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Laura Elaine Miller

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Investigating the role for attention in the irrelevant speech task

Laura E. Miller

Louisiana State University

Abstract

The irrelevant speech effect refers to the negative effects of unattended speech, which worsen serial recall. Previous research, such as Buchner and Erdfelder (2005) which tested the word frequency of target words that participants were to recall later in the presence of auditory distractors, found that the frequency of auditory words used as a distraction may affect serial recall of visually presented words, especially when rare words are used as distractors (Buchner & Erdfelder, 2005). Other research has found that the Operation Span task, a commonly used measure of working memory, did not predict individual differences in the irrelevant speech effect (Beaman, 2004). In a replication and extension of these two studies, participants memorized visually-presented high-frequency target words while being presented with high-frequency and low-frequency distractor words over headphones. High-frequency distractors and low-frequency distractors affected participants about the same, and performance in the silent condition was significantly better. High span participants also performed significantly better than low span participants. The results showed that Beaman (2004) was replicated successfully but not Buchner and Erdfelder (2005). The data, therefore, did not support a role for attention in the irrelevant speech task.

Investigating the role for attention in the irrelevant speech effect

The effects of unattended speech have been proven to worsen serial recall (Salamé & Baddeley, 1982), which is known as the irrelevant speech effect. A series of changing tones or other sounds presented during, or immediately after the presentation of the to-be-remembered items will cause a decrement in recall performance (Beaman, 2004). This is even reported to happen when participants are asked to ignore these distractions. One area of research on the irrelevant speech effect deals with attentional control over this effect. Several views of the irrelevant speech effect will be discussed, and the role of attentional control in each of these views will be highlighted.

There is an assumption of two separate components to the working memory system: one based on phonological coding, while the second is used to store visual material. The ability of a person to perform certain tasks within these systems is known as working memory capacity and is measured with working memory span tasks. Baddeley’s model of working memory includes a central executive which controls a phonological loop and a visuo-spatial sketchpad. The irrelevant speech effect disrupts the articulatory process of rehearsal of the to-be-remembered stimuli on the phonological loop. This model also accounts for visually presented items by saying that it is converted into speech to be put on the phonological loop by the articulatory control process. Articulatory suppression prevents this process from being used as a rehearsal mechanism. However, Baddeley’s phonological loop does not account for why some words are more distracting than others in working memory and exactly why irrelevant items can interfere with the phonological store. In relation to the current research focus, Baddeley’s model does not hold any attentional parameter for the intrusion of the irrelevant speech effect.

Another model is Jones' object-oriented episodic record model (O-OER model) which proposes that auditorily and visually presented items are represented using amodal, abstract depictions. This model proposes a single unitary representational space within which the basic units are objects: amodal, abstract representations of items and events. The processes in which the objects are formed and organized in memory are not seen as being distinct from the processes of perception and attention, so it assumes that certain stimuli interfere with the operation of some modules but not others. Within this model are the changing state hypothesis and the equipotentiality hypothesis. The changing states hypothesis claims items that change are more disruptive than items that are repeated. The equipotentiality hypothesis states that all acoustic events are represented in similar ways, and thus, speech is not more distracting than nonspeech sounds (Jones & Tremblay, 2000). This model does not predict, though, that the irrelevant speech effect will be different when the to-be-remembered items are similar in phonemes. It predicts that the irrelevant speech effect will only be strong in tasks that have a serial order component, and it predicts that speech and nonspeech irrelevant stimuli will have the same results on performance. Because this model assumes an amodal presentation, it makes similar predictions for auditory and visual items. This model also fails to address an attentional role for the irrelevant speech effect (Neath, 2000).

Neath's feature model is centered on the interference model of forgetting. This theory says that forgetting is largely due to interference from confusion of items in the to-be-remembered list by similar items in other material that is either also learned or simply heard like in the irrelevant speech effect (Baddeley, 2000). This largely computational model derives its name from the assumption that items in memory are represented as "vectors of features" (Neath, 2000). There are two types of features: modality-independent features and modality-dependent features. Modality-independent features are the parts of an item that are the same no matter the modality in which they are presented. Modality-dependent features are the parts of an item that are specific to that type of presentation modality. Speech overwrites different features than tones, since tones do not have phonemes. For our purposes, it is worthy to note that Neath's model has included an attentional parameter, *a,* that is adjusted for different demands of a task. As a task's demands increase, the role for attention will also increase according to the feature model (Neath, 2000). Adding irrelevant speech to a task would increase its difficulty and so the attentional resources needed for that task would also increase, according to Neath's model.

Cowan's model also includes a role for attention. The basis of this model is a large store for long-term memory which would make connections with concepts such as word valence, the frequency of the usage of words in the language, and semantic relationships between words. Within this store is an area of recently activated items that have been recently brought to the forefront of attention. Inside of this is the focus of attention. This is what presently occupies the conscious mind at any given point in time (Cowan, 1988).

Individual Differences

A more recent development in the field of memory is the study of individual differences in regard to the irrelevant speech effect. A classic study done by Moray found that some subjects could detect their own names when presented in an unattended auditory channel. In this experiment, the dichotic listening task used headphones where two different sounds are presented in each ear. This "cocktail party" phenomenon is thought to be much more common that it actually is. Moray's study found that only about 33% of the participants reported hearing their name in the unattended channel (Moray, 1959). Wood and Cowan replicated these findings and found that 34.6% of participants heard their name (Wood & Cowan, 1995). In another study, this cocktail party phenomenon was replicated with different paradigm. They found that participants who detected their name in the irrelevant messages have lower working memory capacities (Conway, Cowan, & Bunting, 2001). There were two possible explanations: either high working memory participants were better at monitoring background auditory stimulation and could report hearing their name more often or they could block out auditory stimuli better than low working memory participants. It was found that 20% of the high-span participants and 65% of the low-span participants reported hearing their name. This indicated the latter of the two hypotheses. It seems here that a critical skill in working memory capacity is the ability to block distractions, which may extend to other empirical findings such as the irrelevant speech effect, and it is shown here that high-span participants can do that (Conway et al., 2001). This finding fits with Cowan's model for memory.

Based on the findings of Conway et al. (2001), Beaman (2004) speculated that other auditory stimuli, besides one's own name, could also be distracting in the irrelevant speech effect. Conway et al. (2001) found that individual differences could be measured in working memory span and participants could be categorized as having either a low or high working memory capacity. Beaman wanted to replicate and extend Conway et al. (2001) by measuring individual differences using the Operation Span task (OSPAN), which is a commonly used measure of working memory capacity. If high working memory span participants did not report hearing their name as often (Conway et al., 2001), then it could be speculated that it was due to high working memory span participants having more attentional control in the dichotic listening task. If working memory capacity did predict attentional control of participants, then this would be shown in the irrelevant speech effect. Beaman wanted to use the irrelevant speech task instead of the dichotic listening task to find if it was still the case that high working memory span participants could do better on the task.

In these experiments, Beaman identified individual differences among participants as measured by the Operation Span task (OSPAN). Experiment two of this study demonstrated that proactive interference within short-term memory, as with serial recall, can be predicted based on a person's working memory span, but not with the irrelevant speech effect. In this experiment a median split was used on the OSPAN which means that the median score was used as a dividing point to separate the low span and the high span participants. This could have led to the lack of an effect due to the fact that the lowest high span participants and the highest low span participants would have been too similar to each other. In experiment three, this was corrected by using quartiles. Only the top 25 percent of the high span participants and lowest 25 percent of the low span participants were used in analyses. However, it was shown once again that the size of the irrelevant speech effect did not predict performance on the OSPAN task. Experiment four used free recall instead of serial recall and found that intrusions from semantically-related irrelevant speech occurred more frequently in participants that scored low on the OSPAN. This finding led the experimenter to conclude that OSPAN possibly does not adequately measure susceptibility to the irrelevant sound effect. It is possible that OSPAN only affects the ability to choose between two streams presented in the same modality. This would make OSPAN useless in predicting individual differences in relation to the irrelevant speech effect (Beaman, 2004).

In one study, participants gave self-reports on their susceptibility to noises like speech or background noise. The researchers were hoping to gain insight into individual differences in the irrelevant speech effect. To assess the participants' ability in predicting their own individual performance changes due to noise, each participant's difference in ratings of the two sounds (foreign speech and noise) was correlated with the actual difference in errors made when exposed to the sounds. Overall, the findings revealed that the speech condition was most distracting compared to the background noise or silence condition. The participants were not very accurate in estimating their individual ability in the three conditions. Also, highly noise-sensitive participants had more errors than did the ones that were more insensitive to noise (Ellermeier & Zimmer, 1997).

Elliott, Barrilleaux, and Cowan (2006) reexamined individual differences in working memory and possible attentional parameters. In this experiment, several working memory tasks were run on participants, which included the operation span task and the irrelevant-sound task. This study found that individuals with high working memory spans could filter out distracting tones from the irrelevant-sound serial recall task but not for speech sounds. This finding implied that working memory did not correlate with the irrelevant speech effect as had been expected, which replicated the findings of Beaman (2004; Elliott et al., 2006).

However, another study provides some evidence for the role of attention in the irrelevant speech effect. In Elliott's study (2002), the primary objective was to explore developmental change in the effects of irrelevant sounds. It is possible that in an irrelevant speech task, young children were not recoding the visual items to a phonological form, then the conflict between items would not be occurring in the phonological store as it does with adults. The children and adults in this experiment had to perform a visual span task and a serial recall with irrelevant sounds. The significant interaction between recall performance with auditory condition and age group suggested that the O-OER model of Jones and Tremblay (2000) was not completely satisfactory. The data of the children on the two tasks contradicted the equipotentiality hypothesis. The model predicted greater disruption by speech than by tones, which was true of the youngest children but not of the adults (Elliott, 2002). The results suggested that younger children have a larger effect of irrelevant speech which decreases with age. As age increases, a person's attention becomes more focused. This would account for the role of attention in the irrelevant speech effect.

More recently some interest has been directed towards nonacoustic features of auditory distractors on serial recall such as word valence. It has been speculated that positive and negative distractor words would be more distracting to participants compared to neutral words. The researchers' hypothesis was confirmed: valence of a distractor word will inhibit serial recall more than neutral words or the silence condition. Also it was noted that negative words also distract more than other word valences (Buchner, Mehl, Rothermund, & Wentura, 2006).

As already discussed, Baddeley's phonological loop and Jones' O-OER model do not account for why rare words can distract from the target words more than common distractor words. Buchner and Erdfelder's study (2005) focused on precisely that. Participants had to use serial recall to report words that they had seen that were either low-frequency words or high-frequency words while they heard the words on headphones that were presented as distractors that were also either low-frequency words or high-frequency distractor words. A low frequency word would be a word that is not present in the language as often as a high frequency word, which would be present in the language more often. Theoretically, hearing a high frequency word should not be as distracting because the participant has encountered the words more often. A low frequency word, however, should be more distracting because it is rarer to the participant and the participant's attention might be drawn to this word that they hear less often. It was found that participants did much worse on serial recall performance in the presence of low frequency distractors compared to when they heard high frequency distractor words. Thus, the results were not compliant with the working memory models that do not have a role for attention. The Buchner and Erdfelder study proved that the frequency of auditory words used as a distraction may affect serial recall of visually presented words, especially when rare words are used as distractors (Buchner & Erdfelder, 2005).

Overall evidence has been found that there is a critical skill in working memory capacity to block distractors; however, research has yet to clearly determine whether that skill involves attention. Conway et al. (2001) showed that low working memory span participants were more easily distracted during the dichotic listening task. Beaman's Experiment 4 pointed out that low working memory span participants had a harder time blocking semantically related items on free recall (Beaman, 2004). Elliott et al. found that high working memory span participants could filter out distracting tones better than low working memory span participants (Elliott et al., 2006) and Elliott also found that as age increased, the irrelevant speech effect decreased which would mean attention was becoming more focused with age (Elliott, 2002). If attention did not matter, then none of these researchers would have found these results that support some sort of attentional processing in working memory.

This present study planned to replicate and extend Beaman (2004) and Buchner and Erdfelder (2005). Participants were categorized as having high working memory spans or as having low working memory spans. We were interested in how high-frequency distractor words and low-frequency distractor words affected people with high working memory spans and people with low working memory spans. It was speculated that high-frequency distractor words and low-frequency distractor words would affect participants with high working memory spans about the same. However, participants with low working memory spans should perform significantly worse with low-frequency distractor words than with high-frequency distractor words (Buchner & Erdfelder, 2005).

It is important to note too that it was justified for this experiment to not test low-frequency and high-frequency target words. It was found that the interaction between target and distractor words and the interaction between target words and serial position was not significant. Also the three-way interaction was not found to be significant. (Buchner & Erdfelder, 2005). This meant that there was no interaction among the frequency of the target words that the participants were supposed to be remembering, the frequency of the words that were distracting the participants, and the position of the words in lists in both of these categories. It is also worthy to note that many other studies in the past, even ones studying individual differences in working memory and the irrelevant speech task, did not manipulate word frequency at all or used different distracting tones, background noises, foreign words, or non-words instead of words (Beaman, 2004; Ellermeir & Zimmer, 1997; Salamé & Baddeley, 1982; Conway et al., 2001).

In the current study, the data that were analyzed were the overall effects of high and low word frequency on words remembered compared to those remembered in the silent condition. In determining the role of working memory, as measured by three tasks, quartiles will be used as have been used in previous research (Beaman, 2004). This method will utilize working memory composites analyzed in quartiles to attain the highest high working memory participants and the lowest low working memory participants. This was used as a between-subjects factor to examine individuals' differences in the word frequency effects. Later these were collapsed across word frequency conditions, and correlations were done with working memory capacity and the irrelevant speech effect.

Methods

Participants

The participants were 92 students who were given course credit or extra credit in their psychology courses for their participation. All participants were native English speakers and had no self-reported hearing impairments. Informed consent was received from all participants.

Materials

All participants completed the operation span task, the reading span task, the symmetry span task and the ISE task. Dell monitors and computers were used to present the target words for the ISE paradigm. Headphones were also used for participants to hear the distractor words.

Procedure

Working Memory Screening. There were 496 undergraduates that were run through the Working Memory Screening used across three labs. There were three complex span tests to measure the participants' working memory capacity: the operation span, the reading span and the symmetry span. The operation span task required the participant to solve a simple math equation while trying to remember a set of letters presented after answering the problem, while maintaining 85% accuracy on the math equations. A set could consist from 3 to 7 letters to be remembered in order. The reading span task required the participant to read a sentence silently and determine whether or not it was semantically correct while trying to remember a set of unrelated letters. A set of letters could be from 3 to 7 letters and had to be remembered in order. The symmetry span task required the participant to perform a symmetry judgment task (e.g., whether a design was symmetrical along its vertical axis) while recalling sequences of red squares within a matrix. This sequence of squares could be a set from 2 squares in the matrix to recall to 5 squares.

Irrelevant Speech Task. Of these participants, 92 went on to complete the irrelevant speech task with the added word frequency manipulation. In this task participants were told to remember in order the words presented to them visually and to ignore the words presented auditorily. Target words were of high-frequency whereas distractor words were of either high-frequency and low-frequency. Each to be remembered list consisted of 7 words. There were were 10 silent trials, 10 trials with high-frequency distractors, and 10 trials with low-frequency distractors. The orders of the distractor conditions were determined randomly. There were three practice lists for serial recall. The targets were presented at the rate of 1/s, and the responses were typed by the participant upon receiving the cue to recall. The target words were presented visually while the distractor words were presented simultaneously via headphones plugged directly into the computer. All distractor words were presented for approximately 300-500ms in duration in a female voice and silence was added to each digitized sound file to create a 1/s rate of presentation. Distractor words were also approximately equal in intensity, and they were produced at a level of 70 ± 5 dB(A). Low frequency words were determined on a Kucera-Francis frequency between 0 and 30. High frequency words were determined on a K-F frequency between 100 and above. Word frequency was determined by the MRC Psycholinguistic Database which can be found at www.psy.uwa.edu.au/mrcdatabase.

Results

A 3 x 7 repeated-measures ANOVA was used in analyzing the three auditory conditions across serial positions (positions 1-7), where $N=92$. The main effect of auditory condition was found to be significant, $F_{(2,178)} = 24.19$, $p < .01$. Serial position was also found to be significant, $F_{(6,534)} = 215.54$, $p < .01$. The auditory condition when crossed with the serial position was significant as well $F_{(12,1068)} = 2.43$, $p < .01$. However, no clear apriori theoretical reasons in the models of the ISE to explain serial position differences were found. Therefore, the focus of the post-hoc analyses was on the main effect of auditory condition. The pairwise comparisons using a Bonferroni correction indicated that silence trials (*M*=.43) differed significantly from both the high (*M*=.36) and low frequency (*M*=.36) word trials, whereas the high and low frequency word trials did not differ significantly. Thus, the irrelevant speech effect was found. These data are depicted in Figure 1 with serial position displayed for the three auditory conditions.

To analyze individual differences based on working memory capacity, performance on each of the three working memory tests was transformed into z-scores and an average z-score was computed. This was done due to the nature of the span tasks. The Operation Span task and the Reading Span task have a higher possible scoring range than does the Symmetry Span task. In order to average them giving each equal weight, they were transformed to z-scores. Participants in the top and bottom quartiles were used in the following analyses (high WMC, n=23, and low WMC, n=24), and the characteristics of these participants are described in Table 1.

Only participants with scores in the top and bottom quartiles were included in the next analysis. A 2 x 3 ANOVA was used to analyze the proportion correct scores. Working memory span was a between-subjects factor and the auditory condition was a within-subjects factor. This mixed-model ANOVA showed that there was a main effect of auditory condition, $F_{(2,88)} = 14.36$, $p<.01$. The Bonferroni post-hoc test indicated that the silent condition had the best performance and the high frequency distractor and the low frequency distractor conditions did not differ significantly in performance . There was a main effect of working memory capacity: high span participants did perform significantly better than low span participants on serial recall, $F_{(1,44)} =$

231.84, $p<.01$., but this did not interact with word frequency, $F_{(2,88)}= .203$, $p<.82$. These data are described in Table 2.

Given that there were no differences in the means of the high and low frequency word conditions, these were averaged. An ISE difference score was created by subtracting the average of performance in the word frequency conditions from the silent condition (M=.08, SD=.12). This difference score was entered into a correlation with the average z-score from the WM measures, utilizing all of the participants in the sample. The correlation was not significant, r =.02, p =.84.

Discussion

As mentioned in the introduction of the paper, there have been two camps of how the irrelevant speech effect has been viewed: those models that have a role for attention and those that do not. Baddeley's working memory model and Jones' O-OER model do not include any role for attention, whereas Neath and Cowan do (Neath, 2000; Cowan, 1988). This puts Buchner and Erdfelder's (2005) data at an opposition with the working memory model and the O-OER model. However, Beaman (2004) failed to show a role for attention. The data of this experiment supports Beaman's (2004) findings but not Buchner and Erdfelder's (2005) data. This question that taunts this research team's mind is whether or not there actually is a role for attention in the irrelevant speech effect and how can it be found.

Moray's cocktail party phenomenon measured how many people would recognize their own name in a channel that should be unattended (Moray, 1959). Conway, Cowan, and Bunting (2001) probed further into the matter to find out who it was that was more likely to hear their own name. They found that it was the low-span participants that were distracted by their name in the channel that was to be ignored. An important skill was discovered in one's working memory capacity: the ability to block distractions (Conway et al., 2001). Therefore, high-span participants should be able to ignore distractions better when told to do so than low-span participants.

Beaman (2004) took this idea and applied using other stimuli besides one's own name. Beaman found individual differences in the Operation Span task (OSPAN) but could not get the irrelevant speech task to predict performance on the OSPAN task. It was concluded that the OSPAN might not adequately measure one's susceptibility to the irrelevant speech effect (Beaman, 2004). One idea for why an attentional role was not found in the irrelevant speech task is that the OSPAN does not properly measure individual differences in relation to the irrelevant speech effect.

Ellermeier and Zimmer (1997) found that participants were inaccurate in self-reports at estimating how they would perform under noise and speech distractions. Another interesting finding was that some participants were noted as being "highly noise-sensitive" participants as indicated on a noise sensitivity questionnaire filled out by the participants. These participants performed much worse than participants noted as being more "insensitive" to noise (Ellermeier & Zimmer, 1997). The noise sensitivity questionnaire and self-reports are definitely a different look at individual differences and could be a better indicator than the OSPAN to susceptibilities to the irrelevant speech task. Noise sensitivity could be a link to attention if the participant considers themselves to be a highly noise-sensitive person. If the participant considers themselves to be more intolerant of noise, then they may have more attentional drift when working on a task, which would certainly hinder performance.

Another theory to ponder is whether the irrelevant speech task is not correlated with the working memory model that Baddeley proposed. As previously discussed, Elliott et al. (2006)

found that participants with high working memory spans had little trouble with filtering tones but they did struggle with filtering speech sounds. This study also had replicated Beaman (2004; Elliott et al., 2006). Also, a few years previously Elliott's study in 2002 found that the magnitude of the irrelevant speech effect appears to decrease with increasing age (Elliott, 2002). This finding would lead to the notion that there is an attentional role that is mastered with increasing age as one develops. This also does not fit with Baddeley's working memory model or Jones' equipotentiality hypothesis (Elliott, 2002).

In this study, it was found that individual differences in working memory capacity did not predict the magnitude of the irrelevant speech effect as predicted, which replicates Beaman (2004). However, there was not a significant difference between high and low frequency distracters overall, which failed to replicate Buchner and Erdfelder (2005). Furthermore, participants classified by high or low working memory capacity scores did not differ in the two word frequency conditions.

Some limitations of our study can be seen from our data that was shown in Table 1. When evaluating the ranges of the scores on the individual WM tasks, it can be seen that the maximum values for the low span participants overlapped with the minimum values for high span participants. This was partly due to the number of participants that returned to complete the ISE task after the WM screening. With more participants, the quartiles would have been more exclusive in who was in the quartiles. Also there is a larger degree of variance shown by the standard deviations in Table 1 of the low working memory span participants on the span tasks. Another limitation of this study may have been that not all of the low span participants had very low spans at all, and could be considered "faux" low span participants. This could be a consequence of the study being conducted with only university students. One can presume since the low span participants had been admitted to a university that they really were not possibly as low as laypersons in the community might be. Lastly, it is to be noted that the word frequencies for the distractor words were not as extreme as Beaman's (2004) or as extreme as Buchner and Erdfelder's (2005).

Differences to be considered between our study and Buchner and Erdfelder's is that theirs was conducted in German and participants' responses were spoken aloud whereas our participants typed their responses and the experiment was conducted with native English speakers. It is to be noted, however, that there has not been another successful replication of Buchner and Erdfelder (2005), which is the aim of this research team's future goals. Future research will continue with responses spoken aloud as in Buchner and Erdfelder (2005), on the assumption that typing responses may somehow interrupt the thought processes involved in recalling the words presented visually.

References

Baddeley, A. D. (2000). The phonological loop and the irrelevant speech effect: some comments on Neath (2000). *Psychonomic Bulletin & Review*, 7(3), 544-549.

Beaman, C. P. (2004). The irrelevant sound phenomenon revisited: what role for working memory capacity? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 30(5), 1106-1118.

Buchner, A. & Erdfelder, E. (2005). Word frequency of irrelevant speech distractors affects serial recall. *Memory & Cognition*, 33(1), 86-97.

Buchner, A., Mehl, B., Rothermund, K., & Wentura, D. (2006). Artificially induced valence of distractor words increases the effects of irrelevant speech on serial recall. *Memory & Cognition*, 34(5), 1055-1062.

Cowan, N. (1988). Evolving conceptions of memory storage, selective attention, and their mutual constraints within the human information-processing system. *Psychological Bulletin*, 104, 163-191.

Conway, A., Cowan, N., & Bunting, M. (2001). The cocktail party phenomenon revisited: the importance of working memory capacity. *Psychonomic Bulletin & Review*, 8(2), 331-335.

Conway, A., Kane, M., Bunting, M., Hambrick, D., Wilhelm, O., & Engle, R. (2005). Working memory span tasks: a methodological review and user's guide. *Psychonomic Bulletin & Review*, 12(5), 769-786.

Ellermeier, W. & Zimmer, K. (1997). Individual differences in susceptibility to the "irrelevant speech effect." *Journal of Acousical Society of America*, 102(4), 2191-2199.

Elliott, E. M. (2002). The irrelevant-speech effect and children: theoretical implications of developmental change. *Memory & Cognition,* 30(3), 478-487.

Elliott, E. M., Barrilleaux, K. M., & Cowan, N. (2006). Individual differences in the ability to avoid distracting sounds. *European Journal of Cognitive Psychology,* 18(1), 90-108.

Jones, D. M. & Tremblay, S. (2000). Interference in memory by process or content ? A reply to Neath (2000). *Psychonomic Bulletin & Review,* 7(3), 550-558.

Moray, N. (1959). Attention in dichotic listening: Affective cues and the influence of instructions. *Quarterly Journal of Experimental Psychology*, 11, 56-60.

Neath, I. (2000). Modeling the effects of irrelevant speech on memory. *Psychonomic Bulletin & Review,* 7(3), 403-423.

Salamé, P. & Baddeley, A. (1982). Disruption of short-term memory by unattended speech: implications for the structure of working memory. *Journal of Verbal Learning and Verbal Behavior*, 21, 150-164.

Unsworth, N., Heitz, R., Schrock, J., & Engle, R. (2005). An automated version of the operation span task. *Behavior Research Methods*, 37 (3), 498-505.

Wood, N., & Cowan, N.(1995). The cocktail party phenomenon revisited: attention and memory in the classic selective listening procedure of Cherry (1953). *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 21, 255–260.

Appendix

Low Distractors	K-F Freq	T-L Freq	Concrete	AoA
giant	23	107	515	256
honey	25	274	611	286
penny	25	129	606	186
lesson	29	319	404	272
autumn	22	132	421	278
butter	27	578	618	206
marble	21	92	611	294
orange	23	351	601	203
High Distractors				
money	178	3089	574	247
paper	157	1235	599	229
water	442	2067	616	153
hotel	126	832	591	308
color	141	1541	467	254
second	373	926	344	289
letter	145	1748	577	256
mother	216	3993	579	144
HighTargets				
music	216	660	512	272
woman	224	2431	580	258
answer	152	2132	397	294
number	472	954	395	239
person	175	978	562	242
island	167	395	596	289
summer	134	783	439	253
window	119	1564	609	231
Extra Words				
circle	60	388	515	214
finish	39	1028	343	300
cousin	51	316	502	278
driver	49	311	553	283
pocket	46	572	578	228
pencil	34	186	617	225
palace	38	104	579	294
stable	30	111	562	292
uncle	57	730	580	192

hotel	126	832	591	308
forest	66	209	609	297
garden	60	1036	602	186
minute	53	2353	361	264
apple	9	220	620	211
piano	38	212	615	253

Table 1: Descriptive statistics of the Working Memory measures for those classified as high and low working memory capacity.

	Mean	S.D.	Minimum	Maximum
High WMC n=23				
OSPAN total	70.0	4.48	60	75
RSPAN total	66.96	5.04	55	75
SSPAN total	36.65	4.41	27	42
Z-score Avg.	0.91	0.27	0.57	1.43
Low WMC n=24				
OSPAN total	50.13	12.79	12	67
RSPAN total	41.67	11.30	24	64
SSPAN total	24.67	5.46	13	33
Z-score Avg.	-0.95	0.60	-2.63	-0.36

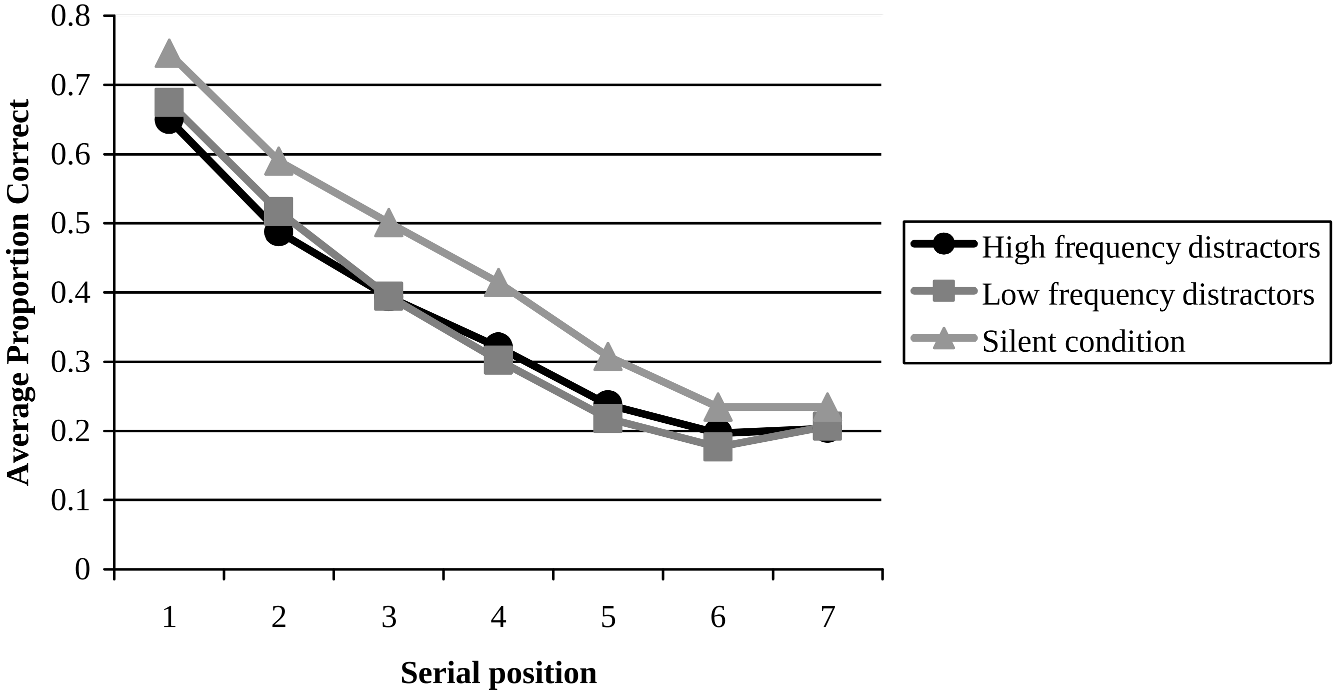
NOTE: OSPAN represents the Operation Span measure, RSPAN represents the Reading Span measure, and SSPAN represents the Symmetry Span measure. The z-score average refers to the average of the z-scores for the three individual measures.

Table 2: High span participants' and low span participants' average recall in each trial type.

	High WMC	Low WMC
Silence	0.51	0.37
High frequency distractors	0.44	0.30
Low frequency distractors	0.42	0.27

Figure Captions

Figure 1. Proportion correct by serial position for all participants across the three auditory conditions (N=92).


0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Average Proportion Correct
1
2
3
4
5
6
7
Serial position
High frequency distractors
Low frequency distractors
Silent condition