over her eyes and nose. This was her first time scuba diving, and she knew she needed courage to leap into the water. Breathing only through her mouth, Suzy took long, deep breaths to calm herself. She felt a hand on her back, turned, and saw her father smiling at her encouragingly. Everything felt wrong, the skin-tight wet suit, the heavy tank on her back, and the uncomfortable flippers wrapped around her feet. Feeling her heart beat faster, she picked up the mouthpiece that was connected to her oxygen tank, and gently put it in her mouth. Tasting the compressed air, Suzy felt a wave of nausea before turning towards the ocean. She awkwardly waddled in her big fins towards the edge of the boat and looked down. She took one last deep breath, and finally, ignoring all her nervous thoughts, she jumped.

4. The Pitcher
It was the first time Johnny had ever pitched for six whole innings. Even though his shoulder was starting to ache, Johnny felt a surge of energy that kept him going. Rusty Heed stepped up to the plate. Rusty was a left-handed designated hitter who had already hit a double in the second inning. Johnny warmed up his arm. Upon the signal from his catcher, Johnny leaned back and whipped the ball forward at 95 miles per hour. Rusty didn't move. "Strike One!" The Umpire yelled. Johnny took a deep breath and repeated the action. Rusty made contact with the ball, sending it flying into the stands behind him. *Foul ball* Johnny sighed, *strike two.* Ignoring the pain in his shoulder, Johnny threw himself forward and released the ball one last time. Rusty swung hard, but the ball flew past his bat into the catcher's glove. "Strike Three!" The Umpire yelled. "You're Out!"

5. Aquarius
According to myth, Aquarius was the most handsome man on earth. Queen Hera, admiring his great beauty, brought him to her heavenly palace to act as water bearer for the court. Zeus quickly became jealous of Aquarius, and began to think of ways to kill him. One evening at dinner, Zeus accused Aquarius of poisoning the water. When Aquarius protested, Zeus dared him to drink a cupful to demonstrate his innocence. At that moment, Aquarius looked Zeus in the eye with the mournfulness of one all too aware of his own imminent demise because he knew what the god had done. He drank a cup of water and immediately began to foam at the mouth, the poison quickly making its way through his body. Grieved by the death of her favorite human, Hera placed Aquarius' spirit in the stars where his beauty could be admired for the rest of time.

6. The Chef
Chef Jacob loved the weekends, because that meant he could cook brunch all morning through the afternoon. Jacob flipped the omelettes and sizzled the bacon, taking in all the sights and smells that he had come to adore after working as head chef for 10 years. Performing these tasks became second nature to Jacob; he could now cook a perfectly over-easy egg with his eyes closed. One of Jacob's favorite activities was experimenting with the traditional brunch foods. Every now and then, he would add his own special touch to classic recipes. Jacob's mixtures almost always received rave reviews. This particular Sunday, Jacob decided to create a new syrup for the banana pancakes. He stirred together maple syrup with strawberry sauce, and added a touch of honey at the end. Bringing the spoon to his lips, he tasted his new concoction and cherished the exotic, fruity syrup.

7. Damsel in Distress
One day, a goblin soldier kidnapped the princess of the Kingdom of Amethyst and carried her away to the lair of the goblin master, Kareve. The king of Amethyst sent his best knight, Cedric, to infiltrate the goblin lair and rescue the princess. The knight rode for days on his horse before he

reached the goblin king's fortress, a menacing structure of rough stone and pointed towers. Although the knight sneaked in stealthily so that he wouldn't raise alarms, he crossed paths with the evil dungeon master. Faced with impending death, the courageous knight dueled using his trusty sword, until the goblin lay lifeless on the ground. The victorious knight proceeded to brave the tunnels until he found the princess sobbing her heart out in a cell. As soon as he laid his eyes on this beautiful maiden, his resolve grew stronger. With one blow of his arms, he broke down the cell door and carried her to safety.

8. Aaron's Fear of Flying

Aaron hated flying. He hated sitting still for hours, being trapped in small spaces, and worst of all, he hated turbulence. This flight had been the longest six hours Aaron had ever experienced. Aaron focused all of his attention on the final outcome: two whole weeks of traveling around France. Whenever the plane rumbled beneath him, or dropped a couple feet in the air, Aaron's heart would start racing. Every time he had to grip the armrests with his sweaty palms, Aaron would think about the Louvre, or the Eiffel Tower, or the Arc de Triomphe, and he would slowly begin to calm down. Aaron had been planning this trip for two years, and he was determined to not let his fear of flying keep him from living out his dream. Aaron closed his eyes and steadied his breathing. *Two more hours* he thought, and for the first time since he left land, Aaron smiled.

9. The Short Basketball Player

Janie was always the shortest girl on her basketball team. Since her height put her at a disadvantage, nobody thought Janie would ever make the Varsity team. But Janie was determined. She stayed after every practice to take shots from the free-throw line. Even at home she would practice in her driveway to work on her ball skills. When tryouts for the varsity team finally arrived, Janie was fully prepared. Though all her opponents were taller, she had the speed and skill to dribble around each one of them. And even though she could never reach the rim to dunk, she had mastered layups and could score on almost every shot. By the end of tryouts, no one doubted that Janie would become the starting point guard. Janie surpassed everyone's expectations. Her teammates admired her for her hard work and steadfast determination, and the coach respected her courage and dedication.

10. The Skier

Sarah felt the wind at her back and the cold frost on her cheeks as she soared down the mountain on her new Alpine skis. She was focused and calm, bending her knees and turning her hips methodically so that her skis made big S's across the top of the mountain and went through each gate she passed. Racing against her opponent, Sarah bent down and leaned forward to pick up speed. Slalom skiing was Sarah's favorite winter sport, and she had been passionate about it ever since her family brought her skiing ten years ago. Sarah only had two more gates to pass in her race, and she knew it would be close. Her worthy opponent was cutting down the mountain next to her with speed and determination. Sarah held her breath and shifted all her weight forward, passing the finish line exactly one second ahead of her opponent.

APPENDIX B

1. Sarah took her kids to the water park
2. The twins made new friends at the playground
3. Isabella bought a new dress for the wedding
4. Jessica frequently dreamed of traveling around the world
5. The family spent the summer remodeling their house
6. Jonathan always regretted dropping out of high school
7. Most grandparents enjoy spending time with their grandchildren
8. The boy bought the book at the store
9. The criminal was a character in the movie
10. Kevin wrote a song for his rock band
11. Sarah designed clothes for her school's fashion show
12. Sterling rode roller coasters at the amusement park
13. Richard studied in a research laboratory in Rome
14. The boy gave his mother a birthday card
15. The dog chased the cat in the cabin
16. The actress forgot her lines in the play
17. The family visited the zoo and the aquarium
18. Jeff and Justin lifted weights at the gym
19. Elizabeth painted her fingernails with pink nail polish
20. The janitors cleaned the classrooms in the school
21. The clown juggled in front of the children
22. The girl built a sand castle at the beach
23. Justin was the winner of the science fair
24. Helen won two thousand dollars in the lottery
25. Helen and Karen went to the same gym
26. Denise bought food and toys for her kitten
27. Sasha drew a picture of the human brain
28. David wanted a new computer for his birthday
29. Hillary worked in the library during the summer
30. The children imagined they were flying an airplane
31. Taylor visited the doctor after hurting his arm
32. Camp was so boring that Sarah ran away
33. After Hillary finished her essay, she finally relaxed
34. Dan works at a medical lab in Boston
35. Rachel disguised herself in a wig and glasses
36. Leanne found a toothpick on her kitchen floor
37. Walter looked for his sneakers under the bed
38. The boy replaced the battery in his clock
39. The comedy troupes were very popular on campus
40. Dana tore a ligament in her left knee