THE EFFECTS OF TOPIC TITLE ON LANGUAGE COMPREHENSION AND WORKING MEMORY RESOURCES

by

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Abstract

This study was designed to explore the effects of topic title and simulated high frequency hearing loss on language comprehension by normal, healthy adults. Thirty-two adult participants with no history of cognitive deficits participated in this study. Each participant listened to four different passages in four different conditions. The four conditions were: (1) title with normal hearing, (2) title with simulated high frequency hearing loss, (3) no title with normal hearing and (4) no title with simulated high frequency hearing loss. Passages were presented segment-by-segment using the auditory moving window technique; most segments were short sentences or clauses. Participants listened to each segment at their own pace by pressing a key. Pause times between segments and overall listening time were recorded for each passage. After listening to each passage, participants were asked to recall out loud what they understood and remembered from the passage. Recall was transcribed and percentages of recalled propositions were calculated. In order to observe changes in processing across a passage, mean pause duration values were also compared across passage position (beginning, middle and end of a passage). The results showed that topic titles facilitated listening comprehension, as shown through better recall performance and reduced processing time. The knowledge of topic titles also reduced the time required for processing information at the beginning of the passage, showing that the knowledge of topic titles facilitates the building of mental representations. The simulated high frequency hearing loss condition did not prove to consistently tax working memory resources during language comprehension. The findings also provided evidence about the relationship between working memory ability and recall performance. Overall, these findings are consistent with the predictions of current language comprehension models.

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Chapter 1: Introduction

Overview and Purpose of Study

The purpose of this thesis is to investigate the effect of a topic title preceding a heard passage, and to investigate whether the knowledge of topic titles can compensate for increased demands on working memory that result from a degradation of the auditory input.

Listening comprehension is a complex and fundamental task that hearing individuals perform frequently. In quiet settings, normal hearing individuals typically have few challenges understanding spoken language, as the speech signal is clear. On the other hand, listeners who are hard-of-hearing commonly exhibit difficulties perceiving speech (Working Group on Speech Understanding and Aging, 1988). Even if speech is perceived and understood correctly, listeners who are hard-of-hearing often complain of being tired and may have more difficulty recalling the material they have heard (Meadow-Orlans, 1985; Working Group on Speech Understanding and Aging, 1988). Normal listeners may also have similar experiences when listening in noisy environments. Such negative experiences could be embarrassing, frustrating and reduce one's self-confidence as a communicator. Furthermore, such experiences may lead to reduced participation in communicative interactions. In order to reduce the negative consequences experienced, it is important to understand factors that may facilitate and/or inhibit language comprehension.

In general, contextual knowledge may be defined as information that provides guidance to ascertain meaning (e.g. surroundings, circumstances, background knowledge, or a general or descriptive topic title). Specific to language comprehension models and research, context is generally referred to as information regarding the general content or framework of a text (Bransford & Johnson, 1972; Miller, Cohen & Winfield, 2006). Contextual knowledge has been found to facilitate language comprehension (Miller et al., 2006). For example, evidence of topic titles facilitating reading and listening comprehension has been well documented (Bransford & Johnson, 1972; Dooling & Lachman, 1971; Little, Pretentice, Darrow & Wingfield, 2005; Miller et al., 2006). One advantage of using topic titles to facilitate language comprehension is that they are easy to incorporate into everyday situations, when listening or reading. In fact, topic titles are widely used and are commonly found in many textbooks, lectures and presentations. Knowledge of how topic titles facilitate language comprehension has been theorized with the help of language comprehension models and theories of the relationship between language comprehension and working memory (Bransford & Johnson, 1972; Little et al., 2005; Miller et al., 2006; Wiley & Rayner, 2000). In the past, both listening and reading studies have mainly used two methods to measure language comprehension: passage or text recall (Bransford & Johnson, 1972; Dooling & Lachman, 1971), and pause or reaction times (Miller & Stine-Morrow, 1998; Little et al., 2005). Recall is a post processing measure that can be used to measure what one remembered or understood from a written text or heard passage (Daniel & Raney, 2007). The time it takes for listeners to process linguistic information is thought to depend on one's processing load (Ferreira, Henderson, Anes, Weeks & McFarlane, 1996), and it has been used to estimate how processing load changes as a function of the presence of a topic title (Little et al., 2005; Wiley & Rayner, 2000). Studies of both reading and listening comprehension have investigated whether topic titles facilitate language comprehension by measuring recall (Dooling & Lachman, 1971; Bransford & Johnson, 1972, respectively). On the other hand, only reading studies have demonstrated how topic titles facilitate language comprehension by estimating processing loads using pause or reaction times (Wiley & Rayner, 2000), even though various theories support the importance of context (e.g., topic knowledge) in listening comprehension (Gernsbacher, 1990; Stine, Wingfield, & Poon, 1989; van Dijk & Kintsch, 1983). In addition, previous research in the field of listening comprehension has not investigated whether the knowledge of topic titles can compensate for reduced processing resources. Therefore, the focus of this study is to investigate whether topic titles facilitate language comprehension by measuring both passage recall and processing time. In addition to this question, this study will also investigate whether topic knowledge can compensate for reduced working memory resources due to a simulated high frequency hearing loss through speech signal filtering. Such evidence is important to contribute to language comprehension models, and also for understanding how we can facilitate language comprehension in everyday communication and in clinical settings.

The following sections will review the evidence about listening and reading comprehension models, the techniques that have been used to measure language comprehension, and the role of working memory on language comprehension. Furthermore, a review of the research on topic titles and language facilitation and working memory compensation will be presented along with the specific hypotheses of the current study.

Listening Comprehension Versus Reading Comprehension

Previous research studies on language comprehension have mainly focused on reading (Ferreira et al., 1996; Wiley & Rayner, 2000). Many language comprehension models have been developed by investigating reading comprehension processes (Gernsbacher, 1990; van Dijk & Kintsch, 1983). Since the current study is in part motivated by evidence and theories developed for reading comprehension, it is important to review the similarities and differences between reading and listening comprehension.

Danks and End (1987) pointed out that it is difficult to tease apart the differences between reading and listening comprehension. They stated:

> (L)istening and reading are language comprehension processes that have available to them the same set of strategies to accomplish the task of comprehension. They differ to the extent that the cognitive demands imposed by the text characteristics, situational factors, and cognitive skills available to the comprehender, result in different processing strategies being heuristic (p. 291).

Generally speaking, both the comprehension of speech and written text are thought to have similarities in terms of 1) the cognitive process used, 2) their use of syntactic structure to construct and establish meaning, and 3) the flexibility and the adaptive nature of the processes that underlie comprehension in the two modalities (Danks & End, 1987; Kintsch, 1993; Perfetti, 1987; Royer, Sinatra & Schumer, 1990). In addition, both listening and reading comprehension are thought to involve the same internal processes (such as the integration of the information at the phonological, sentence and discourse levels) following the initial information encoding stage (Horowitz & Samuels, 1987; Kintsch, 1993; Perfetti, 1987; Royer et al., 1990). Listening and reading comprehension are also both thought to involve the building of conceptual representations (see, for example, Kintsch & van Dijk, 1978); these conceptual representations will be discussed further in the following section regarding language comprehension models. The differences between reading and listening comprehension are generally considered to be related to the different modalities of presentation of incoming information (Horowitz & Samuels, 1987). Listening involves temporal based input where the listener has no control on the rate of input, and is not able to access previously provided information unless the speaker repeats utterances that she/he has previously spoken. Reading involves spatially oriented information, which allows the reader to control the rate of incoming information. By contrast, reading text does not involve prosodic features such as pitch and stress that facilitate listening comprehension (Carlisle, 1991). In conclusion, both reading and listening comprehension processes are thought to involve similar internal processes that involve the building of conceptual representations, following modality-specific information encoding stages. The following section will explore in more detail the mental processes that are likely to be involved in language comprehension.

Language Comprehension Models

Both listening comprehension and reading comprehension are achieved through an interaction of bottom-up and top-down processing (Marslen-Wilson & Welsh, 1978). Specific to listening comprehension, bottom-up processing is generally defined as the recognition of the speech signal on the basis of the properties of the acoustic waveform (Marslen-Wilson & Welsh, 1978; Stine et al., 1989). Top-down processing is generally defined as the use of world knowledge and contextual information (based on, for example, linguistic or world knowledge) to influence one's interpretation and comprehension of the speech signal. Therefore, top-down processing utilizes expectations and world knowledge to guide phonetic processing and word recognition (Pollack & Picket, 1963; Stine et al., 1989). Using topic knowledge for language comprehension would be an example of top down processing (Kintsch, 1988; Daniel & Raney, 2007) as the listener may use topic knowledge to gain greater accuracy between a speaker's intention and the listener's interpretation. For example, topic titles are thought to facilitate language comprehension by providing the listener with the relevant background information that may be required in order to understand the incoming information while avoiding ambiguities and/or misunderstandings.

Reading comprehension models propose that comprehension of a text occurs as a result of text processing at three different levels. This includes processing at the word, textbase and discourse levels (Stine-Morrow, Miller, & Hertzog, 2006). Word level processing is defined as consisting of two processes, orthographic decoding and lexical analysis; the outcome of these processes is the access to word meaning. Textbase level processing refers to the process of identifying relationships between ideas or concepts within a text, and integrating them to form a semantic representation of a text (Kintsch & van Dijk, 1978). This semantic representation can also be called the "microstructure" (Kintsch & van Dijk, 1978). The microstructure connects or establishes relationships between current and preceding clauses and sentences, by combining and organizing propositions to form a textbase (Kintsch & van Dijk, 1978). A proposition is defined by Turner and Greene (1978) as an idea unit, which consists of word concepts in which one of the concepts serves as the relation and the others serve as arguments of the proposition. When reading a text, a reader constructs a list of propositions that establishes reference, causal or temporal relationships in the textbase (van Dijk & Kintsch, 1983). An example of a sentence containing four propositions is shown below. Each proposition is enclosed by parentheses and is composed of a predicate (typically a verb) or relation plus one or more arguments. Arguments are typically nouns but can also be embedded propositions, which are indicated by a reference number.

Sample sentence and its propositional representation

At first it is better to run than to walk

1. (is, run, better)
2. (is, walk, better)
3. (better than, 1, 2)
4. (at first, 3)

Discourse level processing refers to the process through which the outcomes of processing at the word and textbase levels are integrated with prior accumulated knowledge, and results in the building of a situation model (Kintsch, 1998). A situation model is a detailed representation of the intended message of the text. Discourse level processing can also be thought of in terms of constructing the "macrostructure" of a text (Kintsch & van Dijk, 1978). As previously discussed, the main purpose of the microstructure is to form connections between propositions. In contrast to the microstructure, the macrostructure is more global and characterizes the text as a whole rather than locally. For example, it connects or establishes relationships with the more global parts of the text such as between current and preceding paragraphs. The macrostructure is responsible for defining the most relevant or important information of a text such as the main ideas, or gist (i.e., topic) of the text (van Dijk & Kintsch, 1983). Van Dijk and Kintsch (1983) proposed that the macrostructure provides two important functions: 1) It constrains the relevant vocabulary and world knowledge that the listener needs in order to comprehend, and 2) It provides a framework to which new information can be added. Kintsch and van Dijk (1978) proposed a reading comprehension model that involved textbase and discourse level processing. Specifically, Kintsch and van Dijk suggested that a reader constructs a semantic representation of the incoming information in episodic memory. A reader is successful (i.e., can understand the text) when two components are constructed 1) microstructure, and 2) macrostructure.

Gernsbacher (1990) developed a reading comprehension model that involves processing at the discourse level and incorporates the idea of conceptual frameworks -but refers to them as "structures". Gernbacher's structures are comparable to van Dijk and Kintsch's (1983) concept of the macrostructure as both represent the more global relationships of the incoming information. These structures are built as the reader reads a text, as a result of several different steps or processes. First, the reader lays down a "foundation" of the structure that is generally suggested to be represented by the initial words or sentence of a text. Afterwards, incoming information is mapped onto the foundation to continue the development of a structure. If information is not consistent or does not cohere with the previous input, then a “shift” occurs. A shift represents a new substructure that branches off from the primary foundation. Gernsbacher further proposes that memory cells are the building blocks of mental structures. These memory cells are activated by incoming information. When incoming information is coherent with an already built mental structure, new memory cells are not activated. Instead, the new information is mapped onto the already formed foundation by maintaining activation of the same memory cells. If information is not coherent with the previous information, it is likely that different memory cells are activated and form the foundation of a new substructure. An important concept of Gernsbacher’s model is that activated memory cells transmit two kinds of processing signals that, although not specific to language, control the level of activation of other memory cells thereby playing a vital role in structure building. Gernsbacher refers to these processing signals as “suppression” and “enhancement”. Suppression serves to inhibit or decrease the activation of memory cells that represent information that is no longer coherent with incoming information, and therefore unnecessary for structure building. Enhancement serves to activate or increase the activation of memory cells that represent information that is coherent with the incoming information, and is therefore necessary for structure building (Gernsbacher, 1990). Both suppression and enhancement are consistent with van Dijk and Kintsch’s concept of macrostructure as a framework to which new information can be added, as they claim that the macrostructure constrains relevant vocabulary knowledge required by the reader.

In summary, both Dijk Kintsch’s (1983) and Gernsbacher’s (1990) models propose that language comprehension requires the building of a textbase (or microstructure) and a macrostructure (or structure). Such representations are important for both local (e.g., linking meaning between sentences and clauses) and global (e.g., linking meaning between paragraphs and the main ideas) understanding of incoming information, and for the formation of inferences by comprehenders. These representations are held in long-term memory and can be activated in order to integrate new information or to act as a retrieval structure (Ericsson & Kintsch, 1995; Kintsch, 1988). Given the involvement of memory processes in language comprehension, the following section will discuss the role of working memory processes that are likely to be required for the understanding of a message.

The Use of Working Memory Resources During Language Comprehension

There are various theoretical approaches that describe working memory and its involvement in language comprehension, but it is generally agreed that working memory plays an important role in understanding speech (Just & Carpenter, 1992). According to Baddeley and Hitch (1974), working memory can be defined as a cognitive system for 1) the storage of a small amount of information for a short time period, and 2) the ongoing and simultaneous information processing of the information in storage. In listening comprehension, the temporal aspect of speech requires the maintenance of the early part of the message in working memory, while the remainder of the message is perceived, so that an integrated understanding of the entire message is possible (Just & Carpenter, 1992). For instance, in order to understand speech, a transient signal must be held (stored) in working memory for interpretation (Marslen-Wilson & Tyler, 1980), and a listener must integrate the sequence of words over time (Just & Carpenter, 1992). Both of these processes rely on a supply of finite cognitive resources that are responsible for other cognitive functions. Even if information is stored in working memory, it can be lost as a result of decay or displacement memory (Daneman & Carpenter, 1980). Decay results when information is not retrieved, rehearsed or activated after a certain amount of time; displacement occurs when additional information is encoded, activated or generated beyond the capacity of working memory (Daneman & Carpenter, 1980)

It is generally agreed that the amount of working memory resources is limited. Therefore, one can predict that if more resources have to be used to decode a signal, then fewer resources will be available for storage. This prediction has been confirmed by Rabbitt (1968). He found that the presence of background noise taxed the working memory system, and thus reduced performance on tasks requiring the use of working memory, such as working memory span, word recall and comprehension of short passages. In one experiment, his participants listened to lists of digits that were presented in noise or quiet. Participants were asked to either transcribe the list while listening, or to recall and transcribe the list after they had listened to all of the items on the list. When they performed the transcription task while listening, performance did not significantly differ for the noise and quiet conditions. However, when asked to recall and transcribe after listening, listeners performed more poorly in the noise condition than in the quiet condition. This finding suggests that more working memory resources are required when listening in noise, and thus fewer resources are available for storage, which in turn affects later recall. Rabbitt further tested whether recall performance after the noise condition could simply be attributed to poor speech recognition. To do this, Rabbitt divided a list of digits into halves. In one experimental condition, the first half of the list was presented in quiet while the second half was presented in noise; in a second condition, the whole list was presented in quiet. He found that recall for digits in the first half of the list was poorer in the first than in the second condition. This finding demonstrates that recall performance in the first condition was likely to be the result of greater working memory demands, and not due to a misperception of the speech signal. Rabbit also replicated these results by testing recall for short passages, instead of recall for lists of digits. These findings support the prediction that working memory demands increase when listening to speech in noise. The results of a study by Pichora-Fuller, Schneider and Daneman (1995) are consistent with Rabbitt's (1968) findings. Pichora-Fuller et al. investigated the effect of noise on working memory processing. They asked participants to perform two tasks, a word recognition task and a recall task. In the word recognition task, participants were asked to repeat the word at the end of a sentence; in the recall task, participants listened to a set of sentences and subsequently were asked to recall all of the sentences' final words. Each of the tasks were preformed in quiet or in different levels of noise. After partialling out the effect of noise on speech recognition, Pichora-Fuller and her colleagues found that noise significantly affected their participants' ability to recall the final word in a sentence. They proposed that a "toll" is placed on working memory when listening to speech in noise because more resources are allocated to recovering lost information from the speech signal, and fewer resources are available for storage or further cognitive processing.

While the studies reviewed in this section employed recall data to estimate the use of working memory resources during comprehension, recall tasks can only provide an estimate of the use of cognitive resources after the task has been completed. For this reason, such tasks are often referred to as "off-line" tasks, because they provide an indirect estimate of working memory processing by measuring how much (and/or what type of) information has been stored in memory. In order to estimate the use of working memory resources while participants are processing information, researchers have developed so-called "on-line" tasks. The use of on-line tasks in studies of language comprehension and working memory will be discussed in the next section.

Estimating Working Memory Load During Language Comprehension

On-line tasks have been used to systematically investigate language comprehension as it occurs while reading or listening (Little et al., 2005; Miller et al., 2006; Titone et al., 2000). Examples of such tasks are eye-movement monitoring tasks where a researcher tracks the participants eye movements when reading a passage (Just & Carpenter, 1980; Wiley & Rayner, 2000). Longer gaze durations are thought to reflect greater processing loads. The "moving window" technique, another on-line procedure used in reading studies, analyzes a reader's pause times as she/he controls the rate of incoming text on a computer screen (Just, Carpenter & Woolley, 1982). A recently-developed version of the moving window procedure, called the "auditory moving window" (AMW) technique (Ferreira et al., 1996), requires participants to listen to chunked verbal material at their own pace. The duration of between-chunk pauses is measured under the assumption that longer pauses between chunks reflect greater processing time, which in turn is taken to reflect greater processing loads for the preceding chunk or segment. The AMW technique is thought to be a valid tool to observe processing load as the data it provides from listening studies are consistent with those obtained by other on-line techniques for reading studies. For example, Ferreira et al. (1996) demonstrated similar patterns of pauses within a sentence compared to other reading experiments when participants were asked to listen to garden path sentences. Also, consistent reading and listening patterns across a passage (serial position effects) have been found using both the AMW technique and the moving window technique (Stine-Morrow et al., 1996; Wingfield, Kemtes & Miller, 2001). Finally, this technique allows for the presentation of stimuli that are intelligible and reasonably natural, even though the speech signal is parsed into chunks of words, phrases or sentences (Ferreira et al., 1996). One limitation of the AMW technique when using segments that include more than one word is that the task is not completely "on-line", as only processing loads at the end of segments are estimated (e.g., not word-by-word processing).

Under the assumption that pause time is directly proportionate to processing load on-line tasks allow researchers to investigate processing loads in terms of the construction of conceptual representations, or structures (Miller & Stine-Morrow, 1998; Little et al., 2005). For example, on-line reading studies focusing on the microstructure level of a textbase (textbase processing) typically measure pause times between clauses and sentences, in order to estimate the effects of experimental variables on a reader's or listener's ability to integrate new concepts with old ones. The end of clauses and sentences are used as segment boundaries because studies with word-by-word presentations have found that readers and listeners consistently pause at the end of sentences or clauses (Aaronson & Ferres, 1984; Wingfield & Butterwork, 1994; Wingfield et al., 2001). These common "wrap-up points" (where readers and listeners consistently pause) are thought to reflect the time required by readers and listeners to formulate relationships between propositions, and to integrate new concepts with those that have already been introduced

(Aaronson & Ferres, 1984; Wingfield & Butterwork, 1994). In support of this interpretation, Haberlandt, Graesser, Schneider and Kiely, (1986) found that readers pause for longer intervals when new arguments or concepts are introduced**.** These findings are consistent with the idea that language comprehension is achieved through the formation of structures or macrostructures (Gernsbacher, 1990; van Dijk and Kintsch, 1983).

On-line studies focusing on the macrostructure (discourse processing), typically examine the distribution of pause times across the passage by comparing the mean pause times taken in the beginning, middle and end of the passage (Miller & Stine-Morrow, 1998; Little et al., 2005). Such pause times generate a pattern that is thought to be indicative of building of a mental structure or macrostructure by the listener/reader. For example, some studies using the moving technique have shown that readers and listeners spend more time at the beginning of a passage compared to the middle and/or the end of the passage (Stine-Morrow et al., 1996; Wingfield et al., 2001). This effect, called a "serial position" effect, is generally interpreted as evidence that the reader or listener needs to spend a longer time at the beginning of the passage in order to build a framework (Gernsbacher, 1990; Stine-Morrow et al., 1996; Wingfield et al., 2001). The reduction of the time spent at the middle and end of a text are thought to reflect the ease of processing that is attributable to the enhancement and suppression of information within an existing framework (Stine-Morrow et al., 1996).

The language comprehension models and working memory theory discussed above provide the basis for why topic knowledge should facilitate language comprehension, as knowledge has been shown to facilitate the comprehension process (shown through measures of processing time in on-line) as well as recall (Bransford & Johnson, 1972; Little et al., 2005). The focus of this next section will be on the effects of topic knowledge, as provided by topic or passage titles, on the processing of information during language comprehension using both off-line (recall) and on-line (moving windows) tasks.

Effects of the Knowledge of Topic Titles on Working Memory Resource Allocation

Topic titles are thought to facilitate language comprehension by playing a critical role in the building of mental representations or structures of the text (Kintsch, 1988). Specifically, topic titles are thought to facilitate the integration of incoming information at both the microstructure and the macrostructure level. For instance, topic titles are thought to facilitate the building of the macrostructure (Miller & Stine-Morrow, 1998). Topic titles likely activate the memory cells that represent related knowledge. In turn, memory cells are hypothesized to send suppressing and enhancing processing signals to either activate relevant information or suppress irrelevant information (Gernsbacher, 1990). In terms of Gernsbacher's language comprehension model, providing a foundation through a title is advantageous because building a foundation typically requires a relatively long processing time and a large amount of working memory resources (Gernsbacher, 1990; Miller & Stine-Morrow, 1998). Topic titles are also likely to activate relevant prior knowledge, such as mental representations stored in long-term memory (Kintsch, 1998). The activation of previous relevant knowledge facilitates the building a mental representation of a message.

Early studies on language comprehension investigated the recall of idea units from a passage as a function of the availability of topic titles. Bransford and Johnson (1972) asked participants to listen to an ambiguous passage with or without knowledge of topic titles (provided either as pictures or text). They found that participants who received a topic title before listening to the passage were able to recall better than those who did not. Bransford and Johnson hypothesized this outcome was a result of better comprehension because, without a topic title, comprehension of the text was virtually impossible due to the ambiguity of their passages. These findings are consistent with those of a previous reading study by Dooling and Lachman (1971), who found that participants who were presented with a topic title before reading a passage had better recall than those who did not have access to topic titles. The evidence from these early studies supports the hypothesis that topic knowledge facilitates language comprehension. However, off-line studies do not provide detailed information about the allocation of processing resources over time during comprehension. On-line studies, on the other hand, provide a systematic method to analyze a listener's processing resources while they are listening to a passage.

In an on-line reading study, Miller and Stine-Morrow (1998) investigated reading strategies and their relationship to later recall. They were specifically interested to see whether readers of different age groups use different reading strategies (i.e. allocated processing resources differently) when presented with topic titles. Using an independent group design and a moving window procedure, Miller and Stine-Morrow randomly assigned participants to either a "title" or a "no title" group. They found that overall reading times of passages were faster when topic titles were present, and that readers who were not given topic titles spent more time at the beginning of the text than the middle and end of the text. These findings provide support for the hypothesis that topic titles facilitate language comprehension, as well as reduce the demand for processing resources (resulting in reduced reading times). Wiley and Rayner (2000) largely replicated these results using off-line and on-line tasks. They tracked eye movements to determine whether topic titles prior to reading a passage 1) improved comprehension and the memorability of a text, and 2) decreased processing time for ambiguous words. In an experiment, they visually presented four different experimental passages to 32 students, and measured the total reading time for a passage, the time spent in regressions (looking back at previously read words), the number of regressions, the time spent at the end of sentences, and fixation times on individual words. To assess comprehension and memory immediately after each passage was presented, the participants were asked to write down all they could remember from the passage. Recall was scored using a verbatim criterion based on the number of nouns participants wrote down. The authors found when participants had been given topic titles they recalled a greater number of nouns, read passages faster, made fewer regressive fixations, had shorter wrap-up times at the end of sentences or clauses, and read target nouns faster. In a second experiment, 12 participants read four passages that contained ambiguous nouns. Wiley and Rayner found that ambiguous words were read faster when a topic title was present compared to when topic titles were not present. The evidence from this study is consistent with the idea that topic titles are likely to reduce processing load during language comprehension.

Miller et al., (2006) examined the effects of topic titles on reading efficiency on young (mean age = 25.9 years), middle-aged (mean age = 48.2 years) and old adults (mean age = 69.3 years), and further divided both of these groups into high and low working memory span groups. The authors manipulated the availability of topic titles and the presence of an auditory distracter task (divided attention task). Six ambiguous passages were presented using an auditory moving window task. Each participant listened to three passages in the divided attention task and three passages in the full attention task. In the divided attention task, participants' reaction times were measured in response to a click in order to gage working memory resources while reading a text. Participants were to respond to the auditory clicks as fast as possible. The authors also measured reading time, recall, and reading efficiency. Consistent with their predictions, the authors found that titles facilitated language comprehension (by showing improved recall and reduced reading times) and increased reading efficiency. Miller et al. also found that topic titles reduced working memory demands by showing that differences between high and low working memory span groups were smaller when participants had access to topic titles than when they did not. The results from this study provide support for the idea that the knowledge of topic titles not only facilitates language comprehension, but also reduces working memory demands.

While the previously reviewed studies documented the effects of title knowledge on reading comprehension, a study by Tyler (2001) investigated the effects of working memory resource allocation on listening comprehension. He asked native and non-native English speakers to listen to a passage while completing a working memory task. He hypothesized that non-native listeners would have greater difficulty, and would therefore require more working memory resources, when processing a language that they are less familiar with. A task that involved the verification of single digit calculations was used to estimate working memory resource consumption. Tyler hypothesized that topic knowledge would improve performance by decreasing the amount of working memory resources allocated to comprehension and storage; he also expected that non-native speakers would benefit more from topic titles than native speakers. Tyler's results were consistent with these predictions, and supported the idea that topic titles reduce working memory processing demands. However, he did not find the expected difference in working memory task performance between the title and non-title conditions for native speakers, possibly because his working memory task might not have been sensitive enough to precisely estimate working memory processing load. Indeed, Waters & Caplan (2003) demonstrated that test-retest reliability for working memory tasks improves when a composite score was calculated from two to three tasks, instead of just reporting one working memory measure as Tyler did. However, the results from Tyler's study do indicate that topic titles can reduce working memory demands during listening comprehension.

In summary, previous studies found that the knowledge of topic titles facilitates language comprehension by reducing processing loads during reading. Topic titles were also found to result in better recall of written information. The only investigation on the effects of title knowledge on listening comprehension found an effect only for non-native speakers. Even though there is no direct empirical evidence that topic titles facilitate listening comprehension in a native language, there are a number of aural rehabilitation programs that use topic knowledge to facilitate spoken language comprehension. For example, the aural rehabilitation program called Listening and Auditory Communication Enhancement (LACE) instructs listeners to keep the general topic in mind when listening to conversations to facilitate comprehension (Sweetow, 2006). Other programs have proposed that speakers should provide important keywords or context cues to listeners in order to enhance comprehension (Erber, 1988; Tye-Murray, 1998; Tye-Murray, Purdy & Woodworth, 1992). Even though these strategies are commonly used in many aural rehabilitation programs, it has not been empirically shown how the provision of a topic title enhances language processing, particularly during and/or after listening comprehension. The present study will contribute to the understanding of how topic knowledge facilitates spoken language comprehension by utilizing an on-line procedure to track changes in processing loads while participants listen to a passage. Therefore this study may provide support for the use of titles as a strategy to facilitate listening comprehension in therapy programs.

Objectives of this Study

The present study is the first on-line study on the effects of the knowledge of topic titles on listening comprehension. The AMW technique was selected to estimate the allocation of processing resources during listening comprehension at specific points of interest within a passage, without drawing the participants' attention away from the listening task (Ferreira et al., 1996). The pause time data obtained through this procedure were used to analyze changes in processing load across a passage, and to compare processing loads under different task conditions.

The first goal of this study was to investigate whether the knowledge of topic titles facilitates listening comprehension. While several studies have used the moving window technique to investigate reading comprehension, the present study will be the first to apply this technique to investigate the effect of topic titles on listening comprehension. If title knowledge helps listeners in generating a conceptual framework for understanding the passages, then both mean pause durations across a passage and overall listening time should be shorter when topic titles are presented to listeners. A second hypothesis about the effects of topic titles is that when a topic title is present pause durations should be more evenly distributed across the beginning, middle and end sections of the passages, thereby reducing the serial position effect. This prediction is consistent with the idea that listeners will not need to allocate more time and processing resources when listening to the beginning of the text because the knowledge of the title will facilitate the building of a conceptual framework at the beginning of the passage. A third hypothesis is that title knowledge will result in greater amount of recall by reducing language processing demands and allowing more processing resources to be allocated to information storage.

The second goal of the study was to examine whether a degradation of the acoustic signal that simulates a mild hearing loss affects processing time and recall. Both Rabbitt (1968) and Pichora-Fuller's et al. (1995) showed that extra demands are be placed on working memory resources in order to perceive the speech signal in noisy listening conditions. In the current study, the effect of signal degradation will be measured by using high frequency filtering of the speech signal in order to simulate the effects of a mild hearing loss. A high frequency hearing loss is assumed to tax a listener's working memory resources in a similar way as the presence of noise, as the listener is required to focus more processing resources in order to perceive the signal (Rabbitt, 1991). For example, individuals with high frequency hearing loss typically have damage or degeneration to the inner hair cells located in the basal region of the cochlea. As a result an individual will not hear high frequency sounds in speech such as consonants "s", "f" and "th" (Fletcher & Galt, 1950; Speech Intelligibility Index, 1997). Therefore the speech signal will be missing information that listeners require in order to successfully comprehend speech. However, an incomplete speech signal does not mean that the listener will not understand the message, because listeners can use top-down processing to compensate for impoverished auditory information (Marslen-Wilson & Welsh, 1978; Pollack & Picket, 1963; Stine et al., 1989). While a hearing loss can alter many aspects of auditory processing (Baer & Moore, 1993; Zurek & Desloge, 2007), it is generally agreed that the decrease in speech perception ability that results from such hearing losses can be adequately accounted for by a loss of audibility (Turner & Robb, 1987). Therefore, in the present study stimuli were low-pass filtered in order to obtain a listening condition that simulated corresponding to a mild sloping hearing loss (filtered speech condition). If signal degradation produced by filtering the speech signal increases the demands for processing resources for listening comprehension then mean pause and overall listening durations should be longer in the filtered speech condition compared to the normal hearing condition. One would also expect that a listener's ability to recall suffers as a result of the signal degradation in the filtered speech condition. Finally, one would expect to find an interaction effect between topic title and filtered speech conditions, such that the decrease in performance caused by filtered speech will be larger when listeners have no prior knowledge of topic titles.

The third goal of this study was to provide corroborating evidence about the relationship between the amount of recall, and working memory span and vocabulary scores. Since listening comprehension is expected to depend on the use of working memory resources and language knowledge in general, it is predicted that there should be a positive correlation between measures of working memory, vocabulary and recall performance.

To test these hypothesis all participants were presented with four different passages. For each listener, each passage was presented in one of four conditions, including: normal hearing with no topic title, normal hearing with topic title, simulated hearing loss with no topic title, and simulated hearing loss with topic title. Stimuli were presented auditorily using the AMW technique. Participants listened to the previously segmented passages at their own pace by pressing a button to continue listening to the next segment. The time between button pressings was recorded and analyzed. After listening to each passage, participants were asked to recall everything they could remember about the passage. The percentage of propositions recalled was calculated according to the gist criterion (Turner & Greene, 1978). Finally, to investigate the relationship between working memory span scores, vocabulary scores, processing time and recall, each participant completed two working memory span tasks and one vocabulary test prior to listening to the passages.

CHAPTER 2: Methods

Participants

Thirty-two listening participants consisting of 12 men and 20 women between the ages 19 and 40 were recruited for this study (M = 25.8 years, SD = 5.46). All listening participants in the study were native English speakers, had no reported history of significant medical problems that might impair cognitive functioning, such as a cardiovascular accident, and had normal hearing bilaterally according to a pure tone hearing screen test (where normal is defined as equal to or lower than 25 dB HL at octave frequencies from 250 to 8 kHz). One speaking participant was recruited for this study. This participant was a native English speaker and had no reported history of significant medical problems that would impair speech output, such as a cardiovascular accident or a hearing loss. Both the speaking participant and the listening participants were recruited though postings around the University of British Columbia and recruitment flyers sent via e-mail. The use of human participants for the current study was approved by the Behavioural Research Ethics Board of the University of British Columbia. All participants provided written informed consent prior to beginning the study. The ethics certificate and the informed consent (for participants and speaker) used for the study can be found in Appendix A, Appendix B and Appendix C, respectively.

Materials

Four passages (see Appendix D) previously used to demonstrate serial position effects were employed in this study. The passages included modified versions of: “The Serenada” and “Washing Clothes” taken from Bransford and Johnson (1972), and “Columbus” and “First Space Voyage” taken from Dooling and Lachman (1971). Each passage includes empty nouns and ambiguous phrases, and therefore, is described to be difficult to understand (Kintsch & van Dijk, 1978). Consistent with the methods of other reading studies, three passages were entitled “Making and Flying a Kite”, “Washing Clothes”, and “First Space Voyage”, respectively (Miller et al., 2006). The fourth passage was entitled “Discovering America” instead of the previous used title (“Christopher Columbus” Miller et al., 2006), because it was agreed among four researchers (the main researcher, supervisor and committee members for this study) that Discovering America was a title that listeners in the present study’s geographical location would recognize better. One additional (practice) passage from a hiking book was used in order for participants to familiarize themselves with the experimental task.

A propositional analysis for each passage was carried out in order to balance the number of propositions within the first, middle and final portions for each passage, as the number of propositions within a segment has shown to affect the duration readers and listeners take to read or listen to a segment (Titone et al., 2000). The propositional analysis was also used as an inventory list for scoring participants' recall. The propositional analysis was conducted by two judges (including the main researcher of the study and a committee member) using a system developed by Kintsch (1974) and modified by Turner and Greene (1978). After an initial independent analysis, the judges met, discussed and agreed upon any discrepancies. The overall number of propositions for each passage was 50 (Making and Flying a Kite), 49 (Washing Clothes), 50 (Discovering America), and 62 (First Space Voyage). Altogether, the mean number of propositions for all four passages was 53.8 (see Table 1 for further characteristics of each passage). An example of the propositional representation (the outcome of the propositional analysis) of the passage "Making and Flying a Kite" is shown in Appendix E.

Table 1 Passage characteristics

Text Characteristics	Passage			
	Making and Flying a Kite	Washing Clothes	Discovering America	First Space Voyage
No. sentences	14	10	6	8
No. AMW segments	18	16	10	9
No. propositions	50	49	50	62
Mean propositional density per segment	0.14	0.11	0.15	0.16
Mean No. syllables per segment	8.4	10.7	12.7	14.7
% within-clause boundaries	6	6	30	10
% end-of-clause boundaries	17	31	10	10
% end-of-sentence boundaries	78	63	60	78

Note. The abbreviation No. stands for "number of". Propositional density is calculated as the ratio between the number of propositions in the AMW segment and the number of segments (vowels and consonants) in that AMW segment.

All passages were recorded by a male speaker of English at a normal speaking rate, with normal and appropriate intonation. Recording of the passages was conducted in a sound-attenuating booth using an AT3035 30 series Audio-Technica microphone placed approximately at 15 cm from the speaker's mouth. PRAAT software program (version 4.5.06; Boersma & Weenink, 2006) was utilized to record each passage as individual mono-sound files, at a sampling rate of 44 KHz, using an Ultralite Motu audio interface system connected to an iMac (Apple Computers Inc) computer. The recording level was kept constant for all recordings and was set to obtain as high a signal level as possible while avoiding clipping. The speaker was instructed to practice reading the passage out loud three times before recording. Each passage was recorded four times and the best spoken passage (based on clarity of speech) was chosen for the experimental stimuli.

Two versions of each passage were prepared, one for a normal listening condition (unaltered stimuli), and one for a simulated high frequency hearing loss condition. In order to present the passages segment by segment using the AMW technique, all passages were then edited to obtain individual segments that were stored in separate audio files. Passages for the simulated high frequency hearing loss condition were filtered first and then segmented, in order to keep segment and pause durations as closely matched as possible between the two conditions. To generate the simulated hearing loss condition, the passages were low-pass filtered using the the PRAAT software program (Boersma & Weenink, 2006). Filtering was utilized as it is generally agreed that mild hearing losses can be accurately explained in terms of loss of audibility, while more complex factors are involved in more severe hearing losses (Baer & Moore, 1993; Fabry & Van Tassell, 1986; Villchur, 1974; Zurek & Desloge, 2007). Filtering was performed using a de-emphasis (in-line) filter that attenuated energy at the rate of -6 dB/octave with a cut-off frequency of 750 Hz. The filter was applied twice in order to achieve the desired attenuation. Thus, the overall attenuation was -12dB/oct and attenuation did not exceed 50 dB HL at the high frequencies. In order to verify each passage was filtered accordingly, spectral slices of the unsegmented filtered and unfiltered passages were viewed at the same time points, and sound levels (in dB) were compared at octave frequencies (250, 500 Hz 1k, 2k, 4k, 8k, and 16k). See Appendix F for filtering characteristics for each passage.

Segments were created by selecting the majority of the interruption points at locations where naturally occurring pauses were already present, and where natural “wrap up” points took place (i.e., clause and sentence boundaries); this selection method was used in order to maintain some naturalness to the listening task. Some boundaries occurred within clauses in order to minimize the variation of the text characteristics between segments (see Table 1 for a description of where segmentation occurred for each passage, and for the text characteristics for each passage). Each segment was extracted by selecting time points at the beginning and the end of each segment where the sound intensity was at zero (zero crossings) in order to minimize the introduction of transient noise. All naturally-occurring pauses in the passage were kept at the beginning of each segment. The times at which boundaries were made were noted in order to match segment durations for the same passage between conditions. The mean time difference between the same filtered and unfiltered segments was 0.004 sec (range = 0.000-0.018 sec).

General Procedure and Tasks

Participants were tested individually in a double-walled, sound-attenuated booth, during a single session that lasted approximately one and a half hours. First, participants answered a general questionnaire about their health. Next, their hearing was screened at octave frequencies following standard audiometric measurements and procedures. All participants completed two working memory tasks, one vocabulary test and one practice passage. Subsequently, four experimental passages were presented using the AMW technique on an Apple iMac computer, using custom experimental software that was written using the Revolution Studio software package (Runtime Revolution Ltd., 2000-2003). Participants took part in all conditions, so that in total each participant heard four passages in one of the four different conditions (a different condition for each passage). Therefore, each passage was only heard once per participant. The order of conditions and passages were counterbalanced across participants using a random starting order with rotation method (Colbourn, 1984). In total, 16 different orders were used. All auditory stimuli were heard binaurally over Sennheiser HD 280 Pro headphones at a fixed overall level of 69 dBA for the normal hearing condition and 58 dBA for the simulated high frequency hearing loss condition.

Working memory tasks and vocabulary task

A listening span task and an alphabet span task were used to obtain a span score representing working memory performance. These scores were used to see if relationships existed between overall listening duration and working memory span scores, working memory span scores and recall and working memory span scores and vocabulary scores.

The listening span task used in this study was identical to that used by Waters and Caplan (2003) (see Appendix G), and is a modified version of the Daneman and Carpenter's (1980) task. This task is commonly used in listening comprehension research because it correlates with other working memory tasks, including the reading span task (Waters & Caplan, 2003). This task consists of sentences that are divided into seven span levels. Each span level consists of five different trials, and each trial number corresponds to the number of sentences in the corresponding span. As the span increases, the number of sentences presented increases by one.

For instance, span two has five trials each with two sentences, while span three has five trials each with three sentences. The sentences in this task consist of a main clause and a subordinate clause (e.g., “It was the gangster that broke into the warehouse”). Half of the sentences are acceptable, and half are not acceptable. Participants were asked to verify whether each sentence was acceptable or not after hearing each sentence over headphones. Following the completion of each trial, the participants were asked to recall the final word of each of the sentences within the trial. The task was terminated when participants failed to recall all the final words for three or more of the five trials in a span. The number of correct items and the highest span was calculated for each participant.

The Alphabet Span Task (see Appendix H), also taken from Waters and Caplan (2003), was also used to assess working memory. The stimuli in this task consist of monosyllable words of moderate frequency. Similar to the listening span task, there are five trials for each span, and the number of words in each trial corresponds to the span level with seven spans in total. For this task, participants listened to a list of words played over headphones by the researcher. Participants were asked to organize the list of words alphabetically in their head and recall the list out loud in alphabetical order. The task was terminated when the participant failed to accurately recall and alphabetize three or more of five trials correctly. The number of correct items and the span score were calculated for each participant.

To measure each participant’s vocabulary the Shipley Vocabulary Test (1940) (see Appendix I) was carried out. The Shipley Vocabulary test includes 40 target words and involved each participant choosing the synonym of a target word out of four possible options. The number of correct synonyms was tallied for each participant.

AMW task

Passages were played to each participant using the AMW technique. As discussed earlier, using the AMW technique allows the passages to be played in segments over speakers in order to measure the processing load of each segment (Ferreira et al., 1996). For this task, participants pressed the space bar on the computer keyboard to listen to the first segment, and then continued to press the space bar to listen to each subsequent segment. Participants could not repeat segments that had already been played. The time between button presses was taken as a measure of the processing time required for that segment. Thus, longer response times to certain segments indicated larger processing load. This dependent measure is assumed to reflect the cognitive demands of both storage and processing.

During the AMW task participants were instructed to listen to each passage and were advised to take as much or as little time as required in order to understand and recall the story. Before the participant started the experimental tasks, he/she was given a practice passage in order to become familiarized with the AMW task. Participants were instructed to hit the space bar on the computer keyboard in order to continue hearing the next segment. After the last segment of a passage had been presented a message on the screen signaled the end of the passage; the participant was then asked to recall what they remembered from the passage out loud.

Recall task

Recall was recorded using an RCA VR5200 digital voice recorder to ensure participants were reading and processing the passages. Recall was also used as a dependent measure for later analysis. A total of 128 recalled passages were collected and transcribed. All recall was transcribed in Microsoft Word, where transcripts were organized so that each line corresponded to one T-unit (Paul, 2007) for ease of analyzing recall against propositional analyses. Twenty percent of the recalled passages were transcribed by a second transcriber. Inter-rater reliability of the transcriptions was 97% terms of agreement on number of words. When discrepancy occurred between the two transcribers, both transcribers met and agreed on a final transcript.

Statistical Analysis

In order to test the effect of title, filtering condition and serial position on processing time and recall, raw data collected from participants was converted into processing time and recall measures. Calculated processing time measures included “mean pause duration” (MPD) and “overall listening duration”. To calculate MPD, the segments in a passage were grouped into either a beginning, middle or end section depending on a segment’s position in a passage. Segments were organized into such sections (beginning, middle and end) so that the number of segments in each section was balanced for each passage (e.g., there were four segments in each of the beginning, the middle and the end sections of a passage). As discussed earlier, the number of propositions in each section was also taken in account. Next, participant pauses for each segment were averaged within each section. As with previous reading and listening studies, pause time between segments is thought to reflect the processing time readers or listeners require in order to build relationships between propositions (Little et al., 2005; Wiley & Rayner, 2000). Averaging the pause times resulted in three MPD values -representing pause times for the beginning, middle and end sections- for each passage. MPD values were analyzed to determine whether title, hearing, and serial position conditions affected participants' pauses between segments. Overall listening time was calculated by subtracting the time point at which participants pressed a button at the end of a passage from the time point at which participants pressed the button to start listening to the passage. Twenty percent of all data spreadsheets were checked by an individual familiar with data processing, in order to ensure the data used for analysis was accurate.

Recall performance was scored based on the number of propositions recalled using a gist criterion (Kintsch, Kozminsky, Streby, McKoon & Keenan, 1975; Turner & Greene, 1978). This method was used because evidence has shown that in immediate recall, participants' responses contain both word substitutions and paraphrases of an original utterance (Wingfield, Tun, & Rosen, 1995). Therefore, this scoring method counted for both types of recall (verbatim and paraphrasing). Scoring was done by judging each participant's recall for each passage against the propositional analysis previously carried out for each passage. If an argument was incorrectly recalled, it was not counted as correct. For example, if a participant said "one needs little room" instead of "one needs lots of room", the only proposition counted would be *(needs, one, room)*. The total correct propositions recalled and the percentage of correct recalled was tallied for each passage. To check the reliability of the propositional analyses of the 128 passages, a second rater carried out a second propositional analysis on twenty percent of the passages. In terms of the number of propositions correct, the raters agreed 94% of the time.

Statistical analyses was conducted to determine whether differences in performance justified the rejection of the null hypotheses for the experimental condition, for a level of significance smaller than 0.05. Overall three ANOVAs, two MANOVAs and a correlation analysis were conducted. One three-way ANOVA with repeated measures was conducted to test the effects of title (present vs. absent), filter condition (simulated high frequency hearing loss vs. normal hearing condition) and passage position (beginning, middle, final) on MPD. A second three-way ANOVA with repeated measures was carried out in order to see the effect of title (present vs. absent) and filter condition (simulated high frequency hearing loss vs. normal hearing condition) on overall listening duration. For analysis of recall data, a two-way ANOVA with repeated measures was conducted with title condition (absent vs. present) and filter condition (normal vs. simulated hearing loss) as the within-subject factors. A post hoc Mauchy Sphericity test was carried out to check for violations of assumptions for testing within-subjects effects. When significant results were found, effect size was measured using Cohen's *d*. In order to find which means were significantly different from one another (when more than two means existed), post hoc Tukey tests were performed.

Chapter 3: Results

The results from the present study's analyses are presented with regards to processing measures (MPDs and overall listening durations) and post-processing measures (recall) as well as for the results from the MANOVAs and the correlation analysis. Only significant results are reported.

Analysis of Processing Time

To examine the effects of title and simulated hearing loss on processing time, MPD values were analyzed using a repeated measures ANOVA with title (absent vs. present), filter condition (normal hearing vs. simulated high frequency hearing loss) and passage position (beginning, middle and end) as the within-subject factors. It was found that the presence of a title significantly reduced MPDs, $F(1, 31) = 13.88$, $p < 0.01$, $d = 0.44$; ($M_{\text{with title}} = 1555.44$ msec, $SD_{\text{with title}} = 622.71$) ($M_{\text{without title}} = 1848.42$ msec, $SD_{\text{without title}} = 764.94$). In order to show how a topic title affected processing demands across a passage, MPD values across a passage (beginning, middle and end) were compared. As expected, a main effect of serial position was found, $F(2, 62) = 16.85$, $p < 0.01$, as listeners paused longer at the beginning of a passage (M = 1964.15 msec, $SD = 711.57$) compared to the middle (M = 1731.08 msec, $SD = 823.78$) and end (M = 1410.55 msec, $SD = 647.65$) sections of a passage. A post hoc Tukey analysis revealed that MPD values for the beginning section of a passage were significantly longer than those for the middle and final sections of a passage ($p < 0.05$, $d = 0.35$, $p < 0.01$, $d = 0.84$ respectively). Given that an overall serial position effect was demonstrated, it was predicted that topic titles would reduce a listener's processing demands across leading to a reduced serial position effect. The pattern of the means is consistent with this prediction (see Figure 1), and was supported by the presence of a significant Title by Serial Position interaction, $F(2, 62) = 3.21$, $p < 0.05$. Title present ($M_{\text{begining}} = 1727.84$ msec, $SD_{\text{begining}} = 685.64$; $M_{\text{middle}} = 1587.81$ msec, $SD_{\text{middle}} = 743.80$; $M_{\text{final}} = 1350.84$ msec, $SD_{\text{final}} = 680.99$) compared to when a title was absent ($M_{\text{begining}} = 2200.64$ msec, $SD_{\text{begining}} = 884.83$; $M_{\text{middle}} = 1874.35$ msec, $SD_{\text{middle}} = 1037.80$; $M_{\text{final}} = 1470.26$ msec, $SD_{\text{final}} = 685.73$). However, a post hoc sphericity test revealed a Title by Serial assumption violation. As a result, a Wilk's Lamda test was conducted and provided sufficient support that a Title by Serial Position interaction exists $F(2, 31) = 4.55$, $p < 0.05$. An additional post hoc Tukey analysis revealed that MPD values in the beginning section of a passage when titles were presented were significantly shorter (1727.84 msec) compared to the MPD values in the beginning of a passage when titles were not present (2200.64 msec; $p < 0.01$, $d = 0.72$). See Table 2 for further MPD values.

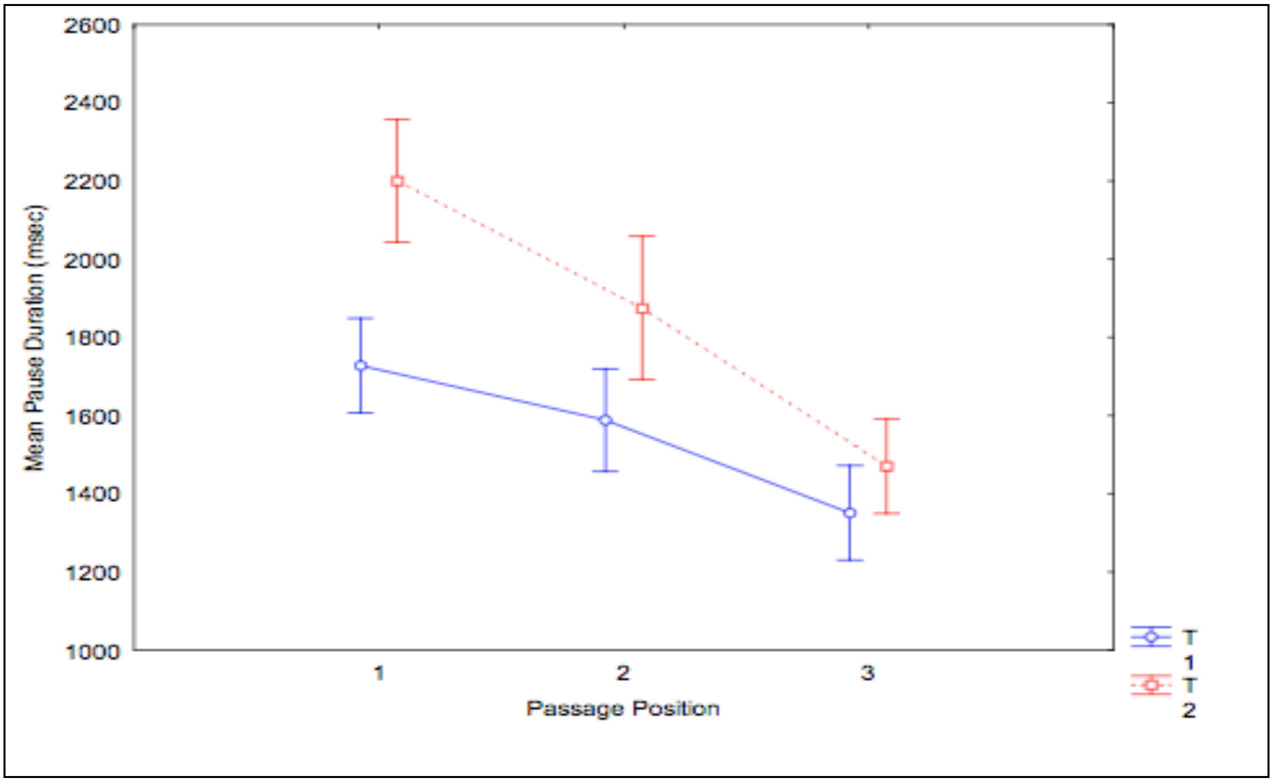

Figure 1 Mean pause durations across passage position at beginning (1), middle (2) and end (3) of passage when topic title was presented (T1) or absent (T2) prior to listening to a passage. Error bars indicate standard error.

Table 2 Mean pause duration values (means and standard deviations) across passage position (beginning, middle and end) for all experimental conditions

	Mean Beginning	Standard Deviation	Mean Middle	Standard Deviation	Mean End	Standard Deviation
Title/Filtered	1933.69	1055.23	1641.84	865.19	1478.38	891.91
Title/ No Filter	1521.63	580.05	1533.78	948.47	1223.31	629.01
No Title/ Filtered	2391.78	912.76	1912.70	1034.81	1486.62	737.33
No Title/ No Filter	2009.50	1247.39	1836.00	1468.62	1453.91	871.16

Overall listening durations were used to measure listener's processing time in order to determine whether titles reduced processing time, and whether listening to a passage in a simulated hearing loss condition increased processing time. A repeated measures ANOVA was conducted with the title condition (absent vs. present) and filter condition (normal hearing vs. simulated high frequency hearing loss) as the within-subject factors. As expected, processing time was shorter when topic titles were presented compared to when absent $F(1, 31) = 4.61$, $p < 0.05$, $d = 0.55$; ($M_{\text{with title}} = 56644.86$ msec, $SD_{\text{with title}} = 8579.48$) ($M_{\text{without title}} = 60595.64$ msec, $SD_{\text{without title}} = 10048.30$). See Table 3 for further overall listening duration values.

Table 3 Means and standard deviations for total overall duration for all experimental conditions

	Mean	Standard Deviation
Title/Filtered	58727.81	11638.11
Title/No Filter	54561.91	9993.84
No Title/Filtered	62024.50	14613.44
No Title/No Filter	59166.78	12987.94

Analysis of Recall

Analysis of recall was used as a post-processing measure to determine whether titles facilitate listening comprehension by improving a participant's memory for a passage, and to test whether increased processing demands (as a result of a simulated high frequency hearing loss condition) resulted in poorer recall performance. To examine the effect of title and simulated hearing loss on recall, a repeated measures ANOVA was conducted with the filter condition (normal vs. simulated hearing loss) and title condition (absent vs. present) as the within-subject factors. As expected, a main effect of title was found, $F(1, 31) = 17.66$, $p < 0.01$, $d = 0.78$; ($M_{\text{with title}} = 30.0\%$, $SD_{\text{with title}} = 11.92$) ($M_{\text{without title}} = 21.9\%$, $SD_{\text{without title}} = 11.58$), confirming that titles facilitated recall. See Table 4 for further means and standard deviations of percentage of propositions recalled.

Table 4 Means and standard deviations for percentage of propositions recalled for all experimental conditions

	Mean	Standard Deviation
Title/Filtered	29.00	6.25
Title/No Filtered	31.03	6.26
No Title/Filtered	20.61	1.62
No Title/No filtered	37.27	2.08

MANOVAs

Two multivariate analyses of variance (MANOVAs) were chosen to identify any main or interaction effects of the independent variables (title and filter condition) on pairs of dependent measures (one analysis for mean pause duration and percentage of propositions recalled, and one for overall listening duration and percentage of propositions recalled) and in order to test the possibility of incorrectly rejecting the null hypothesis as a result of conducting separate univaritate ANOVAs for dependent variables (title and filter). For the MANOVA when MPD and recall were the dependent variables, MPD values (beginning, middle and end) were averaged so that there was one overall value representing MPD per passage (rather than three values). This value is referred to as average MPD. For the MANOVA that involved overall listening duration and recall as the dependent variable the main effect of filter condition was statistically significant, $F(2, 30) = 3.62$, $p < 0.05$; the main effect of title was also significant, $F(2, 30) = 11.32$, $p < 0.05$. When average MPD and recall were the dependent variables only the main effect of title was significant, F (2. 30) 14.19 $p < 0.01$. The effect of title remained for both MANOVA analyses increasing the confidence that a type 1 error was not committed as a result of performing multiple ANOVAs.

Correlational Analyses

Correlations were calculated to provide corroborating evidence on the relationship between working memory and recall (Miller et al., 2006; Stine-Morrow et al., 1996), vocabulary and recall (Stine-Morrow et al., 1996) and overall listening time and recall. For this analysis, participant's total recall (total propositions recalled) for all conditions was used. To test whether the knowledge of titles is associated with reduced working memory demands, Pearson's *r* correlations was calculated between working memory span scores and the percentage of propositions recalled for each of the four experimental conditions.

Consistent with previous research, positive correlations between working memory span scores and recall were found. This analysis revealed that both working memory measures, listening span and alphabet span, were positively correlated with total proposition recalled, $r = 0.50$, $p < 0.05$ and $r = 0.42$, $p < 0.05$, respectively. Vocabulary scores also significantly correlated with total propositions recalled, $r = 0.48$, $p < 0.05$. There was also a significant correlation between listening span scores and alphabet scores, $r = 0.42$, $p < 0.05$ (see Table 5 for a complete correlation matrix). In order to provide evidence that the knowledge of titles reduces working memory demands, correlations were calculated between working memory span scores and the percentage of propositions recalled in each condition. It was found that the positive correlations between percentage of propositions recalled (for each experimental condition) and working memory span scores were smaller when titles were present compared to when titles were absent (see Table 5). For example, a significant positive relationship between alphabet span and percentage of propositions recalled existed when titles were not present ($r = 0.41$, $r = 0.44$ for the no title and normal hearing condition and the no title and simulated hearing loss condition, respectively). However, when a title existed the relationships were no longer significant ($r = 0.24$, $r = 0.11$ for the title and normal hearing condition and the title and simulated hearing loss condition, respectively). The correlations between overall listening duration and all other variables were not significant.

Table 5 Correlations among memory and vocabulary measures, overall duration and the percentage of propositions recalled in each experimental condition and the total propositions recalled.

	LS	AS	Shipley Vocab	Title/ Filtered	Title/ No Filter	No Title/ Filtered	No Title/ No Filter	OLD
LS	--							
AS	0.42 *	--						
Shipley Vocab	0.36 *	0.72 *	--					
Title/ Filtered	0.36 *	0.11	0.22	--				
Title/ No Filter	0.31	0.24	0.32	0.14	--			
No Title/ Filtered	0.39 *	0.44 *	0.43 *	0.59 *	0.17	--		
No Title/ No Filter	0.34	0.41 *	0.39 *	0.15	0.46 *	0.22	--	
OLD	-0.10	-0.14	0.03	0.16	-0.03	0.13	-0.21	--
Total Recalled	0.50 *	0.42 *	0.48 *	0.67 *	0.68 *	0.69 *	0.69 *	0.09

Note: OLD refers to overall listening duration, LS refers to listening span and AS refers to alphabet span. * indicates $p < 0.05$

Chapter 4: Discussion

This chapter reviews and discusses the findings in relation to the research hypotheses proposed in Chapter 1. Other important findings, limitations of this study, and future directions for research are also discussed.

Effects of the Knowledge of Passage Titles on Listening Comprehension

The first goal of the study was to determine whether the knowledge of titles reduced processing time (both MPD and overall listening duration) and increased the amount of recall. An additional prediction was that the knowledge of titles would decrease (or eliminate) the serial position effect. The results supported these predictions. Specifically, MPD was 15.9% shorter when a topic title was presented compared to when it was absent. Overall listening duration was also shorter when topic titles were present (56644.9 msec) compared to when topic titles were absent (56644.9 msec). The percentage of propositions recalled was 8.1% greater with topic titles present (30% in the title condition versus 21.9% in the non-title condition). These findings are consistent with the previous results of language comprehension studies using off-line (Bransford & Johnson, 1972; Dooling & Lachman, 1971) and on-line (Miller & Stine-Morrow, 1998; Wiley & Rayner, 2000) procedures. In addition, Miller et al. (2006) found that topic titles increased reading efficiency, calculated as the ratio between reading time and propositions recalled. These findings are consistent with the idea that reduced processing demands, reflected through reduced MPD and reduced overall listening durations, allow for further cognitive processing such as memory for what the passage was about.

The MPD data from the present study are consistent with the findings of a reading study by Miller and Stine-Morrow (1998), who found that titles reduced participants' pauses at sentence and clause boundaries. The present findings are also consistent with those of Little et al.'s (2005) listening study. Although Little's et al. manipulated familiarity with the passages (rather than the knowledge of titles), both familiarity with a topic and titles are likely to provide a comprehender with a portion of a situation model (i.e., the foundation). Therefore, one would expect to observe similar effects of these variables on processing time measures. Interestingly, the findings of the present study matched the results of the younger adult group in Little et al.'s study. By contrast, their group of older adults showed similar pause durations whether they were or were not supplied with a situation model. Little et al. hypothesized that the difference in performance between younger and older adults was likely due to cognitive consequences of aging. Due to cognitive slowing, older adults may be more sensitive to the greater demands of listening to a passage compared to younger adults (Little et al., 2005). Little et al. suggested that the group difference may also have resulted from a difference in task strategy use. This has been shown in previous studies where a listener may choose to listen to a passage differently depending on the circumstances (e.g., task, motivation or processing load) (Stine-Morrow et al., 1996). For example, a participant may take a long time to process a passage because he/she finds it difficult to process the information while another participant may take the same amount of time because he/she is being more thorough. Altogether, the results from the present study are consistent with the idea that pause durations between sentence and clause boundaries reflect a comprehender's "wrap-up time" and reveal the time it takes to integrate concepts or build relationships between propositions (Aaronson, Ferres, 1984; Wingfield & Butterwork, 1994). Since pause durations directly reflect a comprehender's processing load (Ferreira et al., 1996), shorter pause durations are thought to reflect a reduced processing load and thus easier concept integration. If a comprehender knows what a passage is about (through the knowledge of its title), he/she can more easily create relationships between propositions and can better determine the referents of vague terms (Smith & Swinney, 1992). For example when hearing "First you arrange things into different groups depending on their makeup" when given the title "washing clothes", participants may be more likely to link a vague term such as "things" with "clothes" and "makeup" with "color". If this is true, the benefit of titles should be greatest for passages with vague terminology, such as the passages used in this study.

The present study's results are also consistent with evidence from on-line reading studies. Miller and Stine-Morrow (1998) and Miller et al. (2006) found that participants had shorter overall reading durations when topic titles were presented before a passage. Because it is thought that the time spent reading is proportional to processing load, these findings provide additional support that topic titles facilitate language comprehension by reducing processing demands. It is likely that overall listening durations are shorter as a result of faster concept integration as discussed above. As with the hypotheses of the present study, it is thought that overall listening time also reflects the ease of building a conceptual representation as a result of a title being present. For instance, topic titles are thought to facilitate discourse processing and thus ease the building of a macrostructure through the activation of relevant knowledge and the suppression of irrelevant knowledge. This helps build relationships between concepts (as discussed above) as well as between paragraphs or main ideas (Gernsbacher 1990; Miller et al., 2006). It is possible that faster word level processing might also account for the effect of title observed in language comprehension tasks. However, this alternative could not be tested in the present study because the stimuli were presented in fixed segments of sentences or clauses (Titone et al., 2000). If the present study did measure word-by-word processing, one would expect that the difference between overall duration in the title and non-title conditions may have been greater as word level processing would be directly measured and taken into account. As discussed with MPD, overall listening time may also be affected if a comprehender was using a particular strategy when processing a passage. Miller and Stine-Morrow (1998) found that readers with greater recall performance also took longer to read a passage. Readers may be taking more time in order to fully understand the incoming text and build a better mental representation. However, the correlation between overall listening duration and recall performance was not statistically significant in the present study. It is possible the present study's findings are different from Miller and Stine-Morrow's because some individuals may take longer because they are inefficient at completing a task and that some individuals take longer because they are focusing more effort to do a better job (Miller & Stine-Morrow, 1998).

Consistent with the findings of previous listening and reading studies, it was predicted an overall serial position effect would (Gernsbacher, 1990; Little et al., 2005; Miller & Stine-Morrow, 1998; Stine-Morrow et al., 1996). In the present study, pauses for the beginning of a passage were longer compared to pauses in the middle and end of a passage when no titles were present. These results are consistent with the findings of previous reading and listening studies that have found that comprehenders spend more time processing the beginning of a passage compared to the middle and end of a passage. Longer pause durations in the beginning of the passage are thought to reflect a comprehender building a foundation for a mental model (Gernsbacher, 1990; Miller & Stine-Morrow, 1998; Stine-Morrow et al., 1996). Shorter pause durations at the middle and end of a passage are thought to reflect faster processing time, as a mental model no longer has to be built and incoming information only needs to be mapped onto the already built foundation. In addition to replicating a serial position effect, the present study also tested the hypothesis that pause durations should be shorter and more evenly distributed across the beginning, middle and final sections of a passage when topic titles were presented. This prediction was supported (see Figure 1). Importantly, when titles were presented the processing time in the beginning of the passage was much shorter compared to when a title was not present. These findings are consistent with the results of both previous listening (Little et al., 2005) and reading studies (Miller & Stine-Morrow, 1998). These findings provide insight as to how topic titles facilitate language comprehension at the discourse level. As predicted on the basis of Gernsbacher's (1990) language comprehension model, comprehenders typically take more time at the beginning of a passage in order to build a foundation so that later incoming information can be mapped onto the structure. When a title is present, comprehenders do not have to devote as much cognitive resources to the generation of a foundation, and as a result comprehenders do not need to take more time listening to the beginning of a passage. In addition, topic titles are thought to facilitate discourse level processing through the suppression and enhancement processes signaled from activated memory cells (Gernsbacher, 1990). Such processes activate relevant knowledge or suppress irrelevant knowledge and help establish relationships between the more global parts of the text such as between current and preceding paragraphs.

Effects of High-Frequency Filtering on Listening Comprehension

Consistent with our understanding of language processing and working memory, it was predicted that participants would have longer MPD and overall listening time when listening in the simulated high frequency hearing loss condition compared to the normal hearing condition. This hypothesis was not fully supported. While the trends in MPD values and overall listening duration were consistent with this prediction, the corresponding effects was also not found to be statistically significant. It was also hypothesized that recall would be poorer in the simulated high frequency hearing loss condition compared to the normal hearing loss condition. Although fewer propositions were recalled in the simulated high frequency hearing loss condition, this effect was not statistically significant. The trends found in the current study are consistent with other studies that have found poorer recall performance when speech is presented in noise (Pichora-Fuller et al., 1995; Rabbitt, 1968) or when reading with a distracter task (Miller et al., 2006). Such trends are consistent with the idea that a toll is placed on working memory for those listening with impaired hearing, as more resources are allocated to perceiving the message and fewer resources are available for storage or further cognitive processing. One of my hypotheses related to the effect of high frequency filtering stated that the knowledge of the passage title would compensate for the effect of high frequency filtering. Again, there were consistent trends between the three variables (MPD, OLD and recall) across all conditions. Specifically, when looking at the means for each condition the data arranged in a predictable manner from easiest to hardest condition. For example, MPD was shortest in the title and normal hearing condition, which could be thought of as the easiest condition (M =1426.24 msec) followed by the title and simulated high frequency loss condition (1684.64 msec), no title normal hearing condition (1766.47 msec) and no title simulated high frequency loss condition, which could be thought of as the hardest condition (1930.37 msec). However, the interaction effect between title and high frequency filtering was not statistically significant.

The lack of statistically significant effects involving the simulated high frequency hearing loss condition in most of the statistical analyses that were performed in the present study may be a result of high variability among participants. For example, participant MPD values ranged from 410- 5670 msec and number of propositions recalled ranged from 1-43. It is also possible that the characteristics of the text may have masked any affects of the simulated high frequency hearing loss. For example, listeners may have paused for longer or shorter durations at segment boundaries depending on proposition density and/or number of syllables or segments (consonants and vowels) present in each passage segment. Such text characteristics have been found to have positive correlations with increased pause durations in listening studies (Titone et al., 2000). While previous listening studies controlled for the number of words (Little et al., 2005) or number of segments (vowels an consonants) in each segment presented using the AMW technique (Titone et al., 2000), the present study did not control for number of words or segment length for each segment because such methods would have resulted in additional within clause boundary interruption points. It was important to reduce within clause boundary interruption points because both readers and listeners do not typically pause at these positions. Forcing a listener to pause unnaturally may bring about an unnatural listening task. In addition, it is not clear if pauses at within clause boundary sites would reflect conceptual integration in the same way interruption points at segment and clause boundaries are hypothesized. It is possible that variability due to unequal number of words of sentences across propositions might have masked a relatively weak effect of high frequency listening for passages presented in quiet. In fact, an effect of filter condition was found when overall duration, but not mean pause duration, was combined with recall data in a MANOVA. It is possible that overall listening duration is less sensitive to slight changes in processing load across propositions, and therefore, may be less affected by characteristics of the text. The variability in processing time across propositions may have masked a real (albeit weak) effect of filter condition on MPD values. The inconsistency between findings of MPD values and overall listening durations suggests that the simulated high frequency hearing loss condition did not substantially increase the demand for working memory resources. The high frequency filtering manipulation was likely not as taxing as using noise to degrade a speech signal. Indeed, Yampolsky, Waters, Caplan, Matthies and Chiu (2002) found that sentence processing time was greater for the groups who listened to sentences in noise compared to quiet. Participants who listened in the greater masking condition (-4.5 dB S/N ratio) also had slower listening times than those with less masking (-3 dB S/N). By contrast, listeners in the present study may have been able to compensate for the distorted speech signal by increasing their effort to comprehend the passages (Baskent, Eiler, & Edwards, 2007). Listeners might have implicitly used top down knowledge to a greater extent when listening to the filtered passage. For example, it is well known that the language system can fill in parts of the inaudible portions making the speech meaningful, as it happens in the phonemic restoration phenomenon (Warren, 1970). This explanation is supported in the literature, as mild auditory impairment doe not seem to inhibit word recognition; however, less subtle degradations (such as moderate auditory impairment) negatively effected word recognition (Baskent et al., 2007).

The Relationship Between Recall Performance, Working Memory and Vocabulary Scores

The third goal of the study was to investigate the relationship among recall, working memory and vocabulary performance. Positive correlations were found, as expected, between the total propositions recalled and working memory span scores, vocabulary scores, and recall. Indeed, previous studies on the role of working memory on language comprehension had reported positive correlations between working memory span scores and recall (Miller et al., 2006; Stine-Morrow et al., 1996), and between vocabulary scores and recall (Stine-Morrow et al., 1996). These findings are consistent with the proposal that working memory plays an important role in processing and storage for language comprehension (Daneman & Carpenter, 1980).

In the present study, it was found that the relationship between recall and working memory span scores was smaller in size or was non-significant when topic titles were presented to listeners (see Table 5), indicating that participants with lower working memory spans were achieving greater recall when a title was present. Tyler (2001) also found that topic titles reduced processing demands when non-native English speakers and native English speakers were asked to listen to a passage while completing a working memory task. In addition, Miller et al., (2006) found that readers had greater reading efficiency (the ratio of propositions recalled and reading time) when they had access to relevant contextual knowledge before reading a passage. They attributed this finding to the reduction in working memory demands that resulted from the knowledge of contextual information. All together these studies support the hypothesis that, when listening to ambiguous passages, the knowledge of a title allows individuals to free up working memory resources in order to comprehend spoken language. Having reduced working memory demands allows a listener to hold and manipulate longer segments of information and/or use the extra processing resources for other cognitive functions such as memory storage (Just & Carpenter, 1992).

Limitations of Study

One limitation of the study was the large variability in the MPD, the overall listening time and the recall data among participants. Such variability may be due to confounding factors such as 1) text characteristics, 2) difference in the listening strategies used 3) motivation and 4) differences between passages. This study did not control for text characteristics such as proposition density (the ratio of propositions per vowel or consonant), number of syllables and number of vowels and consonants existing in each chunk or segment, all of which have been shown to influence listening time in a self paced listening study (Titone et a., 2000). Furthermore, previous listening studies that focused on monitoring processing loads have either controlled for the number of words (Little et al., 2005) or the number of segments (vowels and consonants) within segments by segmenting passages in fixed places (e.g. every 4-5 words), or by presenting the stimuli in a word-by-word fashion. In order to maintain a more "natural" listening experience, the present study did not control for any of these factors and instead segmented the passages at sentence and clause boundaries. However, in future studies researchers may be interested in using such methods in order to control for such confounds and possibly reduce variability. An additional factor that may have contributed to variability in the present data is that, although the selected passages are commonly employed in the scientific literature, they were not standardized, and therefore, were not equivalent to each other. It is possible that some passages were more challenging for participants to understand than others. For example, overall the Discovering America passage had on average 15.1% propositions recalled where as the Making and Flying a Kite passage had on average 36.6.0% propositions recalled, The First Space Voyage passage on average 22.9% propositions recalled and the Washing Clothes passage had on average 30.4% propositions recalled. In order to control for differences between passages, it would be beneficial to use passages that are controlled for passage difficulty.

Another limitation of this study was that it did not control for different strategies listeners may be using. For instance, listeners can pause as long as they wish in order to ensure they understand each segment and how it links to previous segments (Kaakinen & Hyona, 2005; Miller et al., 2006; Stine-Morrow et at., 1996). Since the use of strategies were not explicitly discouraged (or encouraged) for this study, it is possible that participants could have used strategies that may have affected their listening times. For example, if a participant was silently recasting each segment in a passage after hearing it, it is plausible that pause times and overall listening times would be longer than typically expected for some participants. This prediction is consistent with Kaakinen and Hyona's (2005) study who found that when participants were probed to "think out loud" or recast each segment they read out loud after reading it, eye fixation times were longer for those segments compared to when participants read without recasting. On the other hand, if listeners were not motivated to participate in the study, they may have listened to the passage very quickly and may have much shorter pause or listening times. Miller et al. (2006) found that participants' motivation (as assessed through measures for interest/enjoyment and effort/engagement) was positively correlated with reading efficiency (reading time/number of propositions recalled). Thus, strategy and motivation may have affected participants' mean pause time, overall listening duration and recall. Future studies may account for such factors by asking participants if they used a particular strategy after listening to all the passages. In the present study, such data was collected for exploratory purposes by asking participants to write down whether they used any particular strategy after listening to the passage; however, this information was difficult to interpret because of the variation in responses and lack of comprehensive descriptions of what their strategy was. For example, some participants used different strategies for each passage but did not clarify which strategy was used for each passage. Therefore, future studies may wish to list strategies that are commonly used in order to obtain more accurate evidence about the strategies used by listeners to perform these tasks.

As mentioned previously, this study did not measure word-by-word processing and thus does not take into consideration the effect of topic titles on word-based processing. For example, measuring sentence and clause boundary pauses (where segment length is fixed for each participant) does not take into account that listeners may be processing words faster as a result of topic knowledge (Smith & Swinney, 1992). Specifically, it has been found that when titles were presented, ambiguous words were processed faster compared to when titles were absent (Wiley & Rayner, 2000). In addition, it has also been found that topic titles speed up the time spent on reading low frequency words compared to high frequency words (Miller & Stine-Morrow, 1998). Although it is assumed that MPD in this current study reflected faster textbase processing, it is also possible that faster MPD also reflected faster word based processing as a result of a topic title.

Future Studies

Future studies could address some of the limitations discussed above. For example, a word-by-word presentation of the passages could provide data on whether the effect of title could be explained in terms of more efficient processing at the word level. In addition, future studies may also wish to increase the difficulty of the simulated high frequency hearing loss condition (increase the working memory demand) by presenting the passages in background noise. Many studies have shown that speech in noise taxes the working memory system (Pichora-Fuller et al., 1995, Rabbitt, 1968). Using noise may also be more consistent to a real life situation compared to other methods that have been used in the past (such as adding a distracter task and using speech compression). In fact, individuals who are hard-of-hearing often complain of difficulty comprehending spoken language in noise (Working Group on Speech Understanding and Aging, 1988). Future studies may also increase the generalizability of the findings by using passages that are not as ambiguous and difficult to understand as the ones used in the present study. Using such passages may have created an extreme case of absence of knowledge. Therefore, it is still unclear if titles would facilitate language comprehension in situations where passages are less ambiguous. This could be achieved by having a pilot study that includes a range of passages that participants rate for difficulty to understand. Afterwards, rated passages ranging from easy to difficult could be used to assess if and how titles facilitate listening comprehension across a range of easy to difficult passages. This will help indicate how robust the title effect is in terms of facilitating listening comprehension and more thoroughly indicate in what contexts titles are most useful.

Finally, future studies may also include language comprehension questions since greater recall does not necessarily indicate better language comprehension (Kintsch, Welsch, Schmalhofer & Zimny, 1990). Like readers, listeners may be able to remember words without actually understanding the gist of a passage. The opposite is also true, listeners may remember the gist but not be able to remember the words verbatim (Kintsch et al., 1990). Therefore, in order to thoroughly investigate if titles facilitate language comprehension, future studies may investigate the effect of title on different levels of comprehension. Daniel and Raney (2007) have investigated this question in a reading study by observing how participants remembered exact words, how participants were able to answer multiple choice questions, and how they were able to apply the newly acquired information to a novel situation after reading a passage. The authors found that a topic title resulted in improved application of knowledge to a novel scenario, and in better performance in answering multiple choice questions. Interestingly, participants were not able to recall exact words from the text any better when a title was present. Future studies addressing the effect of topic title on different levels of listening comprehension will help us understand if using a title is an appropriate way to facilitate listening comprehension when a specific goal of comprehension is required. In addition it may be interesting to investigate if titles increase the accuracy of recall by looking at the amount of errors participants make, as it is theorized that titles (and more generally background knowledge) help build better organized conceptual models (Kintsch, 1988). Such information would provide additional support for how titles facilitate language comprehension.

Conclusions

The present study was carried out in order to examine the effect of topic title on listening comprehension. Consistent with previous research, it was found that topic titles improved recall performance (Bransford & Johnson, 1972). For the first time in a listening study, it was demonstrated that topic titles facilitated language comprehension by reducing processing time, which likely reflected greater ease of textbase and discourse processing. Although the simulated high frequency hearing loss condition did not prove to consistently tax participants' working memory resources, the present study was able to demonstrate that titles can reduce (working memory) processing demands. This study also provided corroborating evidence of the relationships between working memory and recall and vocabulary and recall. These findings are consistent with the predictions of existing language comprehension models (Gernsbacher, 1990; Kintsch and van Dijk, 1978). Although, it is still unclear how topic titles facilitate language comprehension in real world situations (e.g., conversations, lectures, etc.), the present study provides evidence that topic titles may be beneficial to listeners when listening to ambiguous or difficult to understand speech.

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APPENDIX A: Ethics Certificate

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The University of British Columbia
Office of Research Services
Behavioural Research Ethics Board
Suite 102, 6190 Agronomy Road, Vancouver, B.C. V6T 1Z3

CERTIFICATE OF APPROVAL - MINIMAL RISK AMENDMENT

PRINCIPAL INVESTIGATOR:	DEPARTMENT:	UBC BREB NUMBER:
Valter Ciocca	UBC/Medicine, Faculty of/Audiology & Speech Sciences	H09-01159

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT:

Institution	Site
UBC	Vancouver (excludes UBC Hospital)

Other locations where the research will be conducted:
N/A

CO-INVESTIGATOR(S):
Amy Makaroff

SPONSORING AGENCIES:
UBC Faculty of Medicine

PROJECT TITLE:
Effects of topic knowledge on listening comprehension and processing resourses

Expiry Date - Approval of an amendment does not change the expiry date on the current UBC BREB approval of this study. An application for renewal is required on or before: June 25, 2010

AMENDMENT(S):	AMENDMENT APPROVAL DATE: October 20, 2009	
Document Name	**Version**	**Date**

The amendment(s) and the document(s) listed above have been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human subjects.

Approval is issued on behalf of the Behavioural Research Ethics Board and signed electronically by one of the following:

Dr. M. Judith Lynam, Chair
Dr. Ken Craig, Chair
Dr. Jim Rupert, Associate Chair
Dr. Laurie Ford, Associate Chair
Dr. Anita Ho, Associate Chair

APPENDIX B: Listener Informed Consent

Principal Investigator:
Dr. Valter Ciocca, PhD, Director and Professor
School of Audiology and Speech Sciences
UBC Faculty of Medicine
(604) 822-5795

Co-investigator:
Amy Makaroff, M.Sc. Candidate
School of Audiology and Speech Sciences
UBC Faculty of Medicine
(778) 828-0362

This project is for a Master of Science thesis.

The purpose of this form is to give you the information that you need to help you decide if you want to participate in this study. Please read this form carefully and feel free to ask questions about the purpose of this research, what we will do, the potential risks and benefits, your rights as a volunteer and anything else about the research or this form that is not clear.

Purpose
This is a research study about the processes that underlie the understanding of speech. The information obtained in this study will test language comprehension models and may ultimately help us understand how language therapy programs can be made more effective.

Procedures
If you choose to participate in this study, you will take part in one session that will last approximately 90 minutes. All testing will be carried out in the School of Audiology and Speech Sciences located on UBC campus.

During the session you will take part in the following tasks:
1. We will ask you general questions about your health and language background. We will also ask you questions to test you memory and knowledge of vocabulary.
2. (Hearing test): You will be asked to wear headphones and to raise your hand when you hear soft “beeps”. If your hearing is found to be within the normal range, you will proceed to the next task.
3. (Experimental task). We will ask you to sit in a quite room and listen to four spoken stories that will be presented in successive segments. You will control the presentation time of each successive segment. A short story will be used in order to familiarize you with this procedure.
4. (Recall). After listening to each story, you will be asked to recall as much as you can about each story. Your recall will be recorded and later it will be scored by a researcher who is trained in privacy and confidentiality.

Benefits
You will complete a hearing screening to determine whether your hearing ability on the day of testing is within normal limits. If you pass the hearing screening you will know your hearing is within the normal range. If you do not pass this screening you will learn that you possibly have a hearing impairment and will be provided with the needed information to arrange for a detailed follow up assessment with an audiologist. You may also benefit by learning about the research process (e.g. what it is like to be a study participant). Upon request we will send you a summary of the study's overall findings.

Risks, Stress, or Discomfort
There are no known physical risks for the procedures involved during this study. It is possible that the earphones may cause you some discomfort. The researcher can help you adjust them for you. If you become fatigued during the tasks you will be allowed to take a break or discontinue the testing session. No participants will be compelled to complete the activities against his/her will.

Confidentiality
You understand that your identity will be protected by assigning you a participant code. This code will be used to identify all of your forms and computer files. Only group results (no individual results) will be given in any reports about the study. Coded results only (no personal information) will be kept in computer files on a password-protected computer. Hard-copies of documents will be stored in a locked filing cabinet inside of a secured and locked laboratory. Only research members that have been trained in privacy and confidentiality will have access to this information.

Compensation:
In order to defray the costs of transportation and the inconvenience, you understand that you will receive an honorarium of $15.00 for participating in this study.

Contact:
This consent form will be made available to you at least twenty-four hours before you arrange an appointment for participating in the study. If you have any questions or desire further information with respect to this study, you may contact Amy Makaroff via email: asjmak@interchange.ubc.ca or telephone (778)-828-0362.

If you have any concerns about your treatment or rights as a research subject, you may contact the Office of Research Services at the University of British Columbia at (604) 822-8598.

Consent:
You understand that your participation in this study is entirely voluntary, and that you may refuse to participate or that you may withdraw from the study at any time without consequence. You understand that, should you withdraw before completion, you will receive an honorarium of $15.00 as reimbursement.

Subject signature ________________ Date ________

Printed Name of the Subject

APPENDIX C: Speaker Informed Consent

Principal Investigator:
Dr. Valter Ciocca, PhD, Director and Professor
School of Audiology and Speech Sciences
UBC Faculty of Medicine
(604) 822-5795

Co-investigator:
Amy Makaroff, M.Sc. Candidate
School of Audiology and Speech Sciences
UBC Faculty of Medicine
(778) 828-0362

This project is for a Master of Science thesis.

The purpose of this form is to give you the information that you need to help you decide if you want to participate in this study. Please read this form carefully and feel free to ask questions about the purpose of this research, what we will do, the potential risks and benefits, your rights as a volunteer and anything else about the research or this form that is not clear.

Purpose
This is a research study about the processes that underlie the understanding of speech. The information obtained in this study will test language comprehension models and may ultimately help us understand how language therapy programs can be made more effective.

Procedures
If you choose to participate in this study, you will take part in one session that will last approximately 30 minutes. The session will be carried out in the School of Audiology and Speech Sciences located on UBC campus.

During the session you will take part in the following tasks:
1. We will ask you general questions about your health and language background.
2. We will ask to you to read 4 short passages using typical intonation. These passages will be recorded for a listening compression study. You will have as much time as you need to practice reading the passages before they are recorded.

Benefits
You may benefit by learning about the research process (e.g. what it is like to be a study participant). Upon request we will send you a summary of the study's overall findings.

Risks, Stress, or Discomfort
There are no known physical risks for the procedures involved during this study. If you become fatigued during the tasks you will be allowed to take a break or discontinue the session. No participants will be compelled to complete the activities against his/her will.

Confidentiality
You understand that your identity will be protected by assigning you a participant code. This code will be used to identify all of your forms and computer files. Only group results (no individual results) will be given in any reports about the study. Coded results only (no personal information) will be kept in computer files on a password-protected computer. Hard-copies of documents will be stored in a locked filing cabinet inside of a secured and locked laboratory. Only research members that have been trained in privacy and confidentiality will have access to this information.

Compensation:
In order to defray the costs of transportation and the inconvenience, you understand that you will receive an honorarium of $10.00 for participating in this study.

Contact:
This consent form will be made available to you at least twenty-four hours before you arrange an appointment for participating in the study. If you have any questions or desire further information with respect to this study, you may contact Amy Makaroff via email: asjmak@interchange.ubc.ca or telephone (778)-828-0362.

If you have any concerns about your treatment or rights as a research subject, you may contact the Office of Research Services at the University of British Columbia at (604) 822-8598.

Consent:
You understand that your participation in this study is entirely voluntary, and that you may refuse to participate or that you may withdraw from the study at any time without consequence. You understand that, should you withdraw before completion, you will receive an honorarium of $10.00 as reimbursement.

Participant's Statement

The study described above has been explained to me and I voluntarily consent to participate as indicated by my signature below. I understand that I can ask questions and can withdraw from this study at any time. If I have questions about my treatment or rights as a participant I may call the Research Subject Information Line in the UBC Office of Research Services at the University of British Columbia, at 604-822-8598. If I have further questions regarding this study I may also contact the principle investigator or co-investigator at any time.

Your signature below indicates that you have received a copy of the consent form for your own records and indicates that you consent to participate in this study.

____

Subject Signature Date

Printed Name of the Subject

APPENDIX D: Passages

1) Making and Flying a Kite adopted from Bransford and Johnson, 1972 "The Serenada"

A newspaper is better than a magazine. A seashore is a better place than the street. At first it is better to run than to walk. You may have to try several times. It takes some skill but it's easy to learn. Even children can enjoy it. Once successful, complications are minimal. Birds seldom get too close. Rain, however, soaks in fast. Too many people doing the same thing can also cause problems. One needs lots of room. If there are no complications, it can be very peaceful. A rock will serve as an anchor. If things break loose from it, however, you will not get a second chance.

2) "Washing Clothes" adopted from Branford and Johnson, 1972

The procedure is quite simple. First you arrange things into different groups depending on their makeup. One pile may be sufficient depending on how much there is. If you have to go somewhere else due to lack of facilities that is the next step. It is better to do too few things at once than too many. This may seem unimportant, but complications from doing too many can easily arise. A mistake can be expensive. The manipulation of the appropriate mechanism should be obvious. At first the whole procedure may seem complicated, but soon it will become just another facet of life. It is hard to foresee any end to the need for this task.

3) Discovering America adopted from Dooling and Lachman, 1971 "Columbus"

With hocked gems financing him, our hero bravely defied all scornful laughter that tried to prevent his scheme. Your eyes deceive, he said with bold determination. An egg, not a table, correctly typifies this unexplored planet. Now three sturdy sisters sought undeniable proof, forging along sometimes through calm vastness, yet more often over turbulent peaks and valleys. Days became weeks as many doubters spread fearful rumors about the edge. At last, from nowhere, welcome winged creatures appeared signifying success.

4) "First Space Voyage" adopted from Dooling and Lachman, 1971

Joe looked outside from cramped quarters. Numerous unknown objects moved swiftly by in vague blackness around his field. Two fearless companions worked along manipulating buttons while reading complex patterns. Flat familiar homeland now actually resembled a tiny rubber ball. Everyone here and at home knew that only lifeless things would be found among huge cold mountains surrounding deep barren valleys. While families and friends gathered yearning for their safe return, all important papers also anxiously awaited their arrival. For no man had ever made such big news. They were about to make history.

APPENDIX E: Propositional Analysis of Making and Flying a Kite

A newspaper is better than a magazine
1. (is, newspaper, better)
2. (is, magazine, better)
3. (better than, 1, 2)

A seashore is a better place than the street
1. (is, seashore, better)
2. (is, street, better)
3. (better than, 1, 2)
4. (is, seashore, place)

At first it is better to run than to walk
1. (is, run, better)
2. (is, walk, better)
3. (better than, 1, 2)
4. (at first, 3)

You may have to try several times
1. (try, you, times)
2. (times, several)

It takes some skill but it's easy to learn
1. (takes, it, skill)
2. (skill, some)
3. (learn, X, to)
4. (3, easy)
3. (but, 1, 4)

Even children can enjoy it
1. (enjoy, children, it)
2. (even, 1)

Once successful, complications are minimal
1. (are, complications, minimal)
2. (to be, successful)
3*(once 2, 1)

Birds seldom get too close
1. (get, birds, close)
2. (seldom, 1)
3. (too, close)

Rain, however soaks in fast
1. (soaks in, rain)
2. (1, fast)
3. (however, 3*, 3)

Too many people doing the same thing can also cause problems
1. (do, people, thing)
2. (people, many)
3. (same, thing)
4. (cause, 1, problems)
5. (also, 1, 4)
6. (2, too)

One needs lots of room
1. (needs, one, room)
2. (lots, 1)

If there are no complications it can be very peaceful
1. (to be, peaceful)
2. (very, peaceful)
3. (to be, complications)
4. (2, not)
5. (if, 2, 1)

A rock will serve as an anchor
1. (serve, rock)
2. (as, anchor)

If things break loose from it, however you will not get a second chance
1. (break loose, things)
2. (get, you, chance)
3. (2, not)
4. (however, 1, 2)
5. (chance, second)
6. (break loose, from it)

Note: * indicates relationship between two propositions in different sentences.

APPENDIX F: Filtering Characteristics

Target filtering valeus and the mean attenuation obained for each passage measured. Measurements were taken at two different times points for each passage and were compared to target attenuation values (in dB).

	Measured filtering values in dB				
	Making and Flying a Kite	Washing Clothes	Discovering America	The First Space Voyage	Target Values for Filtering
Frequency (Hz)					
125	0.1	0.0	-0.2	-0.1	0.0
250	-0.4	-0.4	-0.8	-1.1	-1.0
500	-2.3	-2.3	-4.4	-2.8	-2.5
1000	-8.6	-8.6	-8.8	-8.6	-8.8
2000	-17.4	-17.4	-17.7	-17.8	-17.5
4000	-29.4	-29.4	-29.0	-28.8	-29.0
8000	-40.0	-40.0	-39.9	-40.2	-40.0
16000	-49.1	-49.1	-48.9	-49.0	-48.0

APPENDIX G: Listening Span Task

Example of Instructions:

In this experiment you will hear a series of sentences through your headphones. You have two tasks:

1. Decide whether EACH sentences you hear makes sense. That is, do you think the sentence is about something that could happen in the real world, or is it impossible? If you think it is a good sentence, press say GOOD. If you don't think it is a good sentence, say BAD. It is important for you to be as fast AND as accurate as possible.

2. The second thing we ask you to do is remember the last word of each sentence you hear. After a list of words the experimenter will ask you to say, out loud, the last word of each sentence you just heard, in the same order you heard them.
If you forget one of the words, make sure to tell the experimenter. For example, if the last words are "cat, dog, mouse" and you forget 'dog', it is better to say, "cat, I forgot the second one, mouse' rather than just saying "cat, mouse".

After you have recalled the words out loud another set of sentences will be presented and you will repeat the above steps.

You will now do a short practice session.
Please ask the experimenter if you have any questions.

Stimuli for Listening Span Task

It was the spectators that watched the play	1	1	good	span2	play
It was the child that bit into the fruit	2	2	good	span2	fruit
It was the drum that beat the child	3	3	bad	span2	child
It was the disc jockey that broke the tape	4	4	good	span2	tape
It was the baby that clenched the cup	5	5	good	span2	cup
It was the pizza that bit into the boy	6	6	bad	span2	boy
It was the ice cream that requested the child	7	7	bad	span2	child
It was the chairs that counted the bride	8	8	bad	span2	bride
It was the statue that defaced the kids	9	9	bad	span2	kids
It was the shipper that mailed the box	10	10	good	span2	box
It was the puzzle that intrigued the child	11	1	good	span3	child
It was the woman that fascinated the art	12	2	bad	span3	art
It was the song that played the tape	13	3	bad	span3	tape
It was the woman that inherited the house	14	4	good	span3	house
It was the bumpy road that slowed down the cars	15	5	good	span3	cars
It was the ticket that scratched the man	16	6	bad	span3	man
It was the pie that cut the cook	17	7	bad	span3	cook
It was the ocean that swallowed up the boat	18	8	good	span3	boat
It was the man that appealed to the clothes	19	9	bad	span3	clothes
It was the marbles that lost the child	20	10	bad	span3	child
It was the woman that cherished the note	21	11	good	span3	note
It was the puzzle that solved the girl	22	12	bad	span3	girl
It was the woman that delighted the gift	23	13	bad	span3	gift
It was the cook that heated the pot	24	14	good	span3	pot
It was the rope that tripped the horse	25	15	good	span3	horse
It was the woman that nibbled on the food	26	1	good	span4	food
It was the cookie that made the girl	27	2	bad	span4	girl

It was the thief that tempted the house	28	3	bad	span4	house
It was the weapon that incriminated the man	29	4	good	span4	man
It was the candy that perked up the child	30	5	good	span4	child
It was the elephant that knocked over the gate	31	6	good	span4	gate
It was the critic that disappointed the play	32	7	bad	span4	play
It was the radio that annoyed the class	33	8	good	span4	class
It was the baby that suffocated the sheet	34	9	bad	span4	sheet
It was the gloves that held up the kid	35	10	bad	span4	kid
It was the souvenir that impressed the man	36	11	good	span4	man
It was the fleeing man that hindered the tree	37	12	bad	span4	tree
It was the basement that flooded the rain	38	13	bad	span4	rain
It was the candles that started the fire	39	14	good	span4	fire
It was the girl that nourished the milk	40	15	bad	span4	milk
It was the rats that finished off the traps	41	16	bad	span4	traps
It was the connoisseur that enjoyed the wine	42	17	good	span4	wine
It was the martini that relaxed the man	43	18	good	span4	man
It was the hot chocolate that enjoyed the child	44	19	bad	span4	child
It was the airplane that thrilled the boy	45	20	good	span4	boy
It was the dollhouse that amazed the child	46	1	good	span5	child
It was the bracelet that pleased the girl	47	2	good	span5	girl
It was the bullet that finished off the horse	48	3	good	span5	horse
It was the gangster that broke into the store	49	4	good	span5	store
It was the furniture that polished the wife	50	5	bad	span5	wife
It was the driver that frustrated the lane	51	6	bad	span5	lane
It was the swimmer that guided the lines	52	7	bad	span5	lines
It was the pedestrian that tripped over the branch	53	8	good	span5	branch
It was the cup that glued the man	54	9	bad	span5	man
It was the painting that inspired the pope	55	10	good	span5	pope
It was the mess that bothered the maid	56	11	good	span5	maid
It was the television that distracted the child	57	12	good	span5	child
It was the man that annoyed the light	58	13	bad	span5	light
It was the tailor that displeased the cloth	59	14	bad	span5	cloth
It was the mirror that excited the cat	60	15	good	span5	cat
It was the maid that polished the sink	61	16	good	span5	sink
It was the housewife that angered the cans	62	17	bad	span5	cans
It was the policeman that provoked the gun	63	18	bad	span5	gun
It was the room that cramped the guests	64	19	good	span5	guests
It was the coffee that woke up the man	65	20	good	span5	man
It was the gangster that cut the knife	66	21	bad	span5	knife
It was the child that bewildered the game	67	22	bad	span5	game
It was the people that excited the play	68	23	bad	span5	play
It was the inspector that rejected the place	69	24	good	span5	place
It was the tenant that irritated the door	70	25	bad	span5	door
It was the director that began the play	71	1	good	span6	play
It was the air conditioner that installed the man	72	2	bad	span6	man
It was the bride that terrified the dress	73	3	bad	span6	dress
It was the check that overlooked the bank	74	4	bad	span6	bank
It was the timer that alerted the cook	75	5	good	span6	cook
It was the symphony that delighted the queen	76	6	good	span6	queen
It was the newspapers that accumulated the maid	77	7	bad	span6	maid
It was the student that took the test	78	8	good	span6	test
It was the jogger that lost the hat	79	9	good	span6	hat
It was the man that pleased the tie	80	10	bad	span6	tie
It was the burglar that tripped the hole	81	11	bad	span6	hole
It was the collector that pleased the chair	82	12	bad	span6	chair

It was the people that hurt the bomb	83	13	bad	span6	bomb
It was the nightmare that frightened the child	84	14	good	span6	child
It was the vacation that enjoyed the king	85	15	bad	span6	king
It was the vacationers that stranded the flood	86	16	bad	span6	flood
It was the housewife that dropped the key	87	17	good	span6	key
It was the assassin that shot the pope	88	18	good	span6	pope
It was the throne that was on the lord	89	19	bad	span6	lord
It was the shopper that enticed the clothes	90	20	bad	span6	clothes
It was their testimony that swayed the court	91	21	good	span6	court
It was the banker that issued the loan	92	22	good	span6	loan
It was the thief that tempted the rings	93	23	bad	span6	rings
It was the fog that crashed the plane	94	24	good	span6	plane
It was the official that seized the drugs	95	25	good	span6	drugs
It was the handkerchief that gripped the girl	96	26	bad	span6	girl
It was the woman that treasured the glass	97	27	good	span6	glass
It was the chair that sat on the child	98	28	bad	span6	child
It was the ship that transported the food	99	29	good	span6	food
It was the woman that chose the dress	100	30	good	span6	dress
It was the officer that ticketed the car	101	1	good	span7	car
It was the spectators that watched the play	102	2	good	span7	play
It was the basement that flooded the rain	103	3	bad	span7	rain
It was the statue that defaced the kids	104	4	bad	span7	kids
It was the woman that delighted the gift	105	5	bad	span7	gift
It was the woman that nibbled on the food	106	6	good	span7	food
It was the girl that nourished the milk	107	7	bad	span7	milk
It was the dollhouse that amazed the child	108	8	good	span7	child
It was the gloves that held up the kid	109	9	bad	span7	kid
It was the shipper that mailed the box	110	10	good	span7	box
It was the fleeing man that hindered the tree	111	11	bad	span7	tree
It was the painting that inspired the pope	112	12	good	span7	pope
It was the wife that angered the cans	113	13	bad	span7	cans
It was the woman that cherished the note	114	14	good	span7	note
It was the souvenir that impressed the man	115	15	good	span7	man
It was the mess that bothered the maid	116	16	good	span7	maid
It was the puzzle that solved the girl	117	17	bad	span7	girl
It was the customer that distracted the stubborn cook	118	18	good	span7	cook
It was the man that annoyed the light	119	19	bad	span7	light
It was the tailor that displeased the cloth	120	20	bad	span7	cloth
It was the cook that heated the pot	121	21	good	span7	pot
It was the baby that suffocated the sheet	122	22	bad	span7	sheet
It was the mirror that excited the cat	123	23	good	span7	cat
It was the marbles that lost the boy	124	24	bad	span7	boy
It was the rope that tripped the horse	125	25	good	span7	horse
It was the child that bewildered the game	126	26	bad	span7	game
It was the rats that finished off the traps	127	27	bad	span7	traps
It was the wife that polished the sink	128	28	good	span7	sink
It was the connoisseur that enjoyed the wine	129	29	good	span7	wine
It was the policeman that provoked the gun	130	30	bad	span7	gun
It was the martini that relaxed the man	131	31	good	span7	man
It was the hot chocolate that enjoyed the cup	132	32	bad	span7	cup
It was the house that cramped the guests	133	33	good	span7	guests
It was the child that bit into the fruit	134	34	good	span7	fruit
It was the woman that fascinated the art	135	35	bad	span7	art
It was the cookie that made the girl	136	1	bad	span8	girl
It was the woman that inherited the house	137	2	good	span8	house
It was the gangster that broke into the store	138	3	good	span8	store

It was the song that played the tape	139	4	bad	span8	tape
It was the airplane that thrilled the boy	140	5	good	span8	boy
It was the noise that woke up the sleepy dog	141	6	good	span8	dog
It was the gangster that cut the knife	142	7	bad	span8	knife
It was the people that excited the play	143	8	bad	span8	play
It was the inspector that rejected the place	144	9	good	span8	place
It was the tenant that irritated the door	145	10	bad	span8	door
It was the invalid that strengthened the food	146	11	bad	span8	food
It was the drum that beat the doll	147	12	bad	span8	doll
It was the professor that scored the test	148	13	good	span8	test
It was the swimmer that guided the lines	149	14	bad	span8	lines
It was the bullet that finished off the horse	150	15	good	span8	horse
It was the bracelet that pleased the wife	151	16	good	span8	wife
It was the housekeeper that bothered the floors	152	17	bad	span8	floors
It was the disc jockey that broke the tape	153	18	good	span8	tape
It was the weapon that incriminated the man	154	19	good	span8	man
It was the telephone that woke up the tired girl	155	20	good	span8	girl
It was the furniture that polished up the maid	156	21	bad	span8	maid
It was the thief that tempted the ring	157	22	bad	span8	ring
It was the driver that frustrated the road	158	23	bad	span8	road
It was the baby that clenched the cup	159	24	good	span8	cup
It was the candy that perked up the child	160	25	good	span8	child
It was the pizza that bit into the boy	161	26	bad	span8	boy
It was the ticket that scratched the queen	162	27	bad	span8	queen
It was the elephant that knocked over the gate	163	28	good	span8	gate
It was the road that slowed down the cars	164	29	good	span8	cars
It was the pie that cut the cook	165	30	bad	span8	cook
It was the radio that annoyed the class	166	31	good	span8	class
It was the critic that disappointed the play	167	32	bad	span8	play
It was the chairs that counted the bride	168	33	bad	span8	bride
It was the ocean that swallowed up the boat	169	34	good	span8	boat
It was the pedestrian that tripped over the branch	170	35	good	span8	branch
It was the ice cream that requested the milk	171	36	bad	span8	milk
It was the man that appealed to the clothes	172	37	bad	span8	clothes
It was the broken cup that glued the box	173	38	bad	span8	box
It was the candles that started the fire	174	39	good	span8	fire
It was their testimony that swayed the court	175	40	good	span8	court

APPENDIX H: Alphabet Span

Example of Instructions:

I am going to play you some words over these headphones. When I finish, I want you to say them back to me after first having rearranged them in alphabetical order. For example, if I say 'tree-vest-arm,' you would say . . .? (Subject should respond 'arm-tree-vest.' If s/he finds this too difficult give an example with only two items.) The number of words will increase as this task continues.

- Span is considered the highest span with 3/5 trials or more correct.
- Test is terminated when participant fails 4 out or 5 trials i.e. need to get at least 2 trials correct to continue.
- Subjects are given an additional 0.5 point if they score 2/5 trials correct on a span higher than the last one for which they got 3/5. For example: Subject A gets 5/5 on spans 2-4; 3/5 on span 5; 2/5 on spans 6 and 7, and 1/5 on span 8. Subject A's total span is 5.5.
- Also tally the total number of items each subject gets correct, but only if they are recalled in the correct order. The response 'arm-tree-vest' in the previous example would count as three correct items whereas the response "arm-vest-tree" counts as one correct item. The response "arm-can't remember the second word-last word is vest" or "arm-tree-can't remember the last one" should count as two items correct. Write down any incorrect responses.
- Calculate items correct and span level achieved

Stimuli for Alphabet Span

Span 2

1. pan (2)	hen (1)	_____	_____
2. cat (1)	pen (2)	_____	_____
3. fern (1)	tent (2)	_____	_____
4. tub (2)	fist (1)	_____	_____
5. cheese (1)	leaf (2)	_____	_____

Span 3

1. girl (3)	couch (1)	frog (2)	_____	_____	_____
2. ghost (2)	scar (3)	cake (1)	_____	_____	_____
3. boot (1)	gull (3)	core (2)	_____	_____	_____
4. cage (2)	bull (1)	rope (3)	_____	_____	_____
5. pig (3)	bone (1)	chain (2)	_____	_____	_____

Span 4

1. slacks (2)	wolf (4)	bowl (1)	tent (3)	_____	_____	_____	_____
2. car (1)	nest (3)	kite (2)	sword (4)	_____	_____	_____	_____
3. smoke (3)	barn (1)	wheat (4)	king (2)	_____	_____	_____	_____
4. pen (4)	hose (2)	jug (3)	fire (1)	_____	_____	_____	_____
5. pin (3)	hook (2)	desk (1)	wing (4)	_____	_____	_____	_____

Span 5

1. chief (2)	bowl (1)	wheat (5)	screw (4)	jug (3)	_____ _____ _____ _____ _____
2. comb (1)	wing (5)	lamp (3)	hoof (2)	tree (4)	_____ _____ _____ _____ _____
3. tie (5)	jail (3)	sword (4)	couch (1)	hand (2)	_____ _____ _____ _____ _____
4. shorts (4)	pot (2)	boat (1)	rug (3)	vest (5)	_____ _____ _____ _____ _____
5. jeep (3)	spoon (4)	cork (2)	tack (5)	bird (1)	_____ _____ _____ _____ _____

Span 6

1. heart (3)	cheese (1)	tent (5)	skirt (4)	glove (2)	wrist (6)	_____ _____ _____ _____ _____ _____
2. noose (4)	wing (6)	belt (1)	crow (2)	gem (3)	pig (5)	_____ _____ _____ _____ _____ _____
3. bomb (1)	dog (3)	crib (2)	pin (5)	ham (4)	star (6)	_____ _____ _____ _____ _____ _____
4. swan (5)	gull (2)	tray (6)	corn (1)	ink (3)	lips (4)	_____ _____ _____ _____ _____ _____

5. fern (2) pen (4) gate (3) spoon (6) cloth (1) rug (5) _____
_____ _____ _____ _____ _____

Span 7

1. raft (6) – key (4) – branch (1) – pig (5) – cage (2) – stove (7) – flag (3) _____ _____ _____ _____
_____ _____ _____

2. bone (1) – gem (3) – worm (7) – patch (4) – ear (2) – slacks (6) – rope (5) _____ _____ _____ _____
_____ _____ _____

3. fern (4) – coat (3) – lock (5) – bus (2) – axe (1) – noose (6) – snake (7) _____ _____ _____ _____
_____ _____ _____

4. pan (5) – bull (1) – knee (3) – egg (2) – suit (7) – mop (4) – ring (6) _____ _____ _____ _____
_____ _____ _____

5. peg (6) – ice (4) – chick (3) – lamp (5) – arm (1) – belt (2) – spine (7) _____ _____ _____ _____
_____ _____ _____

Span 8

1. dress (2) – clock (1) – hut (3) – vest (8) – thumb (7) – ink (4) – steps (6) – peg (5) _____ _____ _____ _____
_____ _____ _____ _____

2. hen (3) – tub (8) – boot (1) – pig (5) – cake (2) – raft (6) – sword (7) – nest (4) _____ _____ _____ _____
_____ _____ _____ _____

3. rug (6) – stone (7) – brain (1) – goose (4) – mop (5) – drill (3) – tent (8) – cage (2) _____ _____ _____ _____
_____ _____ _____ _____

4. ham (3) – lung (4) – root (7) – bull (1) – cork (2) – sling (8) – noose (5) – paw (6) _____ _____ _____ _____
_____ _____ _____ _____

5. pie (6) – van (7) – leaf (4) – wing (8) – hoof (3) – cheese (2) – boy (1) – mule (5) _____ _____ _____ _____
_____ _____ _____ _____

APPENDIX I: Shipley (1940) Vocabulary Test

Name: ______________________

In the test below, the first word in each line is printed in CAPITAL LETTERS. Opposite it are four other words. *Circle* the *one word* which means the *same thing*, or most nearly the same thing, as the first word, A sample has been worked out for you. If you don't know, *guess.* Be sure to circle the *one word* in each line, which means the same thing as the first word.

Sample: LARGE red big silent wet

1. TALK	draw	eat	speak	sleep
2. PERMIT	allow	sew	cut	drive
3. PARDON	forgive	pound	divide	tell
4. COUCH	pin	eraser	sofa	glass
5. REMEMBER	swim	recall	number	defy
6. TUMBLE	drink	dress	fall	think
7. HIDEOUS	silvery	tilted	young	dreadful
8. CORDIAL	swift	muddy	leafy	hearty
9. EVIDENT	green	obvious	sceptical	afraid
10. IMPOSTER	conductor	officer	book	pretender
11. MERIT	deserve	distrust	fight	separate
12. FASCINATE	welcome	fix	stir	enchant
13. INDICATE	defy	excite	signify	bicker
14. IGNORANT	red	sharp	uninformed	precise
15. FORTIFY	submerge	strengthen	vent	deaden
16. RENOWN	length	head	fame	loyalty
17. NARRATE	yield	buy	associate	tell
18. MASSIVE	bright	large	speedy	low
19. HILARITY	laughter	speed	grace	malice
20. SMIRCHED	stolen	pointed	remade	soiled

21. SQUANDER	tease	belittle	cut	waste
22. CAPTION	drum	ballast	heading	ape
23. FACILITATE	help	turn	strip	bewilder
24. JOCOSE	humorous	paltry	fervid	plain
25. APPRISE	reduce	strew	inform	delight
26. RUE	eat	lament	dominate	cure
27. DENIZEN	senator	inhabitant	fish	atom
28. DIVEST	dispossess	intrude	rally	pledge
29. AMULET	charm	orphan	dingo	pond
30. INEXORABLE	untidy	involatile	rigid	sparse
31. SERRATED	dried	notched	armed	blunt
32. LISSOM	moldy	loose	supple	convex
33. MOLLIFY	mitigate	direct	pertain	abuse
34. PLAGIARIZE	appropriate	intend	revoke	maintain
35. ORFICE	brush	hole	building	lute
36. QUERULOUS	maniacal	curious	devout	complaining
37. PARIAH	outcast	priest	lentil	locker
38. ABET	waken	ensue	incite	placate
39. TEMERITY	rashness	timidity	desire	kindness
40. PRISTINE	vain	sound	first	level