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The importance of spatial and talker cues in competing sentence recall

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THE IMPORTANCE OF SPATIAL AND TALKER CUES
IN COMPETING SENTENCE RECALL

by

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Abstract

THE IMPORTANCE OF SPATIAL AND TALKER CUES IN COMPETING SENTENCE RECALL

by

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The listener in a competing message situation has access to multiple acoustic and linguistic cues that enable him or her to separate the target from the competing message(s). Studies have shown that listeners have derived the most benefit from spatial cues (i.e., the spatial location of source relative to competing stimuli), followed by talker related cues (such as differences in voice pitch and voice quality). In the absence of these acoustic cues, listeners have had great difficulty in attending to and recalling the target message. However, generalization of these findings is confounded by a number of issues. Many of these studies used linguistically impoverished stimuli to evaluate their subjects. In the absence of sufficient linguistic information, subjects were probably forced to rely more heavily on acoustic cues. In other studies (eg., shadowing paradigms that used connected discourse), the

attention tasks were far more demanding than would typically be encountered in everyday listening situations. In only a few studies has the listening context involved the processing of competing sentences.

The main purpose of this study was to assess the importance of both spatial and talker cues on various auditory attention tasks (selective attention, divided attention, partial report) and to determine whether auditory attention and recall remains possible when spatial and talker identity cues are omitted. Sentences were used to generalize the findings to natural listening contexts.

The results showed that subjects performed best on all recall tasks when the spatial cue was present. In the absence of the spatial cue, adding the talker cue facilitated performance, although not to the same extent as the spatial cue. Performance dropped significantly when both acoustic cues were removed, however, subjects were still able to repeat a significant portion of the target message(s), especially on short sentences. This suggests that in natural listening situations, individuals not only benefit from spatial and talker cues, but, that short-term spectral cues and linguistic context may also be useful.

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CHAPTER 1: INTRODUCTION

Most auditory perception of a target signal occurs in the presence of competing signals. These target and competing signals are mixed in the two auditory waveforms that enter the ears. Yet, the normal auditory system is able to attribute the acoustic patterns to two or more sources and, if necessary, to attend to one source while ignoring the other(s). Hearing impaired and learning disabled subjects, on the other hand, often exhibit difficulty in attending to a target speech message in the face of competing signals- such as, random noise, music and other speech signals. Although we are aware of many of the factors that contribute to the normal process, the process itself is far from being understood. We know even less about the ways in which impaired subjects differ from normals in this area. Studies, therefore, are required to enhance our understanding of the normal process as well as to determine what it is about the disordered process that makes it so. The latter kind of information, in turn, might help in the design of improved hearing aids and more effective rehabilitation techniques.

It has been hypothesized that there are two kinds of message interference: peripheral masking and informational masking. In peripheral masking, the energy of the target signal in relation to the energy of the noise is insufficient to modify the patterns of activity in the neural system. In informational masking, the informational content of the masker overloads the processing capacities of central perceptual mechanisms. In most natural situations, both kinds of interference are probably present. Psychoacousticians have tended to focus on the first (e.g., masking of tones by white noise), while perceptual and cognitive psychologists have tended to focus on the second (e.g., perception of a target speech message with speech competition).

Studies involving competing messages have typically been concerned with selective auditory attention. This is the auditory ability that enables an individual to selectively attend to a target stimulus while ignoring all irrelevant, competing, inputs (Cherry, 1953; Pollack and Pickett, 1958). However, there are other types of auditory attention behavior such as "divided attention" and "partial report". In both of these attention tasks, subjects are required to attend to and process not just one, but two or more competing messages. In divided attention the subject recalls all messages heard. In partial report the subject recalls only one message but does not know which one until after the presentation. Note that selective attention differs from partial report in that the target message is designated before the presentation rather than after. Studies have shown that subjects perform differently on these three tasks, performance being best on the selective attention task (Broadbent, 1952b; Tolhurst and Peters, 1956; Moray, Bates, and Barnett, 1965).

The literature also indicates that the listener in a competing message situation has access to multiple cues, both acoustic and linguistic, that enable him or her to separate the target from the competing message(s). These cues are of two types: long-term cues that are present throughout continuous discourse and short-term cues that exist only at specific times within words. Long-term cues may include:

Acoustic cues

1. the spatial location of source relative to the competing stimuli (referred to in this paper as the "spatial cue")
2. differences in voice pitch and voice quality (referred to in this paper as the "talker cue")

3. suprasegmental features such as variations in stress and intonation
4. differences in the average intensity levels in the target and competing message
5. variations in the overall speech spectrum in the target and competing message

Linguistic cues

1. semantic relations (such as the relationship between a verbal symbol and its referent)
2. syntactic structure
3. topic matter

Short-term cues may include:

Acoustic cues

1. spectral features, such as short-term variations in fundamental frequency and formant transitions
2. cross-spectrum coherence of amplitude envelope and frequency transitions

Linguistic cues

1. phonemic categorization
2. lexical

It has been shown that the most useful cue in a competing message task is the spatial cue, followed by the talker cue (Broadbent, 1952a and 1952b; Cherry, 1953; Egan, Carterrette, and Thwing, 1954; Webster and Solomon, 1955; Pollack and Pickett, 1958; Treisman, 1964a; and Moray, 1970). In the absence of both of these cues listeners have great difficulty in attending to and recalling the target message. However, generalization of these findings to everyday situations is confounded by a number of issues. First, it is not completely clear if the relative contribution of spatial and talker identity cues vary as a function of auditory attention task. Second, the stimulus materials in many previous studies have involved the use of linguistically impoverished stimuli, such as, spondees or digits. In the absence of sufficient linguistic information the subject is probably forced to rely more heavily on acoustic cues if he or she is to successfully attend to the target message. Consequently, removal of spatial and talker identity cues would result in inferior performance. Third, the attention tasks in many of these studies were far more demanding than would typically be encountered in everyday situations. For example, a number of studies have investigated subjects' ability to "shadow" a target message. Subjects had to attend to both target and competing discourse over long time intervals, while concurrently repeating all words from the target message (Treisman, 1964b; and Moray, 1970). These studies, and others, have shown that removal of long-term acoustic cues, especially the spatial cue, seriously affects performance. However, the demands inherent in the shadowing task may be so great that there is an increased reliance on long-term acoustic and/or linguistic cues and that the removal of any of these cues results in diminished performance.

In only a few competing message studies has the listening context involved the processing of one or two sentences, a situation more representative of everyday listening situations (Egan, Carterrette, and Thwing, 1954; Medwetsky, 1987; McInerny and Boothroyd, 1988). In both the Medwetsky (1987) and the McInerny and Boothroyd (1988) studies, subjects listened to and recalled two sentences presented in only one ear and by the same talker (i.e., with both the spatial and talker cues removed). Surprisingly, in both studies subjects were able to recall more than 80% of the words from at least one sentence. This degree of accuracy contrasts sharply to the poor results found in earlier studies. This discrepancy may be due to a number of factors. First, the inherent redundancy in the sentence materials might have allowed the listener, even in the absence of the spatial and talker cues, to accurately recall the target sentence on the basis of the remaining acoustic cues and linguistic context. This, however, would only account for the discrepancy between studies using sentence materials versus those using linguistically impoverished materials and would not account for the poorer results obtained in the shadowing studies.

Second, in contrast to the shadowing task, individuals listening to competing sentences, one presentation at a time, have more time to process the incoming stimuli before having to recall the target message. Therefore, the mental demands are probably less in the competing sentence task. Third, methodological inadequacies, in both the Medwetsky and the McInerny and Boothroyd studies, might have inflated the subsequent scores. That is, imprecision in matching competing sentences on the basis of onset synchrony, intensity, and duration might have increased the listener's ability to attend to and recall one of the sentences.

In summary, there is no consensus to the necessity of spatial and talker identity cues in various auditory competing message tasks. The purpose of this study was to assess the importance of both of these acoustic cues in three different auditory attention tasks (selective attention, divided attention and partial report). To increase the generalizability to everyday listening situations, only sentence materials were used.

The specific goals of this study were to:

1. assess the contribution of spatial and talker identity cues to performance on auditory attention tasks,
2. determine whether auditory attention and recall remains possible when spatial and talker identity cues are omitted (i.e., when two competing messages are presented by the same talker in the same ear),
3. assess subject performance as a function of auditory attention task,
4. examine the interaction of listening condition and attention task on performance, and
5. examine the effect of sentence length on performance.

CHAPTER 2. REVIEW OF THE LITERATURE

The Importance of Spatial and Talker Cues in Selective Attention

The ability to attend to a target message in the face of a competing message(s), has been investigated since the late 1940's. Researchers such as Licklider (1948) and Hirsh (1950) were among the first to suggest that there were other factors, in addition to peripheral masking, affecting auditory speech perception in a competing message situation. For example, Licklider showed that when subjects listened binaurally under headphones, even with the signal-to-noise (S/N) ratio constant, the phase relations of the speech (masked) signal and noise (masker) could affect intelligibility. Subjects performed significantly better when there was a difference in interaural phase between the speech and noise signals. This finding, known as the "masking level difference", was important since it was one of the first to show that the ability to recall a target message in the presence of a competing message was not determined solely by peripheral masking.

Hirsh (1950) showed that the degree to which speech and noise sources were separated in space also impacted on the reception of the target speech message. Subjects listened to spondees from one loudspeaker and to white noise via a second loudspeaker, both monaurally (one ear occluded by a headset) and binaurally. The dependent variable was the threshold of intelligibility for the spondees. Hirsh found in both the monaural and binaural listening situations that the greater the spatial separation of the loudspeakers, the lower the thresholds. One factor contributing to these lower thresholds was the improved signal-to-noise (S/N) ratios at the ear closest to the speech source. However, Hirsh also found that the subjects' binaural thresholds were lower than the monaural at the same spatial separations (even when the uncovered ear in the monaural listening situation was the one closest to the speech source) and that these differences were larger the greater the spatial separation. Hirsh attributed the lower binaural thresholds to subjects being better able to perceive the target and the noise source as coming from different locations in space.

Broadbent (1952a) examined subjects' performance in a competing message task but contrary to Hirsh's study the interfering stimulus consisted of speech rather than noise. Pairs of yes/no questions about a visual display were presented in telegraphic form. Subjects were asked to attend to and give the correct answer to the target question, while ignoring the competing question. The competing stimuli were presented via one loudspeaker and spoken either by different talkers or by the same talker. The subjects were told ahead of time which voice keyed the target sentence, or, in those presentations where the same talker was used, a designated call sign keyed the target sentence. In one experiment the questions followed one another in time (i.e., sequentially), while in a second experiment alternate words from each question were presented; that is, the words from each question pair interleaved but were non-overlapping.

Broadbent found that subjects did worse when the two messages interleaved, regardless of the listening conditions, even though the subjects had to process the same amount of information and at the same rate in both tasks. Since there was no overlapping of messages in the interleaving task any decrements in performance, relative to the sequential task, could not have been due to peripheral masking but rather to informational masking. Broadbent also found that subjects on the interleaved task performed less well when the same voice was used to present the telegraphic sentences than when different voices were used. This suggests that acoustic cues to talker identity, for stimuli presented from the same location, serves as a means of enhancing perception in the face of a competing message.

Broadbent (1954), following up on the work by Hirsh (1950), looked at the importance of spatial separation in selective attention. Broadbent used the same speech materials as in his earlier study (1952a), the subjects' task remaining the same. The paired questions were spoken by different individuals and were presented via loudspeakers or headphones. When loudspeakers were used, the speech stimuli were presented:

1. through separate loudspeakers and simultaneous onset;
2. stereophonically from two loudspeakers;
3. binaurally- the two messages were mixed and presented from both loudspeakers with simultaneous onsets; and
4. monaurally- the two messages were mixed and presented from one loudspeaker.

Similar listening conditions were used under headphones, with dichotic listening under headphones corresponding to the presentation of speech stimuli via separate loudspeakers. Broadbent found that regardless of the apparatus the least errors occurred under spatial separation- with the fewest errors occurring in the dichotic listening condition under headphones, followed by stereophonic listening in either the loudspeaker condition or under headphones.

Webster and Solomon (1955) also looked at the impact of spatial separation of target versus noise source. Telegraphic sentences were presented, up to a maximum of four, over a number of loudspeakers (varying from 1 to four) differing in their degree of separation. The sentences were spoken by different talkers. There were a number of test conditions, one of which required subjects to selectively attend to and recall one of two or more competing telegraphic sentences. In this condition, the fewest errors occurred when sentences were presented from different loudspeakers and when the separation between two loudspeakers was at its maximum (i.e., 180^0).

Cherry (1953) and Cherry and Taylor (1954) attempted to determine the relative importance of a number of cues in auditory selective attention. Subjects listened under headphones to two competing discourse passages presented at a rapid rate of speech. In addition, subjects were required to repeat concurrently the designated target passage word by word or phrase by phrase. The passages were derived either from context (such as a story or newspaper article) or from a string of cliches strung together with simple conjunctions, pronouns, etc. Subjects could play the tape as many times as they wished until the task was completed.

Cherry found that subjects performed most accurately, and with the least effort, when the target message was fed to the headphone on one ear and the competing message to the other ear. Subjects experienced intermediate difficulty when the competing passages were spoken by two talkers, one male and one female, but presented via only one headphone. The most difficulty was encountered when the competing passages were spoken by the same talker into the same headphone. Regarding the last listening condition, Cherry found that when the passages were presented in context (i.e., from a newspaper or story) subjects exhibited great difficulty but most subjects were able, over time, to reconstruct the entire target passage. Subjects were still able to complete the task, even in the absence of spatial and talker cues, albeit with difficulty. However, when the passages consisted of connected cliches, subjects could not complete the task. They made more errors and asked for more repetitions than on any other task. When subjects did recall words in this task, they tended to do so by recalling complete cliches from either the target or competing passages.

Treisman (1964a, 1964b) modified the Cherry technique for the purpose of studying selective auditory attention. The technique, known as the shadowing method, required subjects to listen to competing discourse passages, while simultaneously repeating all words from the target message. This procedure differed from Cherry's in that subjects in Cherry's study were able to play the tape as many times as they wished until the task was completed, while in Treisman's studies subjects were able to listen only once to the recording. Nevertheless, Treisman obtained similar findings to those obtained by Cherry; that is, removal of acoustic cues resulted in significantly poorer performance. The greatest drop in performance occurred when dichotic cues were removed (i.e., when the target and competing message were heard in only one earphone), while the second greatest decrement occurred when talker cues were removed (i.e., when the target and competing messages were spoken by the same individual). It should be noted that removal of the talker cue was significant only when the dichotic cue had already been removed, that is, it had little impact when the dichotic cues were still present.

Egan, Carterette, and Thwing (1954) published what might be the only research in which competing sentences were used for examining the contribution of different acoustic cues in auditory selective attention. They did four experiments, of which only two will be discussed here. In both experiments, the target and the interfering message were spoken by the same talker. The test material consisted of lists of sentences, each sentence consisting of five key words. A single test item consisted of the simultaneous presentation of two sentences. The target sentence was preceded by the call sign "Mitchel Field", while the interfering sentence was preceded by the call sign "Langley Base". The subject's task was to write down the words from the target sentence. Percent intelligibility scores were derived by calculating the number of key words correctly written down out of the total number possible.

The first experiment examined the effects of filtering on the target or the interfering signal. Sentences were presented monaurally. There was one control and six test conditions. In the control condition, both the target and competing sentence were unfiltered. A mean intelligibility score of 56% was achieved in this condition. In three test conditions, the target signal was high-pass filtered (the filter frequencies being 250, 500, and 1000 Hz) while the interfering signal remained unfiltered. In the other three test conditions, the target message was unfiltered while the interfering message was high-pass filtered at the aforementioned frequencies. Egan et al. found that filtering the target or the interfering signal resulted in greater intelligibility than in the control condition, the highest scores being obtained when the interfering signal was high-pass filtered at 1000 Hz. Egan et al. concluded that because performance was better in any of the degraded target conditions than in the control condition it showed the importance of physical dissimilarity between competing auditory stimuli in a competing message task.

It is important to note that maximum performance in the control condition should not have exceeded 50%. In the absence of any distinctive cue subjects had no way of knowing which sentence was the target. That is, a call sign such as "Mitchel Field" or "Langley Base" provides no cue to the target sentence when both sentences are spoken by the same talker and when neither cue is related in any way to either of the competing sentences. The fact that the mean score was 56% suggests that listeners had access to some cue(s) that helped to key words from the target sentence. The authors pointed out that the sentences were not always perfectly synchronous and did not always have the same duration. Even more importantly, the authors did not indicate how the mean score of 56% in the control condition had been derived. Egan et al. did not indicate whether this score was a function of subjects omitting words from the target sentence or whether subjects correctly recalled all words from one sentence but that the sentence recalled was often the competing sentence (i.e., without knowledge of which sentence was the designated target, subjects only had a 50/50 chance of correctly recalling the target sentence). If the results were due to the latter, it would suggest that subjects were able to process both sentences quite accurately, or, at least that they were able to process one sentence quite accurately (albeit the target sentence only 50% of the time), even in the absence of long-term acoustic cues.

In the second experiment, articulation-gain functions were obtained in both dichotic and monaural listening conditions. The functions were derived by presenting pairs of simultaneous sentences, spoken by the same talker. Each sentence was preceded by a call sign. The intensity of the interfering signal was held constant, while the level of the target signal was varied. Dichotic listening was clearly superior to monaural listening with the 50% speech intelligibility point occurring 27 decibels lower in the dichotic condition. This decibel level is only slightly higher than the value that was obtained when no competing signal was present. Another important finding was that the slope of the function in the monaural listening condition changed at approximately 0 dB S/N ratio. Scores dropped rapidly as the S/N ratio decreased from positive S/N ratios to 0 dB, but as the target signal decreased further in intensity the decrease in performance was more gradual. In fact, at -4 dB S/N subjects' scores were higher than at 0 dB S/N. The authors felt that the change in slope was attributable to many factors. Decreasing the S/N from the highest positive levels caused performance to deteriorate rapidly because of increased peripheral masking. At 0 dB S/N, cue conditions for the target signal were minimal, hence, performance suffered as a function of both peripheral masking and confusion. When the intensity of the target sentence was decreased below the competing message, a distinctive cue was added. This cue partially compensated for the increased peripheral masking resulting from the decreased intensity of the target signal. This, in turn, caused the articulation-gain function to drop off less rapidly than if the interference had been white noise (i.e., the use of white noise would have resulted in a steady decrease in performance purely on the basis of increased peripheral masking).

Egan et al.'s study is important for many reasons. First, it showed that when the source and competing message are maximally separated (i.e., presented from separate earphones), subjects in a selective attention task can attend to a target signal at levels approaching those achieved when the target is presented in the absence of competing messages. Second, it showed that many variables can impact on subject performance in an auditory competing message task. These include: (a) simultaneity of onset, (b) relative duration and intensity of target versus competing message, (c) degree of spatial separation of target versus source, and (d) the long-term spectral distribution of both the target and competing message (manipulated through the use of high-pass filtering in this study). Last, the study showed that it is possible to attend to, and recall, much of a target message in the face of a competing message, even in the absence of spatial and talker cues.

In summarizing the findings from the aforementioned studies, it appears that there are a number of variables that can influence performance on competing message tasks. These include:

1. the degree of spatial separation between the target and interfering message(s),
2. the difference in talker voice quality in the competing messages,
3. the linguistic content in the target message,
4. the long-term spectral distribution of both the target and competing message(s),
5. the relative intensity difference between the target and competing messages, and
6. other factors, such as the synchrony of onset and relative duration of target versus competing message.

Craik and Lockhart (1972) suggested that the importance of spatial and talker quality cues is primarily due to the fact that these cues result in the greatest physical dissimilarity between the target and competing stimuli. They provided a theoretical model in which they postulated that the presence of these cues allows subjects to disentangle the target from the competing message(s) at a very early stage of processing. This, in turn, allows the subject's attention to be directed to the target message with minimal interference from the competing message. Because all subsequent mental effort can be directed toward storing the target in short term memory, the overall mental load is low.

If, on the other hand, the spatial and talker quality cues were to be removed, then the subject's ability to separate the competing messages at an early stage of processing would be diminished. Listeners would have to do some higher order processing of all incoming messages (such as deriving the semantic and syntactic content of each message) before any of the messages could be rejected. This ultimately would result in increased mental load and decreased performance.

Treisman, in summarizing previous findings, as well as her own, stated that, "Cues which are effective in allowing selection are the general physical characteristics of the messages as sounds, for example, the long-term frequency spectrum, the intensity, the spatial localization. Classes of signals distinguished by such features are said to come on different functional channels. Signals in essence, are sorted along and acted upon in the various dimensions. In the absence of such distinctions between classes of sounds, some selectivity of response appears to be possible on the basis of transitional probabilities between words, but this is much less effective." (1964b, page 533).

Auditory Coherence

There has been little research since the early 1970s on the relative importance of acoustic and linguistic cues in selective attention. Instead, studies have tended to be concerned with how acoustic streams are maintained and segregated, rather, than on their subsequent effects on perception.

In everyday life, sounds can momentarily mask each other, yet, somehow we are able to separate the competing sound sources. Our ability to do so has been attributed by some researchers to a process called auditory coherence (Bregman, 1978; Brokx and Nooteboom, 1982; French-St. George and Bregman, 1989). These researchers feel that auditory coherence, in turn, underlies the subject's ability to selectively attend to a target message in the face of competing messages.

Bregman (1978), in summarizing the major findings on auditory coherence, wrote that:

1. Stimuli originating from the same spatial source will be grouped together.
2. Elements will be grouped together if they are similar (eg., spectral composition).
3. Elements changing at a similar rate will tend to be grouped into the same acoustic stream. Smooth and regular change suggests signals arising from the same source, while large discontinuities in frequency and intensity suggest a change in the source.
4. Stimuli undergoing the same kinds of change at the same time are grouped as part of the same event. That is, it is likely that many frequency components arising from an acoustic source will (a) come on and go off at more or less the same

time, (b) glide up and down in pitch together, (c) be amplitude modulated together, etc.

5. The organization of perceptual events and subsequent decomposition of acoustic stream(s) has also been shown to be affected by the observer's goals, memories and skills. An example of this phenomenon is the ability of individuals, listening to a familiar language, to break up the acoustic stream into separate words.

The work on auditory coherence supports the earlier conclusions made by Treisman (1964b) and Craik and Lockhart (1972). That is, the importance of different acoustic cues (especially the spatial and talker cues) and linguistic cues in competing message situations is that they allow the listener to segregate the competing stimuli into separate acoustic streams. In the absence of any of these cues, the listener experiences increased difficulty in sorting the target from the competing message. This, in turn, makes the attention task more difficult.

Neurophysiological Evidence Supporting the Importance of Long-Term Acoustic Cues in Selective Attention

The findings from the behavioral studies are supported by similar results in neurophysiological studies. Naatanen (1985, 1990) and Ahlo, Sams, Paavilainen, Reinkainen and Naatanen (1989) have done a number of neurophysiological studies using electroencephalography (EEG) and/or late auditory evoked response potentials (ERP) to investigate the effects of selective attention on cortical activity. Naatanen (1985, 1990) proposed that one component of the auditory ERP, the so-called "mismatch negativity", reflects a physiological mismatch process that is automatic and unaffected by the direction of attention. Naatanen found that the mismatch negativity habituates with the repetition of a physical stimulus but reappears whenever there is any deviation of a physical parameter in the stimulus. Naatanen speculated that a neuronal representation is generated whenever a particular stimulus is presented. Any deviance in physical attributes in subsequent stimuli results in the generation of the mismatch negativity.

Naatanen also noted that there exists a second component of the late auditory ERP. Unlike the mismatch negativity, this component is enhanced by selective attention. This component, the "processing negativity" is later in onset and lasts longer than the mismatch negativity. Naatanen and others have found that the longest and largest processing negativities are generated by stimuli which are attended to, while the least processing negativity is generated by unattended stimuli. Naatanen has suggested that only those features selected for attention will be involved in the comparison of target and deviant signals. Thus, irrelevant features will not elicit brain wave activity in any significant way, except for generating a mismatch negativity.

Naatanen (1990) also showed that the more physical features a competing signal had in common with a target signal, the longer and stronger the processing negativity for the competing signal (i.e., the greater the processing time and metal effort exerted). The more dissimilar the physical characteristics, the shorter and weaker the processing negativity. This suggests that the mental load will be greatest when the target and competing stimuli are physically similar, a finding that concurs with the earlier behavioral observations by Craik and Lockhart (1972) and Bregman (1978).

Other Auditory Attention Tasks: Divided Attention and Partial Report

In addition to selective attention, listeners in everyday situations must often divide their attention among a number of incoming messages. For example, when an individual is first confronted with competing messages, he or she must often process more than one message before deciding which message to attend to. These different attention tasks likely result in different mental processing loads, which, in turn, might affect the degree to which the various acoustic and linguistic cues contribute to performance.

In the test situation, the ability to share attention among competing messages has been assessed using two different test procedures. One test procedure is called the "divided attention" task (Broadbent, 1958). In this task, the listener must attend to two or more incoming messages and then recall as much as he or she can from all of the competing messages. Since the listener must process all of the incoming speech stimuli greater demands are placed upon the listener than in the selective attention task. These demands, compared to selective attention, include (a) processing a greater amount of information,

(b) attending to information presented at a faster rate (i.e., more information is presented over the same period of time), and (c) retaining one or more messages in memory, while recalling the first message (this might affect recall of the first message). It should be noted that recall of the first message results in a time lapse, possibly decreasing recall of the other message(s)- due to decay in short term memory. In addition, verbal recall of the first message might produce output interference and hinder recall of the other messages.

The second test procedure is called "partial report" (Sperling, 1960; Moray, Bates, and Barnett, 1965). In this procedure, the subject listens to competing messages and only after the presentation is the subject cued as to which message to recall. The primary difference between the partial report and divided attention tasks is that the subject must repeat only one message in the partial report task, while having to repeat all messages in the divided attention task. However, because the subject in the partial report task is not told ahead of time as to which message is the target, he or she can not selectively attend to any one particular message and must attend to all input messages. Hence, subjects in both partial report and divided attention must initially process all competing messages.

Comparative Performance on Selective Attention, Divided Attention and Partial Report

Broadbent (1952b) compared subject performance on different auditory attention tasks. Subjects listened to competing messages consisting of yes/no questions, each question preceded by a call sign. The messages were spoken by different talkers and presented from a single loudspeaker. In one experimental task, subjects were told ahead of time to answer only those messages spoken by one of the talkers and to ignore the messages spoken by the other talker (i.e., selective attention). In a second task, subjects were told to recall the message spoken by one of the talkers, but the target talker was indicated only after the presentation (the term partial report was not coined until later). Broadbent found that subjects performed significantly better on the selective attention task (means of 68% versus 43% for selective attention and partial report, respectively). This finding suggests that selective attention is a significantly easier task than partial report. It is interesting to note that a mean score of only 68% was attained in the selective attention task. The speakers' gender was not mentioned but since the experiment involved naval personnel it is likely that the competing talkers were both adult males. Because their voices were presented from a single loudspeaker, and, if the talkers had a similar voice pitch, then some difficulty would have been expected even in the selective attention task.

Tolhurst and Peters (1956) examined subjects' reception of two simultaneous messages as a function of relative intensity levels. The same talker recorded all of the messages, the messages being recorded on two different channels. Each message consisted of a call sign followed by three words. Competing words were phonetically similar and chosen on the basis of being easily confused with each other.

There was one test and one reference condition. In the test condition, one group of subjects heard the simultaneous messages presented dichotically. The level in one channel was fixed in all listening conditions, while the level in the other channel was attenuated in various step sizes. The subject's task in this condition was to recall both messages (i.e., divided attention). At the same time, in the reference condition, a second group heard only one of the messages (i.e., subsequent to one of the earphones being disconnected). Levels in the reference condition were adjusted to match the corresponding attenuations in the test condition. Speech stimuli in both listening conditions were presented in quiet and in background noise.

Tolhurst and Peters found, as expected, that at the same attenuated intensity level, scores in the reference condition were significantly higher than in the divided attention condition. These differences became larger when the signal-to-noise ratio was decreased. Tolhurst and Peters then looked at the performance-intensity functions for each channel in the divided attention task and found (a) within a particular listening condition (i.e., quiet or noise) attenuation of the signal in one channel decreased reception of that signal, while increasing the reception scores of the unattenuated signal, (b) overall performance remained relatively constant within a particular listening condition; that is, any gains evidenced in one channel were balanced by decrements in performance in the other channel, and (c) the differences in performance between the attenuated and fixed channels became larger as more noise was introduced.

Sperling (1960) was the first to coin the phrase "partial report". He compared partial report and divided attention performance on a visual task. Subjects were presented with brief visual stimuli consisting of alpha-numeric characters, lasting on the order of 50 milliseconds. Different arrays were used to display these stimuli. The arrays varied from a single line, up to 7 characters, to multilayered arrays (i.e., more than one line of characters). The subject's task was to recall as many characters as possible, in correct order of position, from the designated row(s). In the whole report (divided attention) condition, subjects were asked to recall all of the characters that had been presented. In the partial report condition, a cue was given after presentation that indicated which row of characters the subjects were to recall.

Sperling found that the percentage of stimuli correctly recalled on the partial report task was significantly higher than on the whole report task. This was only true, however, when the subjects were asked to respond within one second of stimulus presentation. If subjects were asked to recall stimuli after more than one second after exposure, then subjects performed similarly on both tasks. Sperling concluded that immediately following stimulus offset more information about the array can be reported, but at delays greater than one second this information disappears quickly from immediate memory.

Moray, Bates, and Barnett (1965), using auditory stimuli, did two experiments that followed up on the work of Sperling. In both experiments, subjects listened to sequences of letters presented over one, two, three, or four channels (i.e., from one or more loudspeakers). In the one, two, and four channel conditions a total of 4, 8, 12, or 16 letters was presented, while in the three channel condition a total of 3, 9, 12, and 15 letters were presented. The letters were presented on each channel at a rate of two per second, hence, the total input rate varied across channel conditions (eg., over a two second time span subjects would have had to process 16 letters in the four channel condition, while having to process only four letters in the one channel condition).

In the first experiment, subjects were asked to recall all letters presented. The mean percentage of letters correctly recalled was highest in the one and two channel conditions. Interestingly, subjects tended to report all letters from one channel first and, thereafter, tried to recall all other letters. After first channel recall, all subsequent recall was haphazard and not channel by channel. The channel that was recalled first seemed to be any one that "had a distinctive feature, a slightly earlier start, a momentarily louder signal, etc., that made it stand out from its fellows." (Moray et al., 1965; page 199). Moray concluded that immediately after presentation, subjects can recall items quite accurately (i.e., from the first channel reported), but over time the stored signal deteriorates rapidly. Subsequently, further recall is less accurate and more haphazard.

The second experiment was similar to the first, except that a second condition (partial report) was included. In the partial report task, subjects were told to recall letters from only one loudspeaker, but that the target loudspeaker would be designated only after item presentation. In general, Moray et al. found that recall accuracy on the partial report task (in terms of percentage of items correctly recalled) was significantly higher than on the whole report task, and, especially in the most difficult, four channel condition. Moray also found, similar to Sperling, that if recall was intentionally delayed subjects performed similarly on both the partial and whole report tasks.

The above studies suggest that selective attention is a significantly easier task than both partial report and divided attention. In addition, the studies by Sperling (1960) and Moray et al. (1965) indicate that subjects perform significantly better on partial report than on divided attention tasks. However, Sperling and Moray showed that differences in performance on the various tasks could be significantly altered by manipulating different task variables, such as rate of presentation, number of channels, response delay. Hence, this interdependence between the independent variables chosen and the relative performance obtained on different auditory attention tasks must be considered when any conclusions are derived.

The Importance of Long-Term Acoustic Cues in Divided Attention and Partial Report

In only a few studies has the contribution of long-term acoustic cues (such as spatial and talker cues) in divided attention and partial report tasks been examined. Webster and Thompson (1954) examined subjects' ability to listen and recall two competing messages when the competing messages differed in either: (a) their degree of overlap, (b) the relative intensity of the two messages, and

(c) their relative location in respect to each other (i.e., the two competing messages were presented from an arrangement of six loudspeakers or from one loudspeaker and one earphone). The competing messages were spoken by different individuals. Each message consisted of a call sign followed by three words that were to be repeated. Webster and Thompson found that:

1. Subjects did significantly better when listening to the single loudspeaker and earphone than when listening to any two of six possible loudspeakers. In turn, subjects did better in the multiple speaker condition than when the competing messages were presented via one loudspeaker.
2. When two messages differed in loudness, the louder of the two unequal messages was more likely to be recalled correctly.
3. When the two messages differed in their onsets, recall of the earlier message was slightly better.

It should be noted that Webster and Thompson did not mention whether intensity or time of onset influenced the order in which sentences were recalled. This is an important omission on their part since the order in which the messages were reported could have influenced subject performance.

Poulton (1956) compared selective attention and divided attention performance in different listening conditions. The competing messages were always presented from two loudspeakers with: (a) one loudspeaker on top of the other, (b) the loudspeakers separated 90^0 from each other on the horizontal axis- one left front and one right front, and (c) four loudspeakers used but only two were active at any one time- the maximum angle separating the outside loudspeakers was 90^o. Subjects listened to two messages that were either synchronous or overlapping and were spoken by different talkers. Each message consisted of a call sign followed by three digits that were to be written down. In the selective attention task, subjects were instructed to recall the message keyed by a particular call sign, while in the divided attention task the subjects were instructed to recall both messages. Poulton found:

1. a significantly higher percentage of errors in the divided attention task,
2. in the selective attention task, significantly more errors when the messages were synchronized than when they were partially overlapped; in the divided attention task, more errors occurred for the

synchronized pairings but the difference was less than in the selective attention task, and

3. in both the selective attention and divided attention tasks, variation in the arrangement of speakers did not result in any significant differences.

The third finding seems to suggest that the extent of spatial separation contributes little to auditory attention, however, other studies have shown that spatial cues do provide a significant benefit in auditory attention tasks. There are two possible explanations for this finding. First, the various arrangements of the loudspeakers may not have been sufficiently different to affect performance. A second possible explanation, at least for the selective attention task, is that when the target message location was free to vary it was more difficult for subjects to focus on the target message than when the target message location was fixed. That is, the selective attention task in the former situation was more akin to a partial report task.

There is also some indirect evidence that suggests acoustic cues do aid listener's recall in a divided attention task (and perhaps in partial report). Broadbent

(1956) found that when subjects listened to digits presented dichotically, they tended to recall all of the digits heard in one ear and then all of the ones heard in the other ear. Broadbent hypothesized that each ear served as a "channel" by which information was grouped and stored and from which information was retrieved. That is, the spatial cue helped the listener to perceptually organize the different acoustic stimuli.

Savin (1967) summarized the results from a number of divided attention experiments in which the Broadbent (1956) technique was used. In these studies, there was not only a difference in spatial location but also a difference in: (a) the talker's voice quality (produced by filtering low frequencies; Broadbent, 1956), (b) the talkers' fundamental frequencies (Yntema and Trask, 1963), or even (c) semantic categories, such as words versus digits (Gray and Wedderburn, 1960). In each experiment, the additional distinguishing characteristic was alternated in succession between ears. For example, in the Gray and Wedderburn study, successive word-digit pairs were alternated between ears. On the first item the word was presented in the right ear, while the digit was presented in the left ear; on the second item, the order was reversed with the word presented in the left ear and the digit in the right ear.

In each study, the researchers determined that the subjects grouped and recalled all items by the additional distinguishing characteristic and not by spatial location. Savin concluded that this preferred order of recall reflected auditory perceptual organization.

Treisman (1970), employing the Broadbent technique, asked subjects to recall all items of 6 digit lists (split into 3 pairs). The items were presented either dichotically (3 items to 1 ear and 3 items to other) or diotically. Each digit pair was synchronized for simultaneous onset. Treisman found that the reaction times were faster and errors were reduced when the items were presented dichotically. Treisman suggested that the results were best explained by decreased amount of mutual masking and the greater ease with which digits were disentangled in the preprocessing stage.

In summary, the above results indicate that various long-term acoustic cues do enhance performance in divided attention tasks. Some of the benefits can be attributed to decreased peripheral masking, but the evidence also suggests that long-term acoustic cues can help the listener to organize perceptually and recall different acoustic streams in a divided attention task. What is not known is whether the extent of this enhancement is as great as in the selective attention task. Since subjects in divided attention and partial report tasks must process all incoming messages, presumably, the listener must derive the linguistic content of all these messages. That is, even with all the physical cues present, the subject must still process all of the messages for their phonetic, lexical, semantic and syntactic content. If the linguistic processing stage is the major source of interference in divided attention and partial report tasks, then the contribution of spatial and talker cues (and consequently, the benefits of separate acoustic streams) should be less than in selective attention tasks. If, on the other hand, these acoustic cues serve as perceptual channels and help to "tag" each item (i.e., maintain a perceptual distance between the different acoustic streams during delayed processing even after the stimuli have ceased), then the presence of acoustic cues in the divided attention and partial report tasks might enhance performance as effectively as in selective attention.

Use of Sentence Material on Auditory Attention Tasks

In general, conclusions regarding the relative importance of long-term acoustic cues in auditory attention have been derived using speech materials low in linguistic redundancy. Speech stimuli have included digits, syllables, single words, spondees and telegraphic messages. In difficult listening situations, this lack of redundancy probably forces the subject to rely heavily on long-term acoustic cues, such as spatial and talker cues. If these long-term acoustic cues are removed, little information is left to distinguish the target from the competing message. On the other hand, sentences, especially those presented in context, possess much acoustic and linguistic redundancy. It is possible that this added redundancy is sufficient to allow successful recall of a target sentence in a competing message task, even in the absence of long-term acoustic cues.

The interrelationship of redundancy and speech intelligibility was first demonstrated by Miller, Heise, and Lichten (1950). These researchers assessed speech intelligibility for different speech materials in the presence of white noise. In one experiment, the speech materials consisted of digits (numbers 1 to 9), nonsense syllables and sentences. Miller et al. found that 50% intelligibility was reached at -14 dB S/N for digits, -4 dB S/N for words in sentences, and +3 dB S/N for nonsense words. Hence, using speech materials of greater linguistic redundancy allowed subjects to achieve 50% intelligibility at poorer S/N ratios.

In a second experiment, subjects listened to words presented in isolation and in sentence context in the presence of background noise. The authors found that 50% intelligibility occurred at 6 dB lower when the words were heard in sentence context. Miller et al. concluded that listening performance improves as the number of response alternatives decrease and that the use of sentence materials was comparable to restricting vocabulary size.

Miller and Selfridge (1953) examined speech intelligibility as a function of sentence order approximation. Zero order approximation represented sentences consisting of words chosen at random, while higher order approximations represented the maximum length to which consecutive words were related to each other- in a probabilistic sense- in a sentence. For example, a third order sentence approximation meant that regardless of the particular word chosen in the sentence, no more than two words were associated with the occurrence of that word. Subjects listened to sentences presented in quiet, the subject's task being to write down as many words from the sentence as possible. Sentences varied in length (10, 20, 30 and 50 words long). Miller and Selfridge found that the closer the sentence approximations approached real sentences the higher the speech intelligibility, and, the longer the sentence material the greater the difference in performance between higher and lower order sentences.

Miller and Isard (1963) constructed sentence materials in a hierarchal fashion. The sentences were constructed with: (a) appropriate semantic and syntactic rules (i.e., grammatical sentences), (b) appropriate syntactic but inappropriate semantic rules (i.e., semantically anomalous), and (c) ungrammatic strings of words (i.e., nonsense sentences). The sentences were presented in quiet and in background noise. Five different S/N ratios were used, ranging from +15 to -5 dB. In all listening conditions, subjects performed best on the grammatical sentences and worst on the nonsense sentences. The differences in performance increased as the S/N ratios were decreased from +15 to 0 dB S/N. At -5 dB S/N, the differences became smaller but this may have been due to a floor effect. Miller and Isard concluded that semantic and syntactic rules both exert measurable effects on speech intelligibility.

Boothroyd and Nittrouer (1988) examined the recognition of words at different S/N ratios (+10 to -15 dB) using three types of sentences: (1) high predictability (i.e., grammatical sentences), (2) low predictability (i.e., semantically anomalous), and (3) zero predictability (i.e., nonsense sentences). Each sentence consisted of four words. The improvement in performance was quantified for the addition of both syntactic and semantic context. Boothroyd and Nittrouer found that at a given S/N ratio the probability of word recognition in high predictability sentences (i.e., both syntactic and semantic cues present) were as much as 20-35 percentage points higher than in zero predictability sentences and as much as 10-20 percentage points higher than in low predictability sentences (i.e., with only syntactic cues present). The percentage point differences decreased at the extremes because of floor and ceiling effects. Mathematical analysis showed that semantic context was more effective than syntactic context. Extrapolation of the data also showed that words presented in low predictability, and, especially in high predictability sentences, were recalled more accurately than when the words were presented in isolation.

A number of researchers have shown that the presence of suprasegmental features also improves listener accuracy, especially in difficult listening conditions. The contribution, however, appears to be less than that provided by semantic and syntactic cues (Wingfield and Klein, 1971; Wingfield, 1975; Collier and Hart, 1975; Brokx and Nooteboom, 1982). The findings in these studies indicate that the presence of suprasegmental features make the listening task easier in at least two ways. First, suprasegmental cues, in conjunction with syntactical markers, help the listener to group the various phrase structures (i.e., various suprasegmental cues, such as rhythm and pauses, have been found to coincide with phrase boundaries). This, in turn, helps the listener to derive the intended semantic content. Second, suprasegmental markers have been shown to help the listener in segregating competing voices from one another, thus, enabling the subject to attend to the target speaker more effectively in difficult listening conditions.

Garrett and St. Pierre (1980) also showed that cues identifying the topic of the sentence aid speech perception. Normal hearing subjects listened binaurally to messages, one of 45 questions, embedded in white noise at three different S/N ratios (-5, -3, -1 dB S/N). Relevant cues (i.e., the topic), irrelevant cues or no cues were presented beforehand. Subjects were instructed to repeat as much of the message as they had been able to hear. Garrett and St.Pierre found that subjects performed significantly better when they were aware of the sentence topic beforehand and that the gains derived were larger the worse the S/N ratios.

Speaks (1967) examined the effect of linguistic redundancy on the performance-intensity function. Previous studies had shown that the most important frequencies for intelligibility occurred between 1.5 and 2 kHz with the point of equal intelligibility (i.e., the point where the frequencies above and below contribute equally to intelligibility) occurring around 1900 Hz. Speaks stated that the earlier conclusions were based on speech materials of minimal redundancy (such as CVC nonsense syllables and monosyllabic words) and that the results might be different if materials of greater linguistic redundancy were used.

Speaks presented subjects with closed set lists consisting of ten sentences of third order approximations. Each sentence contained approximately the same number of words and syllables. The sentences were presented monaurally with the subject's task being to identify the sentence heard.

Performance-intensity functions were carried out at several low-pass and high-pass conditions. The results were then compared with those obtained by French and Steinberg (1947); these researchers had used nonsense CVC syllables to derive the point of equal intelligibility. Speaks found that the point of equal intelligibility for the closed-set sentence materials occurred in the region of 725 Hz, a value significantly lower than the 1900 Hz value cited by French and Steinberg. Speaks also found that subject performance always reached 100% for the sentences, regardless of the pass band, if sufficient intensity was introduced. This contrasted with the results obtained for the monosyllables, which showed lower and lower maxima as the pass band became more and more restricted. Speaks felt that this unique interaction of signal level with frequency range was due to the greater redundancy characterizing sentences.

It is difficult to generalize Speaks' findings because of the uniqueness of the sentence material used (i.e., third order sentence approximations) and the subjects' task (i.e., choosing from a closed-set of 10 sentences). Although no studies of crossover frequency have been done using naturally occurring sentence materials, there has been one study using connected discourse (Studebaker, Pavlovic, and Sherbecoe, 1987). In this study, subjects listened to connected discourse spoken by either one of two male talkers or by one female talker. The subjects' task was to estimate the percentage of words they understood. Seven high-pass and seven low-pass filter conditions, as well as one broadband condition, were presented monaurally at each of nine S/N ratios (the masking noise was unfiltered and shaped to match the average one-third octave band speech peaks spectrum of the talker of that passage). Studebaker et al. found that the point of equal intelligibility across the various S/N ratios centered at approximately 1200 Hz (albeit at lower percent intelligibility scores at the poorer S/N ratios). This value was higher than the 750 Hz value obtained by Speaks but lower than the 1900 Hz value obtained by French and Steinberg (1947).

The above studies show that presentation of closed-set third order sentence and connected discourse materials, compared to nonsense syllables, result in lower frequency values for the point of equal intelligibility for low- and high-pass filtering. These results suggest that the added redundancy inherent in sentence materials results in a decreased reliance on weak high frequency acoustic cues.

Levitt and Webster (1991) nicely summarized the interrelationship of redundancy and speech intelligibility by comparing the percentage of speech items (nonsense syllables, words and sentences) understood correctly as a function of the articulation index. Levitt showed that maximum performance was achieved at lower articulation indices for speech materials with the least number of alternatives or greatest redundancy (such as test vocabulary restricted to 32 phonetically balanced words or via naturally occurring sentences). That is, for sentence materials the same speech intelligibility score was achieved at an articulation index that was significantly less than that required for nonsense syllables.

In summary, subjects in difficult listening situations are able to attend to and recall more of the target stimulus when listening to sentence materials than when listening to nonsense syllables or monosyllabic words. The improvement in performance, as a function of increased redundancy, has been quantified in many ways, including: (1) better performance at lower S/N ratios, (2) lower frequency values for the point of equal intelligibility, and (3) higher speech intelligibility scores as a function of the articulation index. The findings suggest that the inherent redundancy in sentence materials, compared to CVCs or telegraphic sentences, allows subjects to perform more accurately in situations of increased noise or in situations of distorted spectral quality.

The Contribution of Spatial and Talker Cues in Competing Sentence Tasks

Only one published study has been done in which a competing sentence task was used to investigate the contribution of acoustic and linguistic cues to speech intelligibility. This was the Egan et al. study (1954) that was discussed earlier. It will be recalled that Egan et al. investigated the contribution of various long-term acoustic cues on competing sentence recall under headphone listening (i.e., spatial cues, relative intensities in the target versus competing message, and filtering of either the target or interfering signal). All of these cues were shown to impact on performance, with the greatest benefit being provided by the spatial cue. In the absence of any distinctive long-term acoustic cue, subjects recalled only 56% of the words from the target sentence. This finding suggests that long-term acoustic cues must be present, even in a competing sentence task, if subjects are to recall the target message accurately. However, this inference is somewhat negated by the fact that when no distinctive cues were present, subjects had no way of knowing which sentence was the target. In addition, Egan et al. did not indicate whether the mean score of 56% resulted from subjects mixing words from the two input sentences or from subjects correctly recalling most words from one sentence but the sentence recalled was the target sentence only one half of the time.

Two other studies, both unpublished, have looked at subject performance in a competing sentence task in the absence of long-term acoustic cues. These studies differed from the Egan et al. study in that the subjects' task was one of divided attention rather than selective attention.

Medwetsky (1987) investigated subjects' ability to recall two competing sentences when both spatial and talker cues were removed. Sentences from the CUNY Topic Related Sentences Sets (Hnath, Hanin and Boothroyd, 1986) were used. Sentence length varied from 3 to 14 words. The sentences were recorded by a single male speaker. The final product consisted of two recorded channels of sentence materials that were matched for number of words, intensity, and simultaneity of onset but differed in sentence topic. The sentences were presented monaurally with the subject's task being to recall as many words as possible from both sentences. Medwetsky found that subjects correctly recalled, from at least one sentence, more than 90% of the words for sentences up to 11 words long and more than 80% of the words from sentences 12 words and longer. Subjects correctly recalled more than 80% of the words in the second sentence for sentences up to 6 words long and approximately 55% of the words for sentences of 9 words or more. Medwetsky also found that subjects incorrectly misassigned words to the opposite sentence less than 1% of the time. These findings suggest that the inherent redundancy in sentences is sufficient to allow successful recall of at least one sentence in a competing sentence task, even in the absence of spatial and talker cues. There were, however, a number of methodological inadequacies in this study that might have artificially boosted subject performance and include: (a) although an attempt was made to equalize the overall average intensity of the competing sentences, this likely did not occur, (b) many of the sentence pairs might not have been adequately matched for simultaneous onset, and (c) sentences were matched for word length but not for overall duration; it is possible that subjects were able to hear some words in one sentence without competition.

A follow-up study by McInerny and Boothroyd (1988) on the effect of noise on competing sentence recall attempted to rectify some of the methodological inadequacies in the Medwetsky study. Sentences of 9 words or more were recorded, digitized, and stored on computer. A software package was used to align sentences of similar length for simultaneous onset. Only the scores obtained in the quiet condition will be reported here. McInerny and Boothroyd found that subjects achieved mean scores of approximately 80% for the first sentence recalled and approximately 55% for the second sentence recalled. These results are similar to those obtained by Medwetsky.

Further evidence that subjects can attend to and recall a target message in a competing message task, even in the absence of spatial and talker cues, can be found in a study by Cherry and Kruger (1983). They compared the selective auditory attention skills of learning disabled children with those of normal achievers aged 7 to 8 years. The target material consisted of taped recordings of the Word Intelligibility by Picture Identification (WIPI) test (Ross and Lerman, 1971). The WIPI test is a closed response task consisting of 25 sets of pictures, each set consisting of six pictures; the subject's task is to point to the picture corresponding to the test word presented.

There were three competing message conditions in the Cherry and Kruger study but only one is pertinent to the present study. In one competing message condition, a story was recorded by the same talker who presented the target stimuli. The target and distracter were presented diotically under earphones at a 0 dB S/N ratio. The 8-year old normal achievers obtained a mean score of 84%. Hence, these children were highly successful in attending to and identifying the target stimuli in face of the competing messages, even though there were no spatial, talker or long-term intensity cues present. Because the target stimuli were presented in a closed-set task, it is not known whether the restricted number of alternatives contributed to the high scores obtained. However, it should be recalled that the oldest subjects in this study were eight years old and it is possible that older subjects would have obtained even higher scores.

In summary, the importance of long-term acoustic cues, specifically spatial and talker cues, in a competing speech perception task remains unresolved. Since naturally occurring sentence stimuli are typical of the speech stimuli encountered in everyday situations, the use of such stimuli in a competing message task might be more predictive of the importance of spatial and talker cues in everyday life. A related issue is whether the contribution of these acoustic cues varies as a function of the recall task.

CHAPTER 3: METHOD

Subjects

Twelve subjects participated in this study. Subject selection was based on several criteria. These were:

1. Age- Between 18 and 45. Studies by Jerger (1973), and Jerger and Hayes (1977) suggest that presbycusis, as evidenced by phonemic regression and poorer central auditory functioning, generally occurs in subjects older than 50 years of age. Since presbycusis could potentially have affected subject performance in this study, no subjects older than 45 were chosen. In addition, since many of the sentences used in this study often dealt with sophisticated subject matter all subjects chosen were older than 18. Table 2 shows the age of each subject who participated in this study. The subjects' ages ranged from 24:8 to 43:11 years, with a mean of 30:6 years.
2. English as the Native Language. Many studies have shown that non-native English speakers do more poorly on tests of competing messages in the English language than native English speakers (Keydar and Katz, 1976; Rawiszer, 1979). Only

those subjects who reported that their first and primary language was English were chosen to participate in this study.

3. No History of Learning/Listening Disability. Studies have also shown that learning/listening disabled individuals often do poorly on tests of competing messages (Willeford, 1980; Musiek and Pinheiro, 1985). Therefore, none of the subjects chosen had any known history of learning/listening disability.

4. Right Handedness. Studies of left- and right-handers have shown differences in dichotic listening ability (Bryden, 1970; Satz, Achenbach, Pattishal, and Fennel, 1965; Satz, Fennel, and Jones, 1969). To avoid any possible biases due to differences in handedness, only right-handers, as determined by using the Edinburgh Handedness Inventory (1971), served as subjects (the inventory is shown in Appendix A). Subjects are considered to be predominantly righthanded if they receive a score higher than 80%. Table 1 shows the subjects' results on the Oldfield Scale. All subjects had handedness scores higher than 90%.

5. No Previous Exposure to the CUNY Topic Related Sentences Sets. This was to prevent any possible learning effects that could have biased the results obtained in this study.

6. Normal Hearing Bilaterally. All individuals meeting the above five criteria were tested auditorily under earphones. Subjects were seated in an Acoustic Systems single-walled sound treated suite (Model #RE120). A Beltone portable audiometer (Model #112) was used to present pure tones of .25K, .5K, 1K, 2K, 3K, 4K and 8K Hz. Only those subjects having bilateral thresholds of 20 dBHL or better were chosen. The subjects' air conduction puretone three-frequency average threshold (re. ANSI, 1969) in the left and right ears are shown in Table 1.

Table 1. Demographic data for the 12 experimental subjects. These include the subject's gender, age, handedness quotient on the Oldfield Scale and puretone three-frequency average (500, 1000, and 2000 Hz).

	Subject	Gender	Age Yrs:Mos	Handedness Quotient (%)	3-Freq Avg Puretone Threshold (dBHL) Left	Right
1.	MC	F	40.5	100.0	3.3	3.3
2.	AH	F	25.6	100.0	0.0	0.0
3.	DW	F	25.3	100.0	6.6	5.0
4.	LT	F	24.8	100.0	5.0	1.6
5.	CL	F	26.11	100.0	0.0	-1.6
6.	RJ	F	31.7	90.0	5.0	5.0
7.	PO	F	32.0	100.0	0.0	-1.6
8.	LC	M	43.11	100.0	6.6	10.0
9.	TB	F	26.6	90.0	1.6	0.0
10.	KM	M	34.0	100.0	5.0	5.0
11.	SH	F	26.9	95.0	5.0	5.0
12.	VB	F	28.10	100.0	0.0	0.0

Test Material

The sentences used in this study were taken from the CUNY Topic Related Sentences Sets (Hnath, Hanin and Boothroyd, 1986) of which there are 72 sets. Each set has 12 sentences, varying in length from 3 to 14 words, with a total of 102 words. There are four declaratives, four interrogatives, and four imperatives in each set, with each sentence having a different topic. The same 12 topics are maintained across sets and counterbalanced across sentence length. One of these sentence sets is shown in Appendix B.

Preparation of Test Tapes

1. Recording of Test Talkers

Two adults, one female and one male, were recorded. Both speakers were native English speakers. Sixty sentence sets had already been recorded by the female talker and transferred to laserdisc prior to this study. These were sentence sets 1-60. Twelve additional sentence sets, sets 61-72, were recorded for this study. The male talker recorded sentence sets 1-60 for this study.

Figure 1 shows a block diagram of the instrumentation used for the new recordings of the female and male talkers. Each talker was isolated in a sound treated suite and seated at a distance of 18 inches from an omni-directional microphone (Electro-Voice, Model #635A). This microphone was connected to the microphone input of a tape recorder (Marantz PMD-430) located outside the suite. The tape recorder served as a pre-amplifier. The talker's level was adjusted, using the VU-meter of the tape recorder, to peak at 0 dB. The speech signal was then transmitted, via the headphone output of the Marantz tape recorder, to the line input of a digital audio processor (SONY PCM-81) and digitized. The digitized signal was relayed from the video output of the digital audio processor to the video input of a video recorder (Panasonic AG-6300) and recorded onto the video track of a high grade videotape (Kodak HGX).

2. Digitizing and Transferring the Recorded Material to Computer Disk

In order to measure sentence duration and to synchronize sentence pair onsets, it was necessary to transfer and save the recorded test material to computer disk. The sentences were transferred one at a time and stored in separate files. Figure 2 shows a block diagram of the instrumentation used in transferring the video laserdisc sentences to computer disk. The sentences were transmitted via the audio output of the video laserdisc

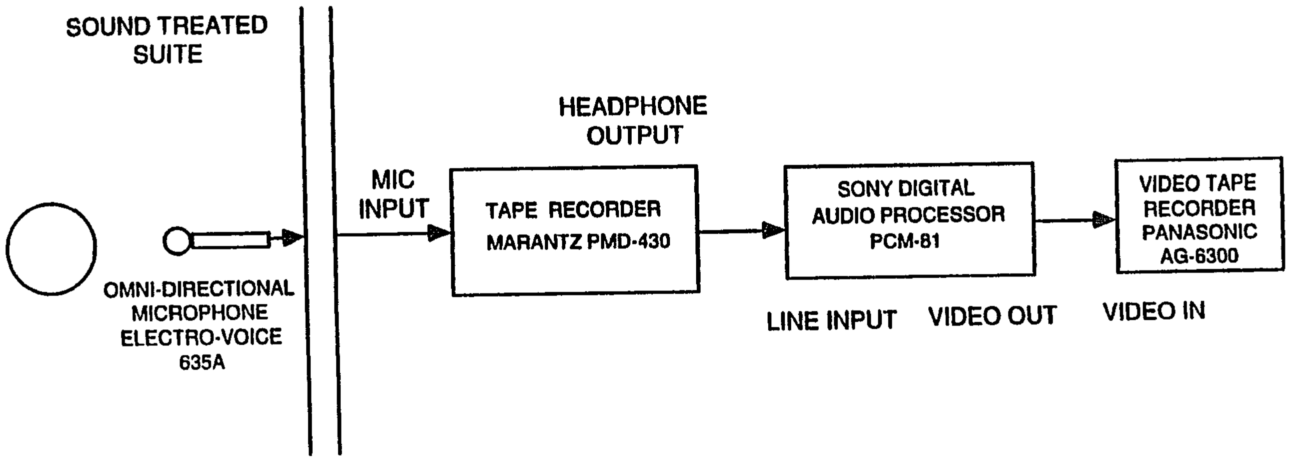

Figure 1. Block diagram of the equipment used to record the test talkers.

player (Pioneer Laservision Player LD-V4200) to the auxiliary input of a stereo pre-amplifier (NAD-1020). The level was adjusted using the VU-meter to peak at 0 dB. The output sentences were then filtered, using a 10 kHz anti-aliasing filter, and digitized by an analog/digital (A/D) converter housed inside an IBM compatible computer (ME-286). The sentences were sampled at a rate of 20,000 per second, converted to binary form with 12-bit accuracy and stored on the hard drive of the computer. Sentences were monitored, using a splitter, at the output of the anti-aliasing filter. The monitoring path involved connecting the output of the anti-aliasing filter to the tape input of a stereo amplifier (Realistic SA-150), the output of which was connected to a loudspeaker (XAM-5E).

Figure 3 shows a block diagram of the instrumentation used to transfer the sentence material from videotape. The sentences were played back on a portable VCR (Panasonic NV-8420). The video output of the VCR was transmitted to the video input of a digital audio processor (Sony Digital PCM 501-ES), at which point the digitized speech signal was converted back to analog form. The speech signals were then relayed, via the line output of the digital audio processor, to the auxiliary input of a stereo pre-amplifier (NAD-1020) and amplified. All subsequent

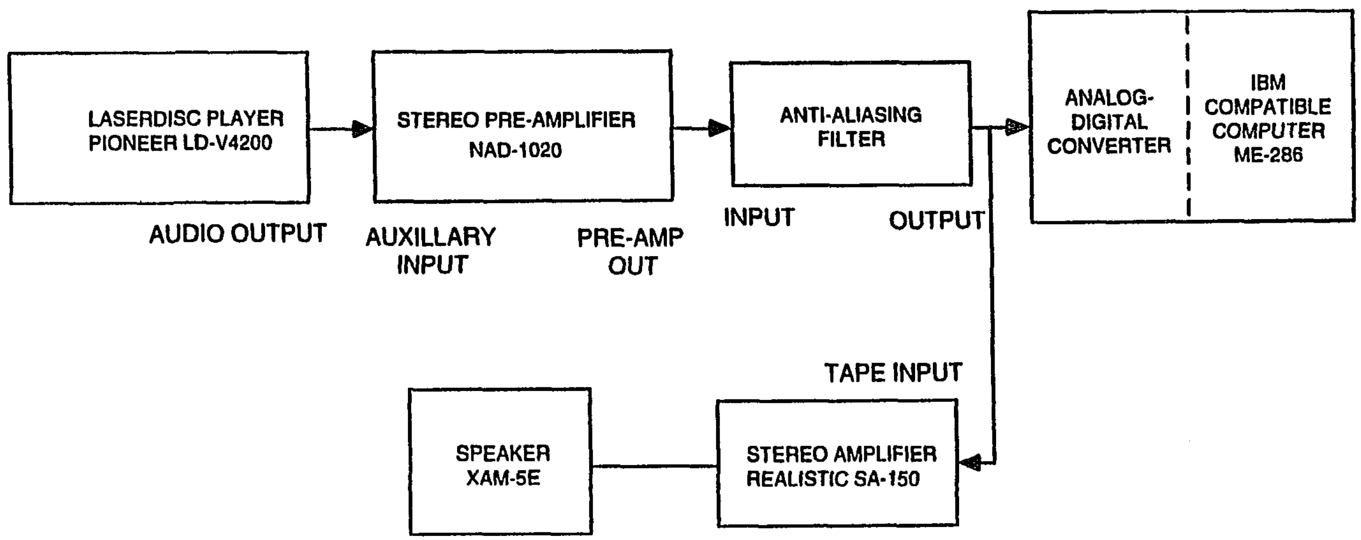

Figure 2. The equipment used to transfer and store the laserdisc sentence material to the hard drive of the computer.

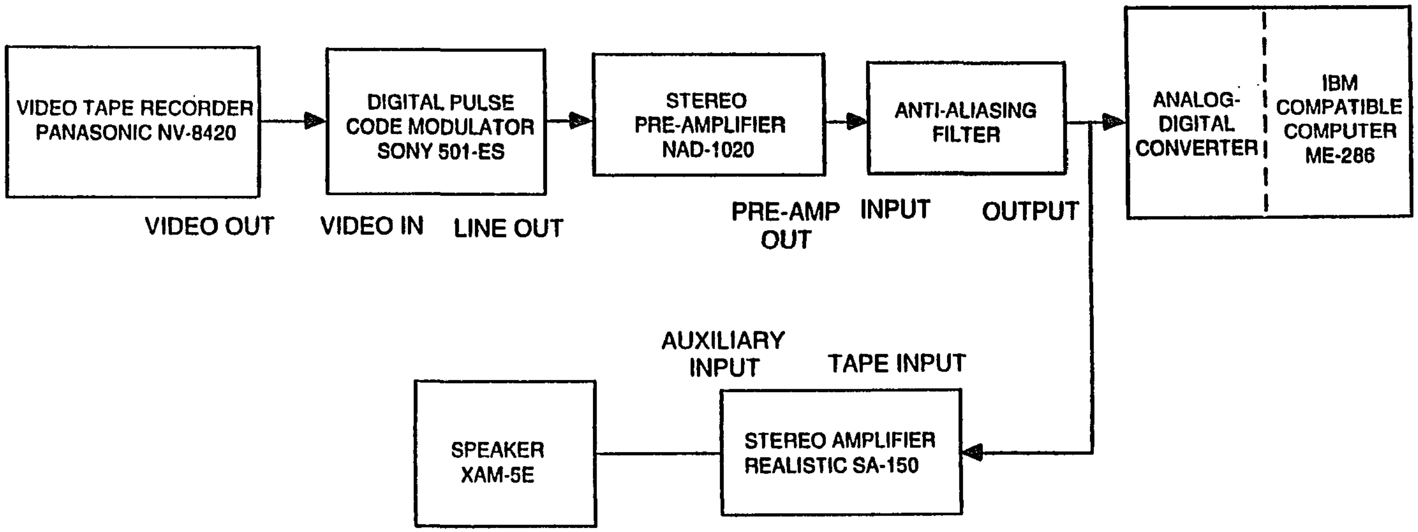

Figure 3. The equipment used to transfer and store the additional recorded sentence material to the hard drive of the computer.

connections/functions were identical with those shown in Figure 2.

3. Editing the Sentence Material

A waveform editing computer program modified for this study was used to eliminate all non-speech portions in each file. The program automatically (a) located the start and end of each sentence and (b) measured the duration of each sentence. Pilot studies showed the automatic editing procedure to be reliable. That is, the durational values for a sample of sentences, be it by automatic or manual editing, were found to be within 5 milliseconds of each other.

Sentence waveforms were displayed on the computer monitor one at a time. The average noise level before sentence onset was determined, which then served as a reference value for that particular sentence. A threshold value for speech sampling was then entered manually; that is, an intensity level sufficiently greater than the reference value was entered. Threshold values varied as a function of the level of the background noise and the intensity of the initial speech segment of the sentence. Only those sampling values greater than the threshold were stored in the edited file.

The program sampled 5 millisecond segments, beginning from the point of the first cursor. The point at which the program found three consecutive samples of greater intensity than the threshold was designated as the beginning of the sentence. The program then sampled 5 millisecond segments in the reverse direction from the end of the file. The same sampling criteria designated the end of the sentence. The duration of each sentence item was then determined and attached as an extension to the file name (eg., F70903.090 where .090 denotes that this file is 0.90 seconds in duration. Because DOS file extensions permit only 3 characters, sentence durations in milliseconds were rounded to the nearest centisecond, hence, with 5 msec precision).

The edited file was then displayed on the screen. This was done to ensure that no extraneous noise had been included and that no portion of the speech sample had been deleted. If any irregularities were noted, the editing process was repeated with different threshold values entered.

4. Selecting Sentence Pairs

Sentence pairing was guided by the following criteria:

1. All sentences chosen had to have a signal-to-noise ratio of greater than 25 dB.
2. The durational difference between sentences in each pair could be no greater than 100 milliseconds (a duration unlikely to include more than one syllable).
3. The sentence topics had to be different.
4. Sentences were paired by grammatical function, that is, interrogatives with interrogatives and declaratives/imperatives with declaratives/imperatives.
5. No sentence could be used more than once.

Final selection required an equal number of sentence pairs across all sentence lengths in which either both sentences were spoken by the female talker (the same talker condition) or one sentence member was spoken by the female talker and the other sentence spoken by the male talker (the different talkers condition). An attempt was made to have similar mean durations for each sentence length in the same talker and the different talkers sentence sets. The mean durations, collapsed over sentences, for each sentence length are shown for the same talker and different talkers sentence sets in Appendix C.

A total of 576 sentences was chosen; 288 were included in the same talker pairs and 288 in the different talker pairs. For each condition, there were 12 sentence pairs for each sentence length. The text for all sentence pairs is shown in Appendix D.

5. Equalizing the Overall Intensity Levels of Sentences

The primary goal of this stage was to equalize the overall average intensity of each sentence in a sentence pair. A secondary goal, for convenience in testing subjects, was to ensure that all sentence pairs had the same overall average intensity.

An arbitrary intensity was chosen as the reference value to which the overall average intensity of each sentence was compared. A computer program was written to: (a) measure the overall average power in each sentence and (b) attach a decibel value, relative to the reference value, to each sentence filename.

The second stage in the equalization process occurred during the recording process and is discussed in Section 8.

6. Randomization of Sentence Pairs

A computer program was written for randomizing the sentence pairs that were to be presented in each test condition. Since each subject was assessed on 12 different task x listening conditions, with two trials each, 24 sets were needed for each tape.

Randomization of sentence pairs occurred sequentially. This was done first for the same talker files and then for the different talkers files. The first stage involved the randomization of sentence length; that is, the sentence lengths, from 3 to 14 words, were varied randomly. In the second stage one sentence pair for each sentence length was selected at random, without replacement, from the stored files and stored on computer in a table with their filenames and extensions. When sentence pairs had been selected for all sentence lengths, the two stage process was repeated. This process was repeated 12 times for both the same talker files and the different talkers files. The end result of this process constituted the sentence pairings for all 24 test conditions for that particular test tape.

It should be noted that after each sentence pair had been selected, the corresponding text files were stored in a sub-directory. Each sub-directory contained the 12 sentence pairs for a particular set. A simple print command in DOS produced the test forms that corresponded to each test tape.

7. Alignment and Outputting of Sentence Pairs

The first step involved the alignment of sentences in each sentence pair for simultaneous onset. Because of computer system limitations, it was not possible to output the digital data for both sentences of a sentence pair through independent channels. It was, therefore, necessary to merge the sentence data into a single stream, in which samples of one sentence were interleaved with samples of the other sentence. The merged data were stored as one file with the attenuation values attached. In the second step, software used the attenuation values for each file member of the sentence pair to adjust programmable attenuators (see Section # 8). The merged data were sent to a digital-to-analog (D/A) converter housed within the computer frame. The D/A converter split the merged data into the original data streams and then converted these into two independent analog signals. The signals were then relayed to the programmable attenuators, adjusted for intensity and then output. To obtain the sentence output at the same rate at which the original data were sampled

(20,000 samples/second), it would have been necessary to achieve an output rate of 40,000 samples/second for the combined data streams. However, system limitations necessitated limiting this sampling rate to 20,000 samples/second. Consequently, the output data for each sentence were obtained at a rate of 10,000 samples/second. This resulted in the output duration of each sentence being twice the input duration. To restore the original duration and frequency/time variations, the regenerated sentences were recorded simultaneously onto separate tracks of a 2-track audiocassette tape and subsequently played back at twice the recording speed (this procedure is discussed in more depth in Section 8).

8. Recording of Individual Test Tapes

Step 1 of Figure 4 illustrates the sequence by which sentence pairs were transferred from computer and recorded onto audiocassette tape. As mentioned in the previous section, the derived attenuation values were used to adjust each programmable audio-attenuator. Each sentence pair output from the D/A converter was passed through a 5 kHz anti-imaging filter. The sentences were then channeled to the separate programmable audio-attenuators. This adjustment, in turn, equalized the output power level of each sentence. The output from each programmable audio-attenuator was then relayed to the left and right channels of a two-speed cassette tape player/recorder (Tascam-122).

The output data of each sentence were processed at one-half the input rate. It was, therefore, necessary to record the regenerated sentences, simultaneously, onto cassette tape and, subsequently, play these sentences back at twice the recording speed. Step 2 in Figure 4 shows that the sentences were recorded on a Tascam-122 two-speed audiocassette player/recorder and then played back at high speed (i.e., twice the standard speed) and recorded, on line, to a different audiocassette player/recorder (Harman/Kardon TD-392). This recording process was repeated 12 times, for each of the 12 one-half speed tapes, resulting in 12 different master cassettes.

It should be noted here that the same talker sets were transferred first to the master tape, followed by transfer of the different talkers sets. In making the test tapes, the same talker and different talkers sets were copied from the master tape in the order that they were to be presented to that particular subject (eg., a same talker set might have been followed by listening conditions requiring three different talker sets in a row).

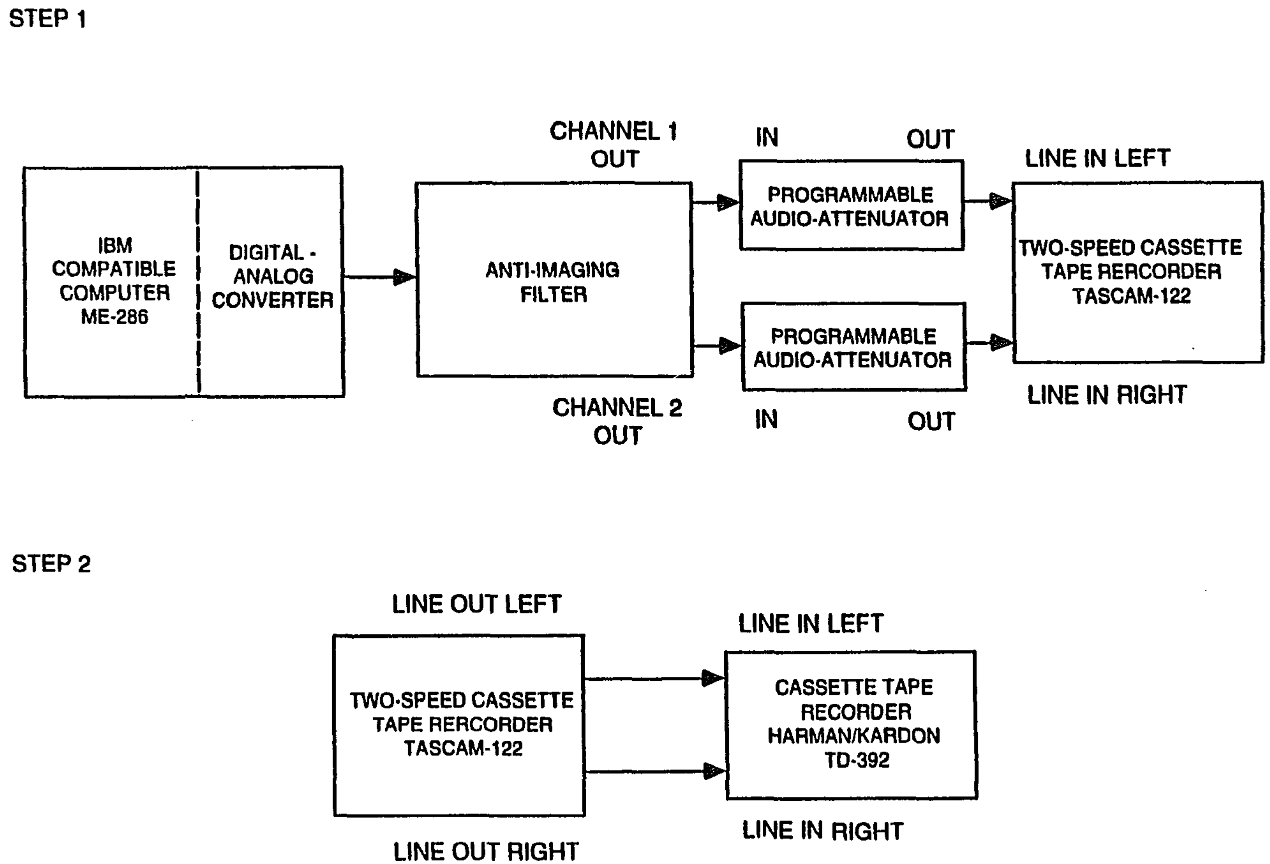

Figure 4. The two step process for transfering the stored sentence material onto cassette tape.

Besides the 12 master test tapes, one additional master tape was prepared. This tape consisted of different sentence material and was recorded for the purpose of: (a) finding a subject's most comfortable listening level and (b) assessing a subject's performance in the control condition.

9. Calibration of Test Tapes and Test Equipment

Several steps were taken to ensure that the test tapes were calibrated. The first step required the recording of a calibration tone onto a metal audiocassette tape. A tone generator (Leader LAG-27) was connected to both line input channels of the two-speed audio cassette recorder (Tascam-122). The tape playback output of these channels, in turn, were connected to an AC voltmeter (Leader LM-181A). With the tape recorder in the record mode, the tone generator and both attenuators of the tape recorder were adjusted until a level of 0 dB on the VU meter of the tape recorder was reached. Fine adjustments of each attenuator were then made until the voltage readings for each channel on the voltmeter were equivalent; this assured that equal intensity signals recorded on both channels would be reproduced with equal intensity. Once this was done the tape was rewound and the tone was recorded at standard speed, for approximately 15 seconds, onto each track of the metal cassette tape.

The second step required the recording of the sentence material onto this metal tape (discussed in Section 8). That is, once the overall intensity of a particular sentence pair had been adjusted each sentence pair was output from the programmable audio-attenuators and recorded onto the metal tape at standard speed.

In the third step, the left and right output channels of the Tascam tape recorder were connected, on line, to the respective input channels of a second audio cassette tape player/recorder (Harman/Kardon TD-392). These channels, in turn, were connected to the AC voltmeter. The recorded 500 Hz tone was played back on the Tascam tape recorder, but now at high speed. With the Harman/Kardon cassette recorder in record mode, the input attenuators were adjusted as done in step one. The calibration tone was then recorded onto the master tape. For recording of the sentence pairs onto the master tape, the output attenuator of the Tascam recorder was adjusted until the speech stimuli were observed to produce peak levels of -5 to 0 dB on the VU-meter of the Harman/Kardon recorder. This setting was then maintained for the rest of the master tapes.

The last step involved copying the recorded material from the master tape onto the test tape. This step was identical with the third step, except that the master tape was played back at regular speed and the same talker and different talkers sets were copied onto the test tape in the order that they would be presented in the experiment.

The equipment used in testing was also calibrated. To ensure that the earphones (TDH-49) were calibrated, an automatic frequency sweep response of each earphone was done. Each earphone was connected to a random sine-wave generator (Bruel & Kjaer, Type 1024), the latter with a reference output level of 1/2 volt RMS. The output from each earphone was delivered to a 6 cc coupler, measured on a sound level meter (Bruel and Kjaer, Type 2203) and printed out using a graphic level recorder (Bruel & Kjaer, Type 2305). The output was approximately 120 dBSPL across the frequencies 250 to 8K Hz, the earphones not differing in their frequency response at any point by more than 1 dB.

The two audio-mixer amplifiers using in testing subjects were calibrated by connecting the outputs of each audio mixer-amplifier to an AC voltmeter (Leader LM-181A) and using the recorded calibration tone on one test tape to adjust the output attenuators of each audio-mixer amplifier until equivalent voltage readings were obtained from each amplifier.

Experimental Design

Subjects were assessed in 13 conditions, one control condition plus 12 test (competing) conditions. Subjects were assessed first in the control condition. Sentences in the control condition were presented diotically, without competing sentences, and varied from 3-14 words in length. The subjects were assessed twice in the control condition. The results in the control condition served as a baseline to which the results from all test conditions, for that particular subject, could be compared (Appendix E lists the sentences recorded in the control condition).

The twelve test conditions consisted of different combinations of the three recall tasks and four listening conditions. The three recall tasks were: (1) selective attention, (2) divided attention, and (3) partial report. For each recall task, the subjects were assessed in the following four listening conditions:

1. Competing sentences differed by talker sex and were presented dichotically; that is, the sentence spoken by the male speaker was presented to one ear, while the sentence spoken by the female

speaker was presented in the other ear (dichotic-different talkers).

2. Competing sentences were spoken by only one talker (the female) and were presented dichotically; that is, one sentence was presented to one ear and the other sentence presented in the other ear (dichotic-same talker).
3. Competing sentences differed by talker sex but were presented monaurally (monaural-different talkers).
4. Competing sentences were spoken by the same talker and presented monaurally (monaural-same talker).

Subjects were assessed twice in each test condition. The order in which subjects were tested was counterbalanced, using a Latin Square design, across all task and listening conditions. In addition, in the selective attention and partial report tasks, where only one sentence was designated as a target, the number of target sentences was equally distributed for right versus left ear. Table 2 summarizes the 12 task x listening conditions.

Table 2. Summary of the twelve test conditions. The twelve conditions consisted of various combinations of the four listening conditions and three recall tasks.

TEST CONDITIONS

LISTENING CONDS.	SA	PR	DA	EAR(S) OF PRESENTATION	SUBJECTS CUED BY *
	RECALL TASKS				
DICHOTIC CONDS.	DT	DT	DT	Alternate ears	Sex only
	ST	ST	ST	Always dichotic	Ear only
MONAURAL CONDS.	DT	DT	DT	Alternate ears	Sex only
	ST	ST	ST	Always monaural	Topic only **

SA = Selective Attention
PR = Partial Report
DA = Divided Attention

DT = Different Talkers
ST = Same Talker

* subjects were cued only in the selective attention and partial report tasks

** information about ear is implicit

Test Equipment

Figure 5 shows a block diagram of the instrumentation used in testing the subjects. Each test tape was played back on an audio cassette player/recorder (Tascam-122). Depending on the test condition, the output from the cassette player were relayed to both earphones or to only one earphone.

The line output from the left channel of the cassette player was relayed, via a Y-splitter, to input one of one audio mixer-amplifier (Coulbourn S82-24) and input one of a second mixer-amplifier. The line output from the right channel of the audio cassette player was relayed similarly to input two of the first mixer-amplifier and input two of the second mixer-amplifier. The output of mixer-amplifier one was transmitted to the left earphone (TDH-49), while the output of mixer-amplifier two was transmitted to the right earphone.

Gates one and two of the first audio mixer-amplifier were connected to inputs two and four of a control box (made specifically for this study); this channeled the output to the left earphone. Gates one and two of the second mixer-amplifier were connected to inputs one and three of the control box, which channeled the output to the right earphone. Inputs one and two, and, inputs three and four of the control box were in contact with separate on/off switches (both of which were grounded). Switch position determined the earphone(s) in which the sentences were heard.

Equipment was also used to automatically turn on/off the tape recorder. An IBM compatible computer (Microtelesis 286-SX) with an enclosed Data Translation Input/Output (I/O) board was connected, via an interface, to the remote control terminal (with built-in integrated circuits) of the Tascam tape recorder. The binary out of the data translation board controlled the on/off switch of the remote control. Analog input to the computer was provided by connecting input two of the second mixer-amplifier, via a Y-splitter, to an anti-aliasing filter. The filter, in turn, was connected to an A/D converter on the I/O board. As long as there was a sufficiently intense analog input the tape recorder continued to play. Once the input value dropped below the designated threshold value the computer, via the I/O board connection to the remote control, shut off the tape recorder. The playback system was reactivated by pressing the "Enter" key on the keyboard. By this means, the subject was able to initiate the playback of each sentence pair.

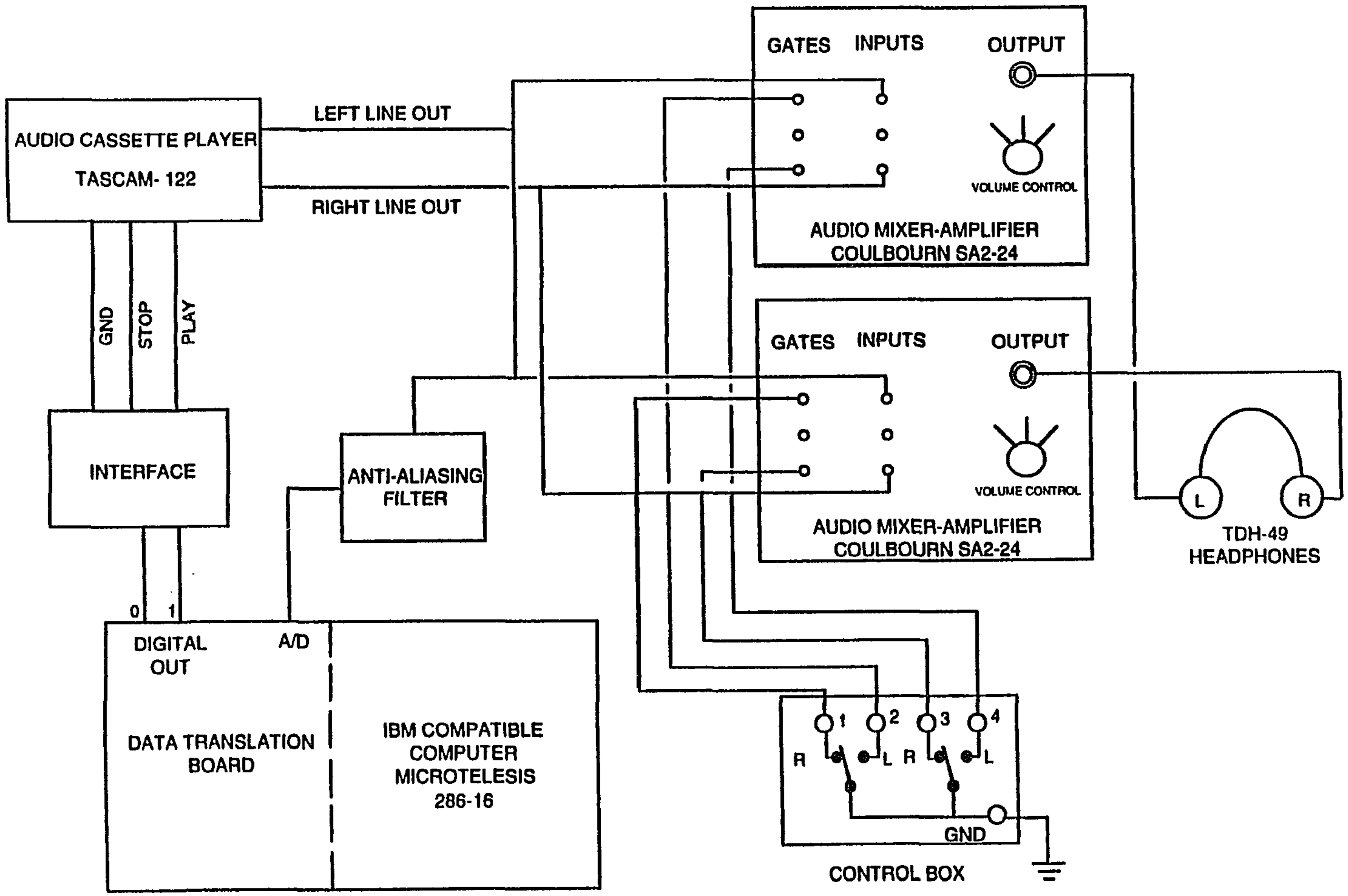

Figure 5. Block diagram of the equipment used in presenting the sentence stimuli to the subjects.

Test Procedure

All testing occurred in an Industrial Acoustics Company single-walled sound treated suite (Model #404-ACT). The subject's most comfortable listening level (MCL) was determined first, using the method of adjustment. Five sentences, 13 to 14 words long, recorded by the female talker were presented diotically. Subjects were asked to vary the output attenuator of the cassette player (Tascam-122) until they felt that the listening level was comfortable. Since the levels of these sentences were equal to those in the control and test sentences, all subsequent presentations were at the subject's MCL.

The subjects were assessed next in the control condition. The subjects were told that: (a) they would be listening to a female talker presenting a sentence to both ears, (b) the talker would present a number of sentences and that the sentences would vary in length, and (c) they should repeat as much of each sentence as possible. The subjects were given two trials.

In the test conditions, the subjects were told that they would hear two competing sentences. Depending on the particular test condition, the subjects were told that they would hear the sentences monaurally/binaurally (if monaurally, in which ear) and whether they would hear one or two talkers. The subjects were then told to repeat as many words as possible from the target sentence in the selective attention or partial report tasks or to repeat as many words from both sentences in the divided attention task.

In the selective attention and partial report tasks, the examiner cued the subject as to which sentence was to be recalled. The cues were presented on cards. Table 2 lists the cues used in each of these test conditions. In the selective attention task, the cue card was shown before sentence presentation, while in the partial report task the cue card was shown after the presentation. No cue cards were used in the divided attention task since the subject was required to recall both sentences.

The examiner had copies of all test sentences. After each test item, the examiner circled the words that the subject had repeated correctly. A Sharpe audio cassette tape recorder (RD-688AV) was also used to tape all subjects' responses for later verification.

CHAPTER 4: RESULTS

Subjects received two trials in both the control condition and in all 12 test conditions (i.e., three recall tasks x four listening conditions). The number of words correctly recalled for each sentence length, plus the number of words incorrectly inserted from the competing sentence, are shown in Appendix F. In addition, the total scores and the means (expressed in percentage), summed across sentence lengths, are shown.

For the purpose of this study replication was not an experimental variable, hence, for all subsequent analyses scores have been combined across the two trials for the purpose of deriving a measure of average performance in each test condition.

Appendix F shows that each subject in the control condition achieved perfect or near perfect performance across all sentence lengths. Only two subjects made any errors, the errors occurring in sentences of 12 words or longer. Hence, in the absence of competing messages most subjects were able to recall sentences perfectly, regardless of sentence length.

The raw data in each test condition were then averaged across subjects, the group means shown in Table 3. It should be noted that three recall task scores are indicated for divided attention: (1) divided attention- first sentence reported, (2) divided attention- second sentence reported, and (3) mean of first and second sentences reported on the divided attention task.

Only three means are shown for sentence length. Calculations of the means for all twelve sentence lengths in each test condition showed that although the means generally decreased with increased sentence length there was much variability from one length to another. In an attempt to smooth out the variability, this examiner arbitrarily reduced the number of sentence lengths from 12 to 3. For this and subsequent sections the newly defined sentence lengths were labeled as:

1. Short (sentences 3 to 6 words long)
2. Medium (sentences 7 to 10 words long)
3. Long (sentences 11 to 14 words long)

Subjects' scores for the three designated sentence lengths were calculated by adding the total number of words correctly recalled by a subject over the four sentence lengths of each sentence length category and then dividing this sum by the maximum number of words that could have been recalled. Individual scores as well as the group means, standard deviations, and standard errors for all three sentence lengths in each test condition are shown in Appendix G.

Table 3. The mean percentage of words correctly recalled, collapsed over subjects, for short (3-6 words), medium (7-10 words) and long sentences (11-14 words) in all twelve test conditions.

TASK	PRESEN-TATION	TALK-ERS	3-6 WORDS	7-10 WORDS	11-14 WORDS	ALL SENTENCES
SELECTIVE ATTENTION	MONAURAL	SAME	74.1	69.5	65.0	68.1
		DIFF	88.2	94.1	94.7	93.6
	DICHOTIC	SAME	98.4	99.9	99.2	99.3
		DIFF	98.6	99.8	98.8	99.1
		MEAN	89.8	90.8	89.4	90.0
PARTIAL REPORT	MONAURAL	SAME	71.3	58.8	56.1	59.7
		DIFF	78.5	75.5	65.5	71.1
	DICHOTIC	SAME	95.6	86.9	84.5	87.3
		DIFF	93.5	94.1	84.8	89.5
		MEAN	84.7	78.8	72.7	76.9
DIVIDED ATTENTION FIRST SENTENCE	MONAURAL	SAME	88.2	76.5	76.1	78.4
		DIFF	94.2	86.8	80.6	85.1
	DICHOTIC	SAME	98.4	95.7	89.2	93.0
		DIFF	98.6	95.7	86.6	91.8
		MEAN	94.9	88.7	83.1	87.1
DIVIDED ATTENTION SECOND SENTENCE	MONAURAL	SAME	50.5	34.2	30.7	35.2
		DIFF	62.3	58.6	42.4	51.4
	DICHOTIC	SAME	96.8	84.4	62.3	75.7
		DIFF	90.3	78.6	64.3	73.7
		MEAN	75.0	64.0	49.9	59.0
MEAN OF DIVIDED ATTENTION TASKS	MONAURAL	SAME	69.4	55.4	53.4	56.8
		DIFF	78.3	72.7	61.5	68.3
	DICHOTIC	SAME	97.6	90.1	75.8	84.4
		DIFF	94.5	87.2	75.5	82.8
		MEAN	85.0	76.4	66.5	73.0

Table 3. Continued

TASK	PRESEN-TATION	TALK-ERS	3-6 WORDS	7-10 WORDS	11-14 WORDS	ALL SENTENCES
MEAN OF ALL TASKS	MONAURAL	SAME	71.0	59.8	56.7	60.4
		DIFF	80.8	78.8	70.8	75.3
	DICHOTIC	SAME	97.3	91.7	83.8	88.8
		DIFF	95.3	92.1	83.6	88.5
		MEAN	86.1	80.7	73.7	78.3

A three-way repeated measures analysis of variance (listening condition x recall task x sentence length) was carried out to examine the significance, if any, between the means in the different test conditions. Because divided attention average scores were derived from the average of divided attention #1 and divided attention #2 scores, they could not be included in the same analysis of variance since this would have violated the assumption of independence. Thus, two separate analyses were done. Table 4a includes the analysis of variance results when selective attention, partial report, divided attention #1 (i.e., the first sentence reported on the divided attention task) and divided attention #2 (i.e., the second sentence reported on the divided attention task) scores were included. Table 4b includes selective attention, partial report and divided attention average scores (i.e., the mean of divided attention #1 and #2). The data were transformed using the arcsine transform to increase the homogeneity of variance. Any 0% and 100% values were adjusted using Bartlett's technique (Kirk, 1984).

Tables 4a and 4b show that all main effects and interactions exceeded statistical significance at the .005 level. In the following sections, the results from various analyses as they relate to each main effect and interaction will be discussed. Unless specified, all results mentioned pertain to analyses in which divided attention #1 and #2 scores were included.

Table 4a. Three-way repeated measures analysis of the variance in the arcsine data (divided attention #1 and #2 scores included). The main effects were listening condition (monaural-same talker, monaural-different talkers, dichotic-same talker and dichotic-different talkers), recall task (selective attention, partial report, divided attention #1, and divided attention #2) and sentence length (short, medium, and long).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
LISTCOND (L)	16.4859	3	5.4953	117.84	<0.0001
ERROR	1.5389	33	0.0466		
RECALL (R)	13.9126	3	4.5375	107.49	<0.0001
ERROR	1.3931	33	0.0422		
SENTLEN (S)	3.4503	2	1.7252	130.60	<0.0001
ERROR	0.2906	22	0.0132		
L x R	1.5634	9	0.1737	10.36	<0.0001
ERROR	1.6600	99	0.0168		
L x S	0.3760	6	0.0627	5.08	0.0002
ERROR	0.8135	66	0.0123		
R x S	1.4441	6	0.2407	16.69	<0.0001
ERROR	0.9518	66	0.0144		
L x R x S	0.5700	18	0.0317	2.60	0.0006
ERROR	2.4131	198	0.0122		

Table 4b. **Three-way repeated measures analysis of the variance in the arcsine data (divided attention average scores included). The main effects were listening condition (monaural-same talker, monaural-different talkers, dichotic-same talker and dichotic-talkers), recall task (selective attention, partial report and divided attention average) and sentence length (short, medium, and long).**

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
LISTCOND (L)	12.8017	3	4.2672	124.23	<0.0001
ERROR	1.1336	33	0.0344		
RECALL (R)	5.3267	2	2.6633	103.30	<0.0001
ERROR	0.5672	22	0.0258		
SENTLEN (S)	1.6193	2	0.8097	85.81	<0.0001
ERROR	0.2076	22	0.0094		
L x R	0.6667	6	0.1111	10.15	<0.0001
ERROR	0.7226	66	0.0110		
L x S	0.3049	6	0.0508	5.36	0.0001
ERROR	0.6252	66	0.0095		
R x S	0.9148	4	0.2287	20.54	<0.0001
ERROR	0.4898	44	0.0111		
L x R x S	0.2896	12	0.0241	2.71	0.0026
ERROR	1.1735	132	0.0089		

<u>The main effect of listening condition</u>

The group means and standard errors for each listening condition, collapsed across recall task and sentence length, are shown in Table 5 and illustrated in Figure 6. The added presence of the spatial and/or talker cues clearly enhanced performance. Relative to the monaural-same talker condition, the mean improvement was approximately 28 percentage points in either dichotic listening condition and 15 percentage points in the monaural-different talkers condition. Yet, even in the absence of both spatial and talker cues, subjects were able to correctly recall more than 60% of the words from the target sentence.

Results from the three-way repeated measures analysis of variance revealed that the main effect of listening condition was highly significant (p <0.0001). Post-hoc testing, using the Tukey procedure for pair-wise comparisons, was then performed to determine the significance of differences among the arcsined means. These results are shown in Table 6. The group means for each listening condition were significantly different from each other at the .01 level, except for the two dichotic listening conditions which were not significantly different from each other. Subjects performed significantly better in the dichotic conditions than in either monaural condition. In fact, the addition of the talker cue when the dichotic cue was already present, provided no additional enhancement. In the absence of the spatial cue, however, the addition of the talker cue did improve performance, although not as dramatically as the addition of the spatial cue.

Table 5. Group means for each listening condition, collapsed across recall task and sentence length. In addition, with the monaural-same talker condition serving as the baseline, this table shows the percentage points benefit derived as spatial and/or talker cues were added.

Listening Condition	Means in %	Percentage Points Benefit
Monaural-same talker	60.4	----
-different talkers	75.3	14.9
Dichotic-same talker	88.8	28.4
-different talkers	88.5	28.1

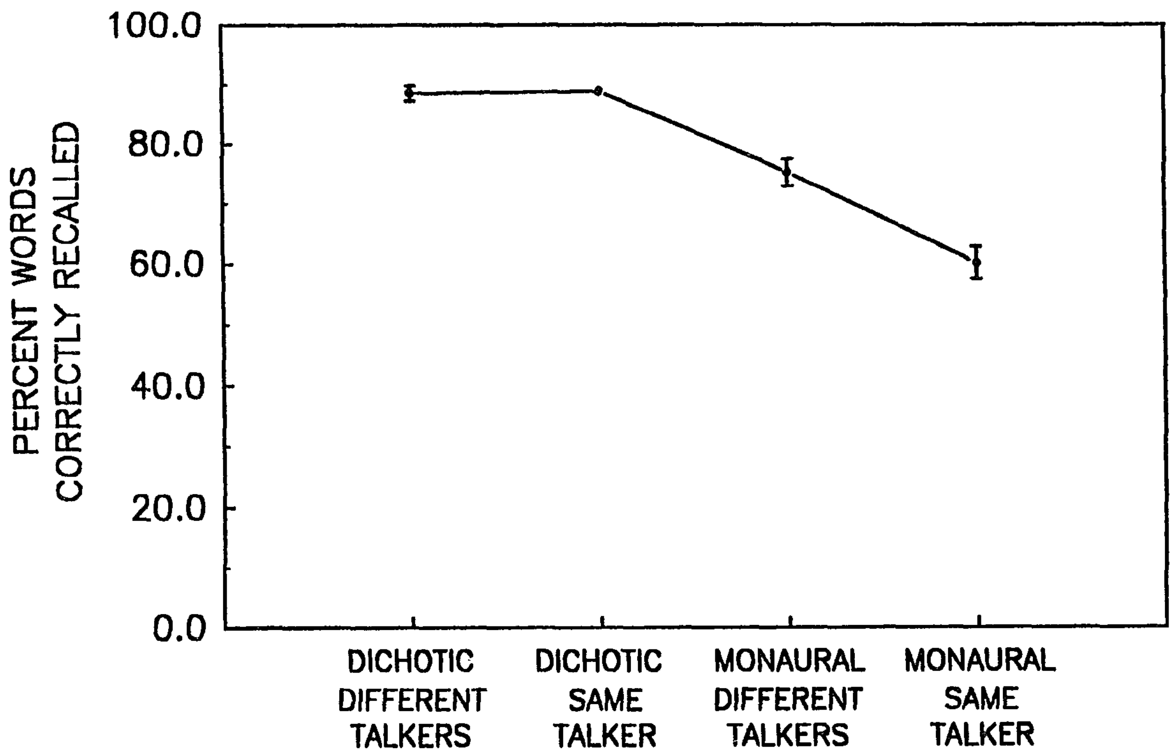

Figure 6. Group means and associated standard errors in all four listening conditions, collapsed across recall task and sentence length.

Table 6. Post-hoc analysis, using the Tukey procedure of pair-wise comparisons, for determining the significance of differences among arcsined means for the main effect of listening condition.

Key: M-S = Monaural-same talker
M-D = Monaural-different talkers
D-S = Dichotic-same talker
D-D = Dichotic-different talkers
CVT = Critical Value Tukey

	D-D	D-S	M-D	M-S
D-D		.005ns	.191**	.380**
D-S			.186**	.375**
M-D				.189**
M-S				

$CVT_{.05}$ = 0.063
$CVT_{.01}$ = 0.078

The main effect of recall task

The group means and standard errors for each recall task, collapsed across listening condition and sentence length, are shown in Table 7 and illustrated in Figure 7. Tables 4a and 4b showed that the main effect of recall task was highly significant ($p<0.0001$).

Post-hoc testing using the Tukey procedure was then performed, the results shown in Table 8. All means were significantly different from each other at the .01 level, except for the comparison of divided attention average and partial report which was significantly different at the .05 level. It will be seen that subjects performed:
(a) best on the selective attention task, (b) better on divided attention #1 than on partial report, and in turn, significantly better on partial report than on divided attention average, and (c) significantly poorer on the divided attention #2 task than on all other tasks.

Table 7. Group means for each recall task, collapsed across listening condition and sentence length. The relative performance for all recall tasks are shown, with mean performance in selective attention serving as the reference.

	Means in %	Percentage Points Drop
Selective Attention	90.0	----
Divided Attention #1	87.1	2.9
Partial Report	76.9	13.1
Mean of Divided Attention Tasks	73.0	17.0
Divided Attention #2	59.0	31.0

Table 8. Post-hoc analysis, using the Tukey procedure of pair-wise comparisons, for determining the significance of differences among arcsined means for the main effect of recall task.

Key:
- SA = Selective Attention
- PR = Partial Report
- DIV1 = Divided Attention #1
- DIV2 = Divided Attention #2
- DIVA = Divided Attention Average
- CVT = Critical Value Tukey

	SA	DIV1	PR	DIV2
SA		.108**	.236**	.445**
DIV1			.128**	.337**
PR				.209**
DIV2				

$CVT_{.05} = 0.063$
$CVT_{.01} = 0.078$

	DIVA
SA	.291**
PR	.049*
DIVA	

$CVT_{.05} = .044$
$CVT_{.01} = .057$

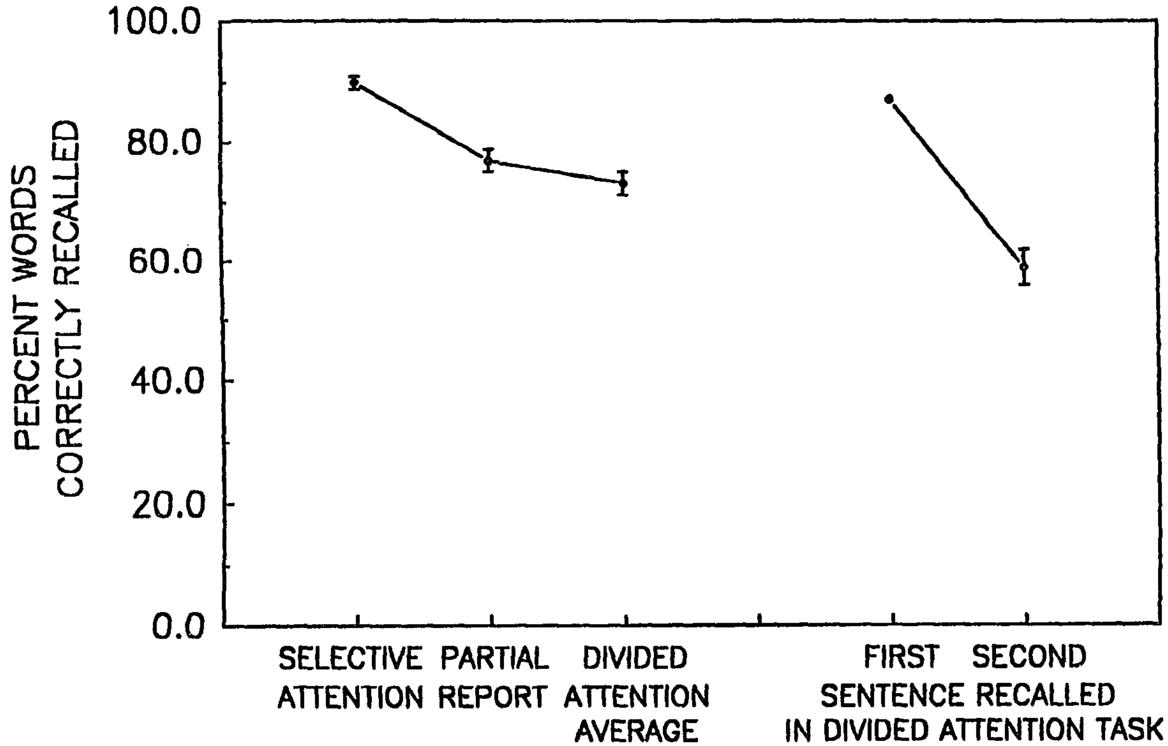

Figure 7. Group means and associated standard errors in all three recall tasks, collapsed across listening condition and sentence length. Three scores are shown for divided attention (first sentence recalled, second sentence recalled, and the average of the first and second sentences recalled).

The main effect of sentence length

The group means and standard errors for each sentence length, collapsed over listening condition and recall task, are shown in Figure 8. Table 4a showed that the main effect of sentence length was highly significant ($p<0.0001$). Post-hoc testing (Table 9) shows that only the comparison between mean performance on short versus long sentences was significantly different from each other ($p<.01$). This suggests that subjects' overall ability to correctly recall words from the target sentence(s) diminished gradually as sentence length was increased.

Table 9. Post-hoc analysis, using the Tukey procedure of pair-wise comparisons, for determining the significance of differences among arcsined means for the main effect of sentence length.

Key: CVT = Critical Value Tukey

	Short	Medium	Long
Short		.073ns	.158**
Medium			.085ns
Long			

$CVT_{.05} = 0.117$
$CVT_{.01} = 0.154$

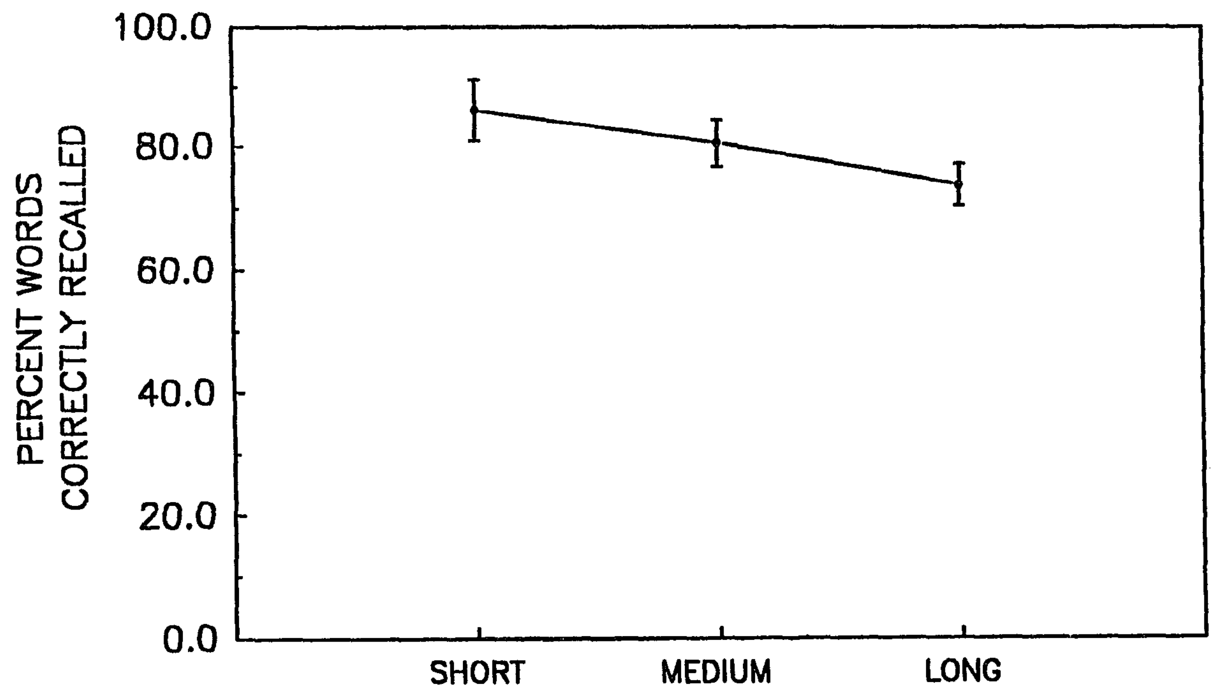

Figure 8. Group means and associated standard errors for all three sentence lengths, collapsed across listening condition and recall task.

<u>The interaction of listening condition and recall task</u>

Figures 9a (divided attention #1 and #2 scores included) and 9b (divided attention average scores included) show the group means for recall task as a function of listening condition, while Figure 9c shows the group means for listening condition as a function of recall task. It will be seen from Tables 4a and 4b that listening condition interacted significantly with recall task (p<.0001 in both tables).

Separate one-way repeated measures analyses of the variance in the arcsine data were then carried out in order to examine the significance, if any, between the means of one main effect at each level of the second main effect (i.e., tests of simple main effects). The results are summarized in Appendix H (Tables H1 and H2). The main effect of recall task was significant at each level of listening condition (at least at the .0003 level), while the main effect of listening condition was significant at all levels of recall task (p<.0001) .

Post-hoc testing, using the Tukey procedure, was then carried out at each level of both main effects. The results are shown in Appendix H (Tables H3 and H4). In

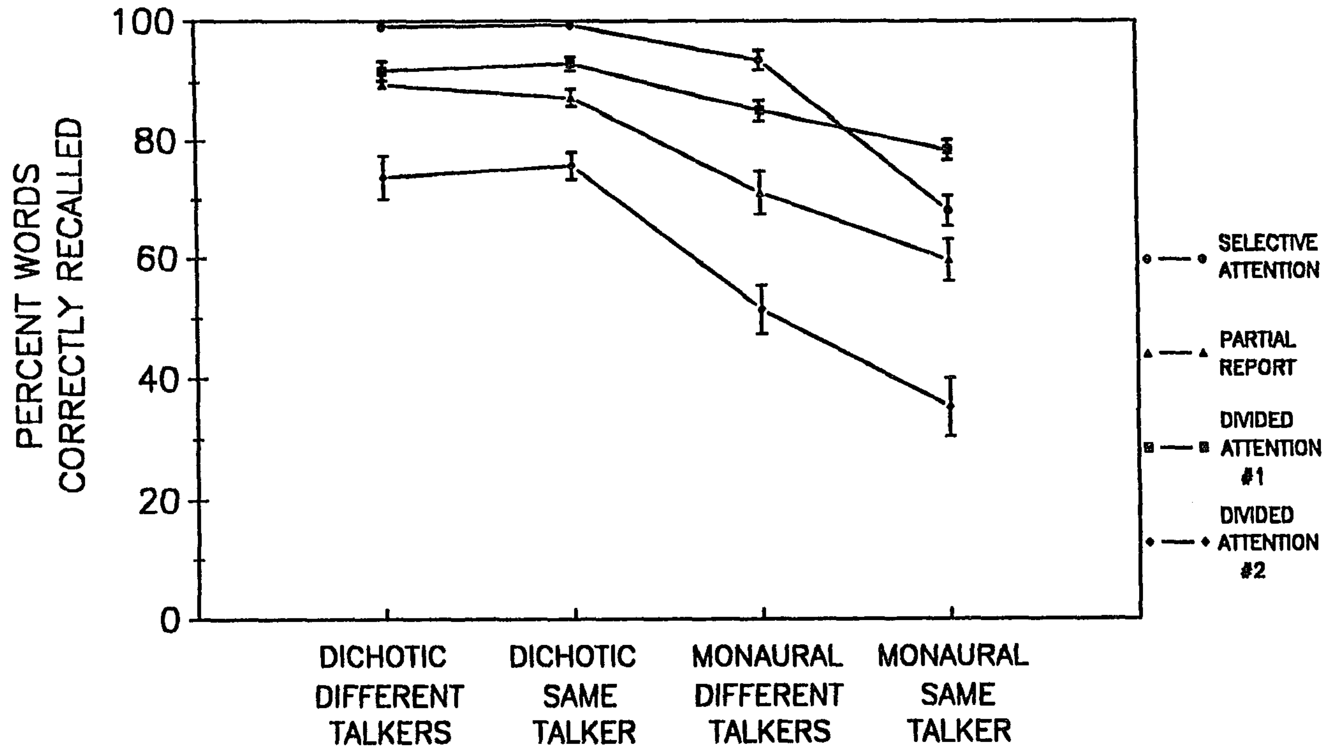

Figure 9a. Group means and associated standard errors in all four listening conditions as a function of recall task (divided attention #1 and #2 scores included). Scores were collapsed over sentence length.

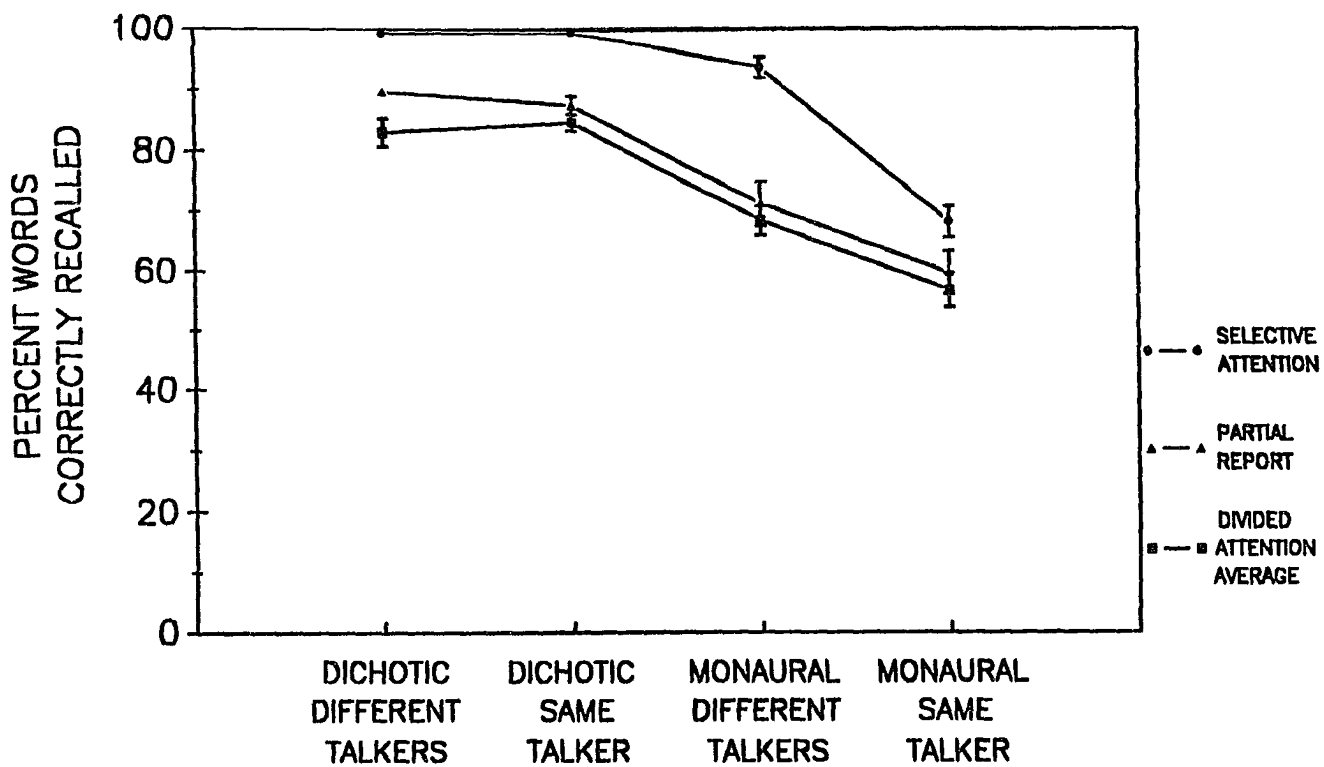

Figure 9b. Group means and associated standard errors in all four listening conditions as a function of recall task (divided attention average scores included). Scores were collapsed over sentence length.

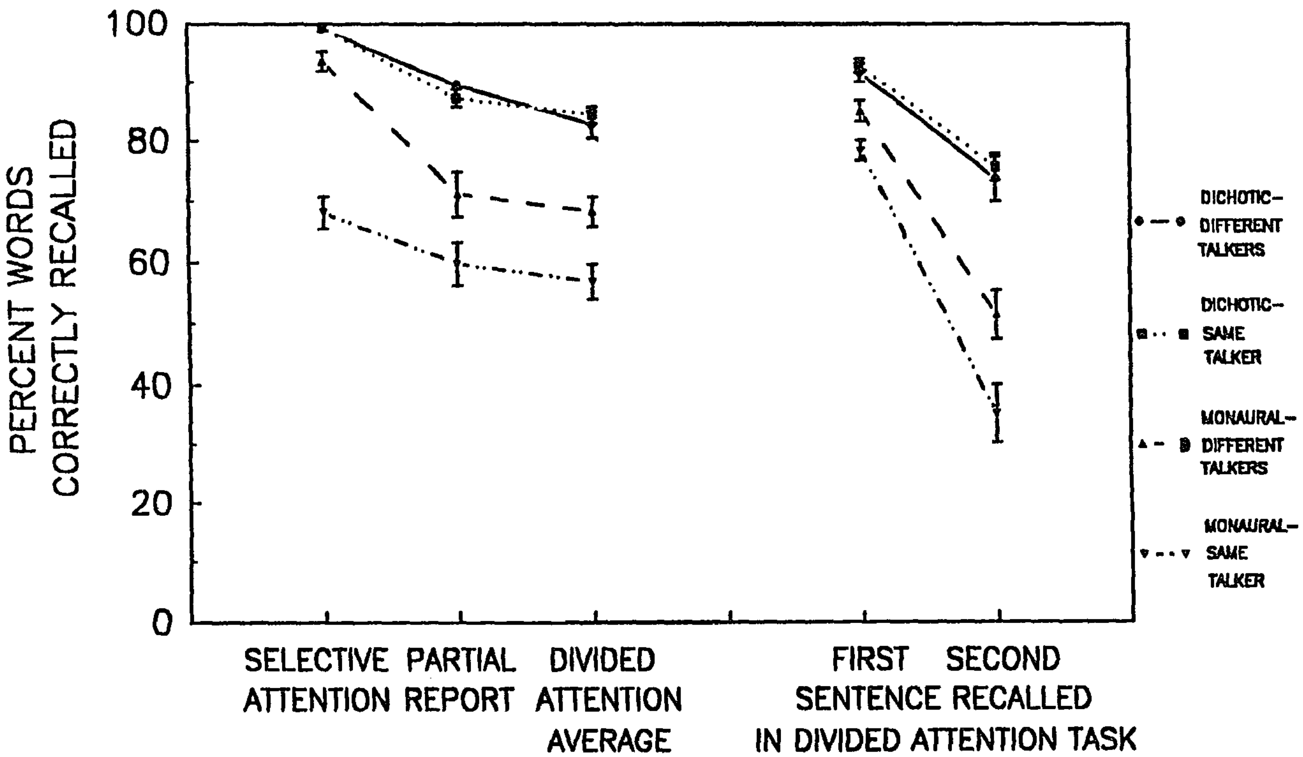

Figure 9c. Group means and associated standard errors in all three recall tasks as a function of listening condition. Scores were collapsed over sentence length.

respect to listening conditions subjects performed significantly better on selective attention than on all other tasks, except in the monaural-same talker condition where subjects performed best on the divided attention #1 task. In all listening conditions, except monaural-same talker, subjects performed significantly better on selective attention than on partial report ($p < .01$). Subjects did not perform significantly different on these two recall tasks in the monaural-same talker condition.

Subjects performed similarly on divided attention #1 and partial report in the dichotic-different talkers condition. When cues were removed, performance dropped more on partial report than on divided attention #1, the discrepancy in scores being greatest in the monaural-same talker condition.

Performance was similar on partial report and divided attention average in all listening conditions, except for the dichotic-different talkers condition in which subjects performed significantly better on partial report ($p < .01$).

Subjects performed significantly better on divided attention #1 than on divided attention #2 across all listening conditions, the magnitude of the difference being greatest in the monaural listening conditions (especially in the monaural-same talker condition).

Divided attention #2 performance was significantly worse than on all other recall tasks.

In respect to recall tasks, a consistent pattern of performance was observed. Regardless of recall task:

1. Mean performance in each dichotic listening condition was significantly higher than in either monaural condition.
2. Dichotic-different talkers and dichotic-same talker means were not significantly different from each other. That is, when the target and competition were assigned to different ears the addition of talker differences did not significantly enhance performance. Note that in only the selective attention task were the group means close to ceiling levels (i.e., 100%). Hence, a ceiling effect cannot account for the similarity in performance in both dichotic listening conditions on the other recall tasks.
3. Subjects performed significantly better in the monaural-different talkers condition than in the monaural-same talker condition on all recall tasks. Adding the talker cue did improve performance, relative to the monaural-same talker condition, but

to a significantly less degree than when the spatial cue was added.

The Interaction of Listening Condition and Sentence Length

Figure 10a shows the mean performance for each listening condition at each sentence length, while Figure 10b shows mean performance for each sentence length as a function of listening condition. Table 4a showed that the interaction of listening condition and sentence length was highly significant ($p<.001$).

The results from tests of simple main effects are summarized in Appendices I1 and I2. The main effect of sentence length was highly significant ($p<.0001$) in each listening condition, while the main effect of listening condition was highly significant ($p<.0001$) at each sentence length. Post-hoc testing, using the Tukey procedure (Appendix I3 and I4), shows that the group means for dichotic-different talkers and dichotic-same talker listening conditions were not significantly different from each other, regardless of sentence length. Note that in both listening conditions, subjects recalled more than 95% of the words correctly from the target sentence(s) at short

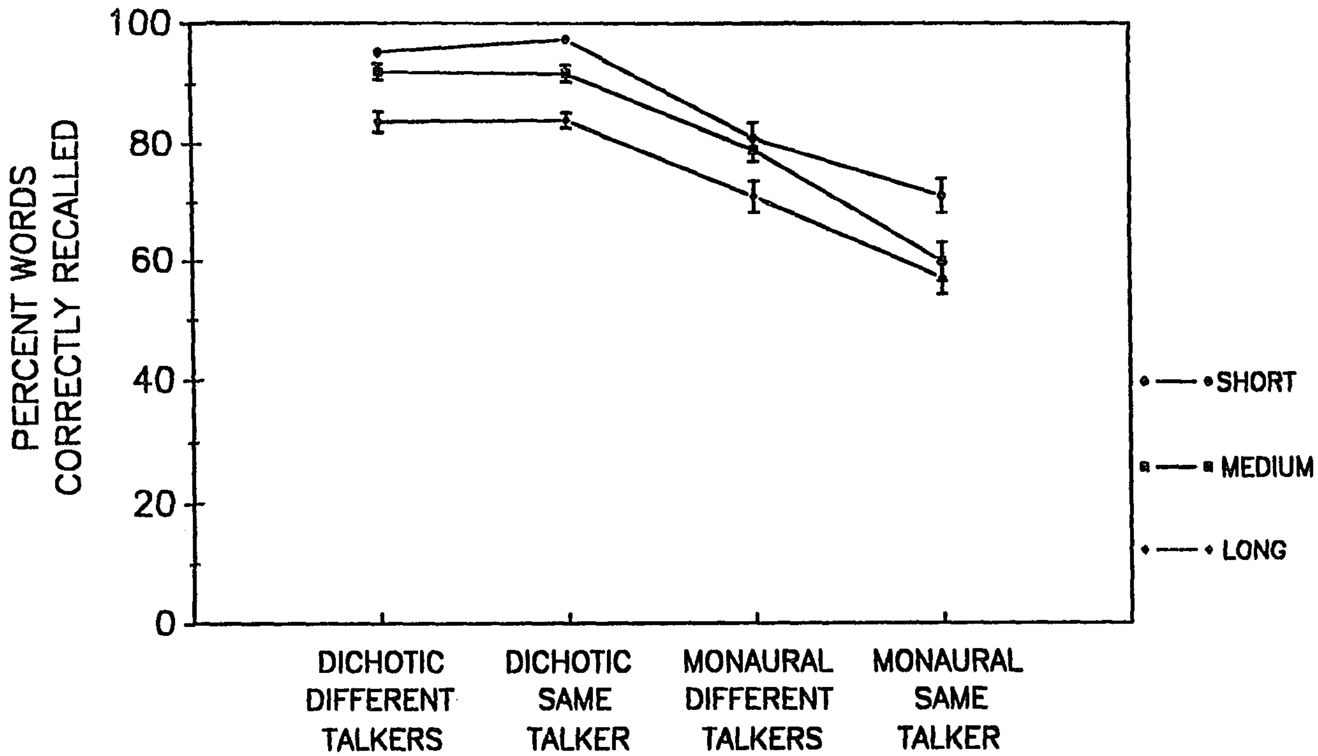

Figure 10a. Group means and associated standard errors in all four listening conditions as a function of sentence length. Scores were collapsed over recall task.

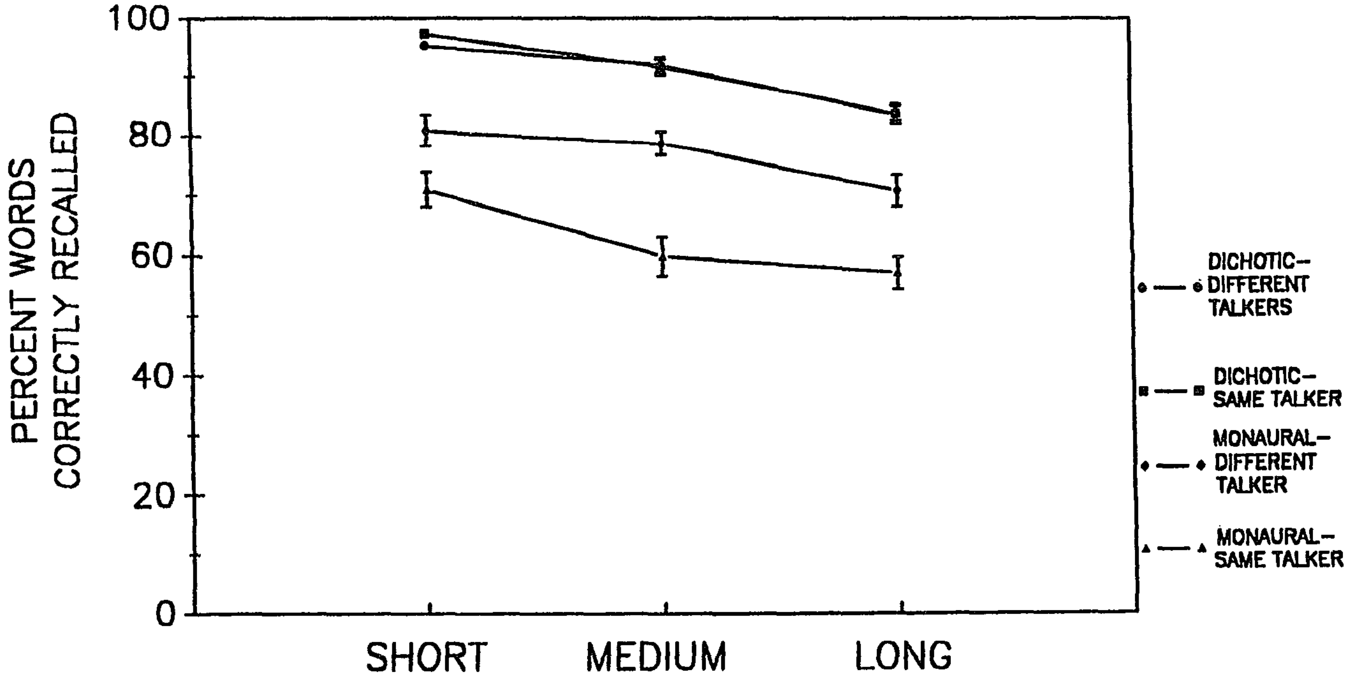

Figure 10b. Group means and associated standard errors at all three sentence lengths as a function of listening condition. Scores were collapsed over recall task.

sentence length. Although performance decreased significantly with each subsequent increase in sentence length ($p<.01$), subjects were still able to recall more than 83% of the words correctly, even on long sentences, when the spatial cue was present.

Regardless of sentence length, subjects performed significantly better in both dichotic listening conditions than in either monaural listening condition ($p<.01$) and significantly better in the monaural-different talkers condition than in the monaural-same talker condition ($p<.01$). In the monaural-different talkers condition, subjects achieved similar mean scores at short and medium sentence length. Performance on both of these sentence lengths was significantly better ($p<.01$) than that achieved on long sentences. This pattern contrasts to that observed in the monaural-same talker condition, whereby, subjects performed significantly better ($p<.01$) on short sentences than on medium and long sentences and similarly on medium and long sentences.

The Interaction of Recall Task and Sentence Length

Figure 11a shows the mean performance for each recall task as a function of sentence length, whereas, Figure 11b (divided attention #1 and #2 scores included) and Figure 11c (divided attention average scores included), show mean performance for each sentence length as a function of recall task. Tables 4a and 4b showed that the interaction of recall task and sentence length was highly significant ($p<.0001$).

Tests of simple main effects were carried out, the results summarized in Appendices J1 and J2. The main effect of recall task was highly significant at each sentence length (at least at the .0004 level), while the main effect of sentence length was highly significant ($p<.0001$) in each recall task, except in selective attention where no significant difference between the means were observed as a function of sentence length. Post-hoc testing, using the Tukey procedure, was then carried out at each level of both main effects (Appendix J3 and J4). The results show that performance on the selective attention task did not drop off significantly as a function of sentence length. Hence, differences in performance on this task was due primarily to differences in listening

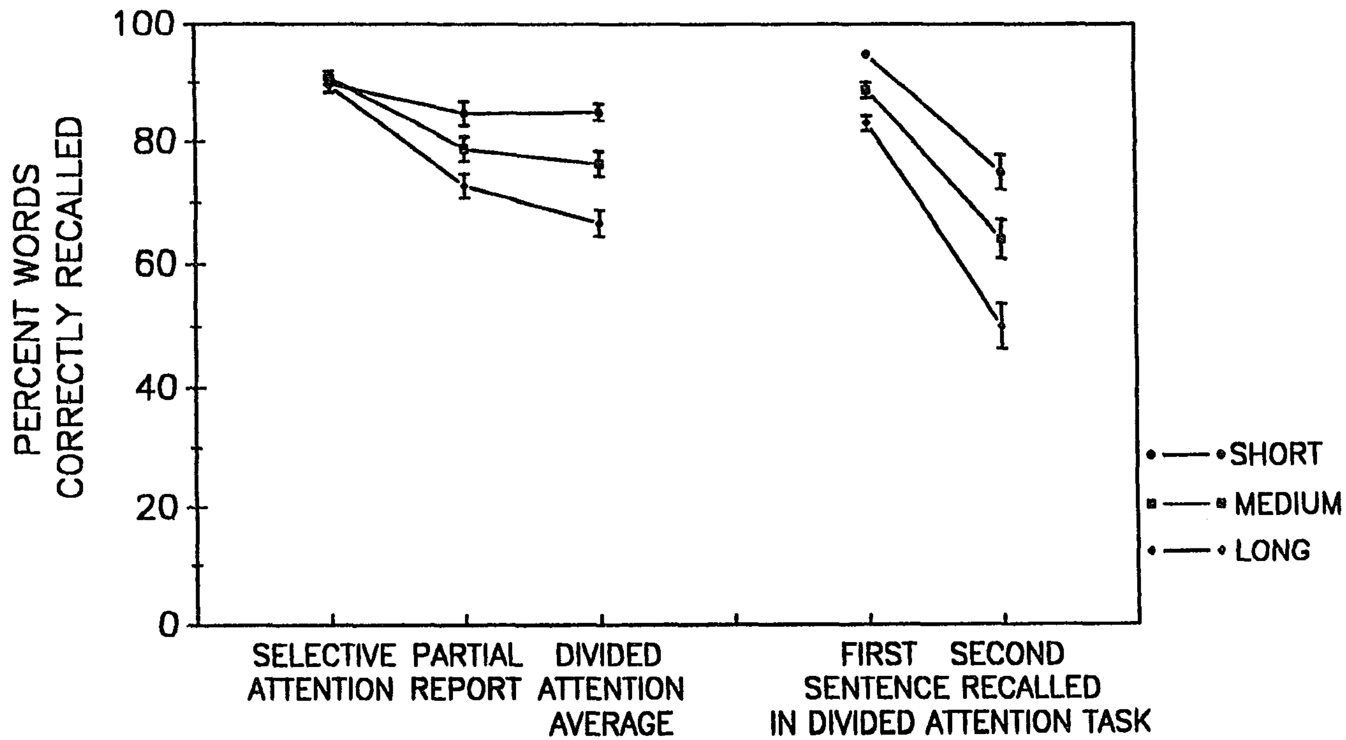

Figure 11a. Group means and associated standard errors in all three recall tasks as a function of sentence length. Scores were collapsed over listening condition.

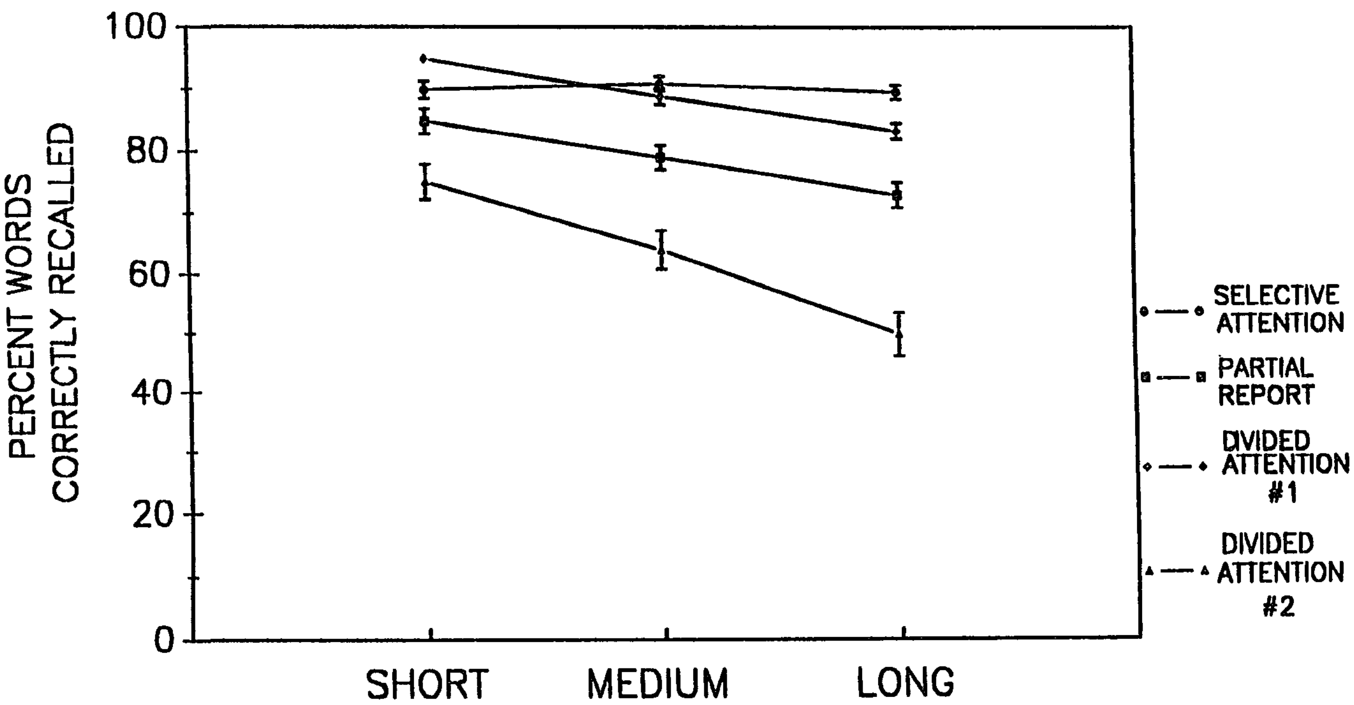

Figure 11b. Group means and associated standard errors at all three sentence lengths as a function of recall task (divided attention #1 and #2 scores included). Scores were collapsed over listening condition.

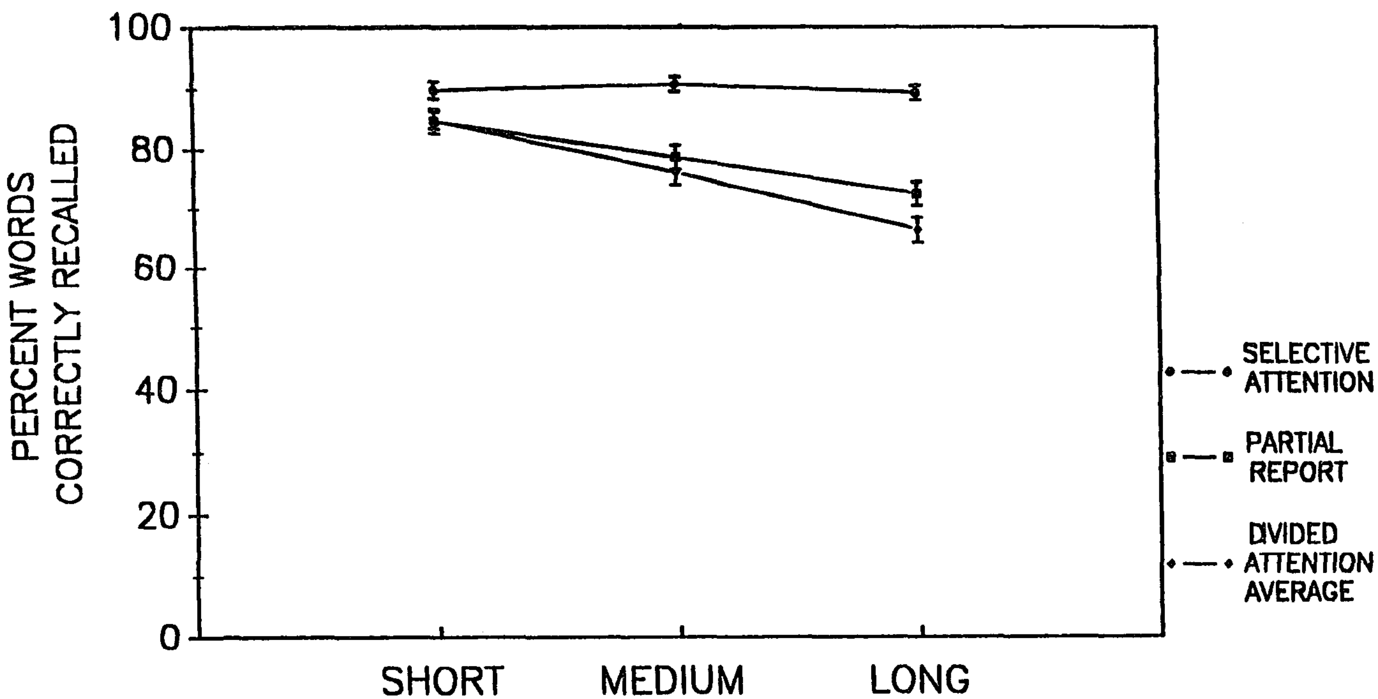

Figure 11c. Group means and associated standard errors at all three sentence lengths as a function of recall task (divided attention average scores included). Scores were collapsed over listening condition.

condition and not sentence length. However, on all other recall tasks scores dropped off significantly as sentence length increased ($p<.01$).

At short sentence length, subjects performed significantly better on divided attention #1 than on all other tasks. At medium sentence length, subjects performed similarly on selective attention and divided attention #1, the scores on these two tasks being significantly better than on the other recall tasks ($p<.01$). Increasing the sentence length further to long sentences resulted in subjects performing significantly better on selective attention than on divided attention #1 ($p<.01$), a finding contrasting with that observed at short sentence length. Performance on these two tasks at long sentence length, in turn, were significantly better than on any other recall task ($p<.01$).

At short sentence length, subjects performed similarly on the selective attention and partial report tasks (although there appears to be a trend toward significance in favor of selective attention). As sentence length was increased, subjects performed significantly better on the selective attention task at both medium and long sentence lengths ($p<.01$).

There was no significant difference in performance between partial report and divided attention average at short and medium sentence lengths but there was a significant difference in performance at long sentence length, in favor of partial report ($p<.01$).

Subjects performed significantly worse on divided attention #2 across all sentence lengths than on any other recall task ($p<.01$).

The Interaction of Listening Condition, Recall Task, and Sentence Length

Tables 4a (divided attention #1 and #2 scores included) and 4b (divided attention average scores included) showed that the three way interaction of listening condition x recall task x sentence length was significant at the .0006 and .0026 levels, respectively. Separate two-way repeated measures analyses of the variance, in the arcsine data, were carried out at each level of the third factor, the results shown in Appendix K. Companion graphs to each of these analyses are shown in Figures 12-14. The key findings are summarized in the following sections.

Listening Condition

Appendix K shows that the two-way interactions of recall task x sentence length were highly significant in all listening conditions ($p<.0001$), except in the monaural-same talker condition where the interactions were not significant.

It will be seen from Figure 12 that subjects performed similarly in both dichotic listening conditions, irrespective of recall task and sentence length (except on the partial report task for medium sentence length where subjects performed better in the dichotic-different talkers condition). It can also be seen that subjects in these listening conditions achieved scores of over 90% on all recall tasks at short sentence length. Hence, even on the divided attention task, subjects were able to process and recall both sentences very easily. In fact, at medium sentence length, subjects were still able to recall more than 85% of the words from both sentences when the spatial cue was present. In the monaural-different talkers condition, subjects maintained their level of performance on partial report, divided attention #2, and divided attention average tasks as sentence length was increased from short to medium length. Performance on these tasks dropped only when sentence length was increased from medium

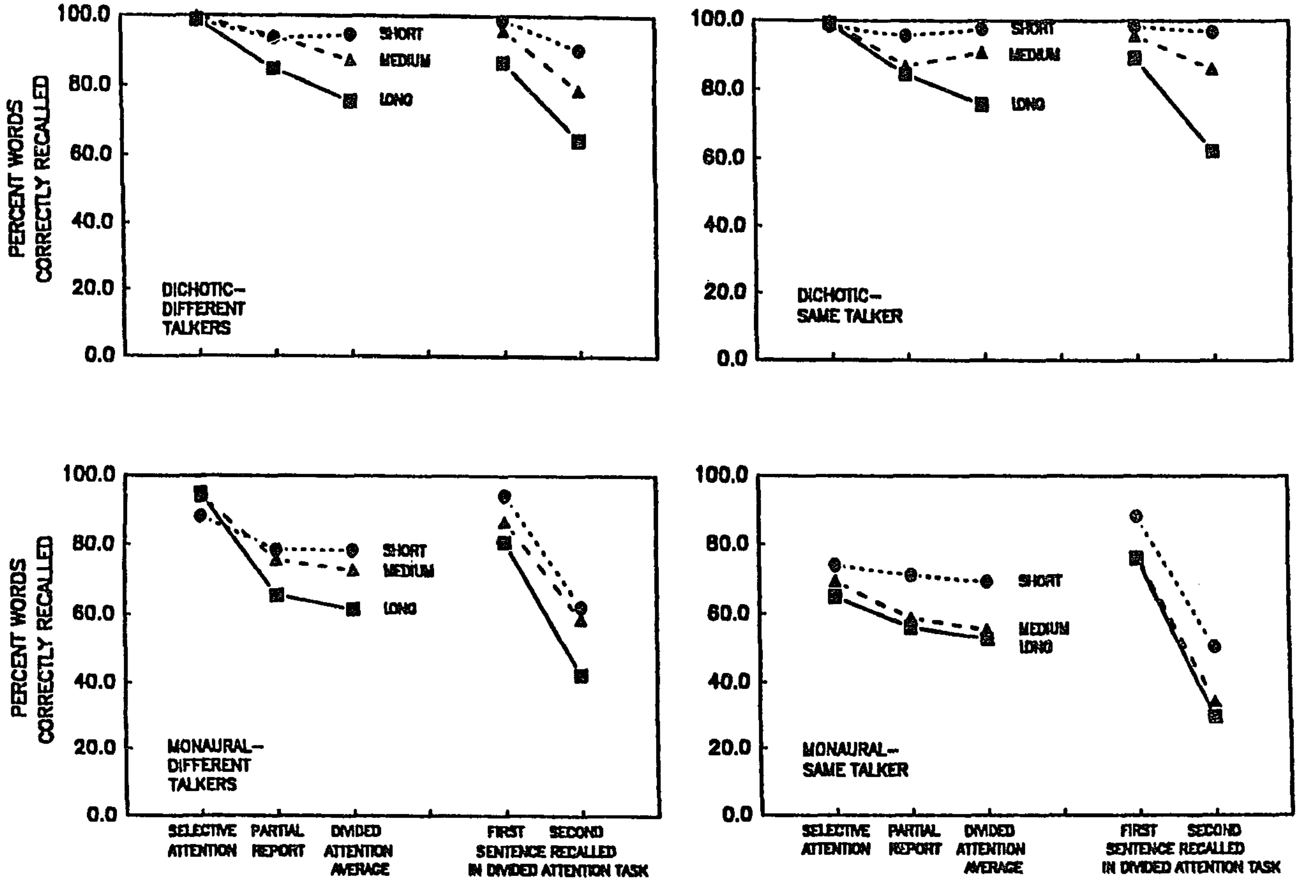

Figure 12. Group means for all four listening conditions as a function of recall task and sentence length.

to long sentences. This contrasts with the pattern observed in the monaural-same talker condition; that is, subjects performed significantly better on these recall tasks for short sentences than on medium and long sentences. In the monaural-same talker condition, subjects performed similarly on the selective attention and partial report tasks. One-way repeated measures analyses of variance in the arcsine data were carried out for the purpose of comparing performance on these two recall tasks at each sentence length. Table 10 summarizes these findings. There were no significant differences between selective attention and partial report performance at short and medium sentence length, although a trend to significance was noted for medium sentences (i.e., $p=.058$). A significant difference, in favor of selective attention, was found only when long sentences were presented ($p<.05$).

Recall Task

Two-way interactions involving listening condition x sentence length task were significant, at least at the .05 level, on almost all recall tasks except for divided attention #1 where the interaction of listening condition x sentence length was not significant.

Table 10. Summary of one-way repeated measure analyses of variance in the arcsine data for the main effect of recall task (selective attention, partial report) at each sentence length in the monaural-same talker condition.

Sentence Length	Sum of Squares	DF	Estimated Mean Square	F-Ratio	Tail Prob.
Short	0.0099	1	0.0099	0.39	0.5428
	0.2772	11	0.0387		
Medium	0.0685	1	0.0685	4.44	0.0588
	0.1694	11	0.0154		
Long	0.0526	1	0.052	7.72	0.0179
	0.0749	11	0.0068		

It will be seen from Figures 13a and 13b that subjects achieved near perfect performance on the selective attention task in almost all listening conditions across all sentence lengths; the exception was the monaural-same talker condition where means between 65 and 75% were obtained.

Divided attention #1 performance varied the least across sentence lengths as a function of listening condition, yet, a discernible pattern of performance as a function of listening condition and sentence length can still be observed. In the dichotic listening conditions subjects achieved near perfect scores for short and medium sentences and dropped in performance only on long sentences. In the monaural-different talkers condition, subjects achieved scores on medium sentences intermediate to those attained on short and long sentences, while in the monaural-same talkers condition subjects achieved significantly higher scores for short sentences than on medium and long sentences (the latter two scores being essentially identical).

There is a remarkable similarity in partial report and divided attention average performance. Only in the dichotic listening conditions did performance on these two tasks differ. In the dichotic-same talkers condition, subjects performed similarly on both tasks for short and medium sentences and only on long sentences did subjects perform significantly better on the partial report task. In the dichotic-different talkers condition, performance was identical on both recall tasks for short sentences but as sentence length increased subject scores diverged, in favor of partial report. Further examination of the data reveals that the greater drop in divided attention average scores in both listening conditions was due primarily to a drop in divided attention #2 scores.

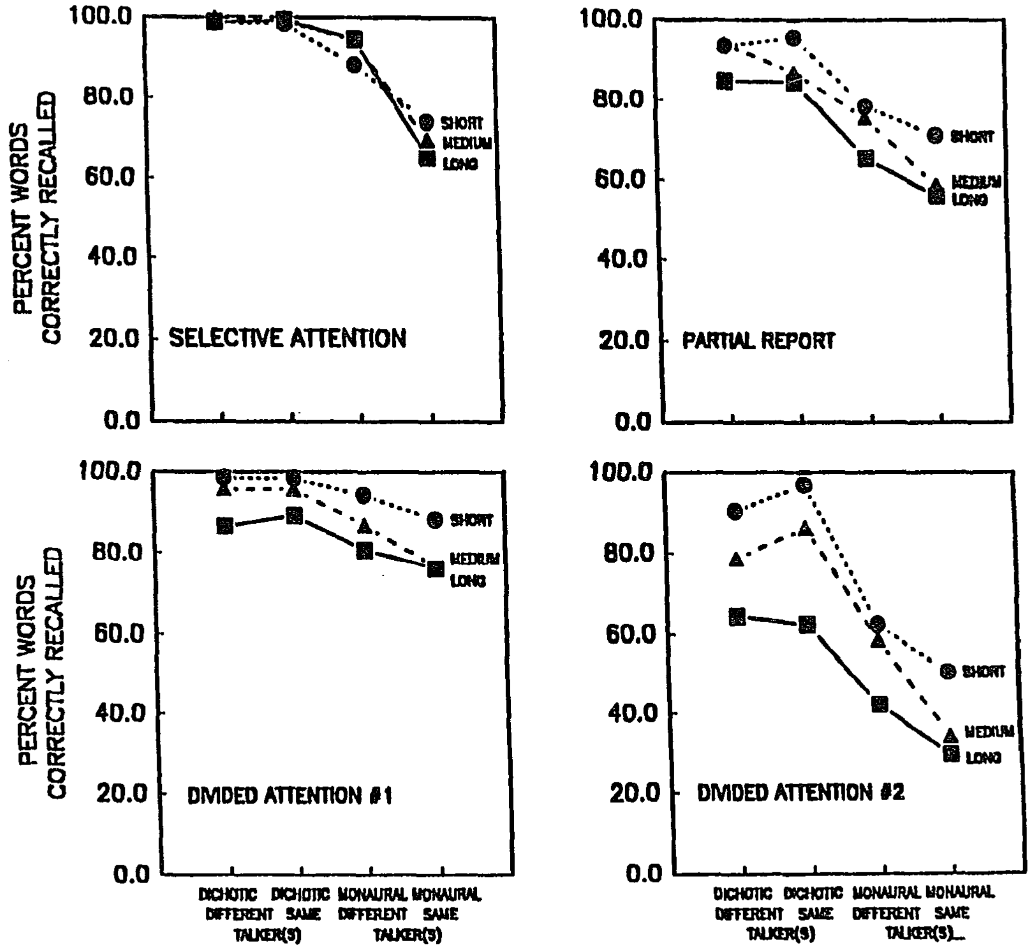

Figure 13a. Group means for all three recall tasks as a function of listening condition and sentence length (divided attention #1 and divided attention #2 scores included).

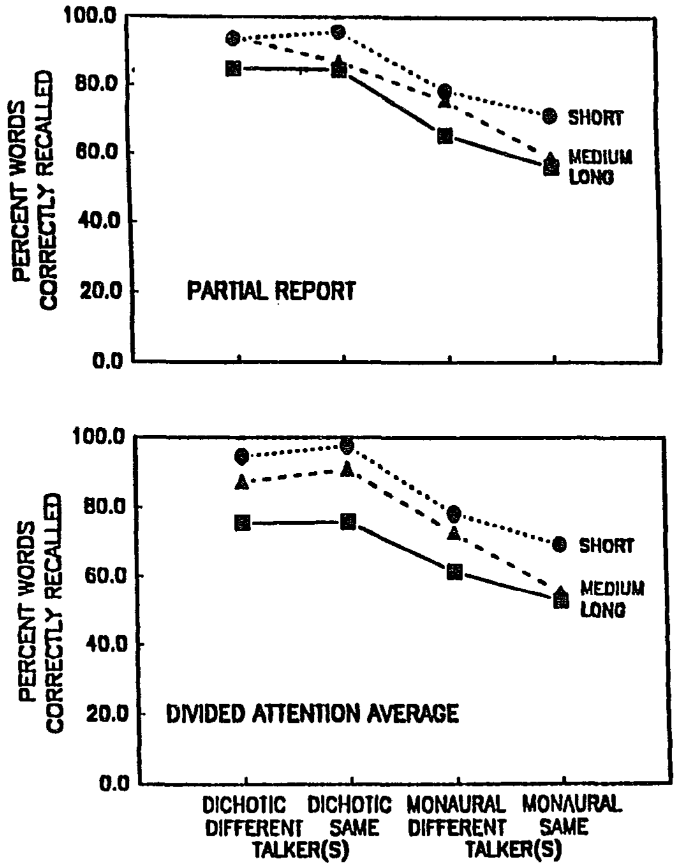

Figure 13b. Group means on partial report and divided attention average as a function of listening condition and sentence length.

Sentence Length

Appendix K shows that all two-way interactions of listening condition and recall task were significant (at least at the .002 level), except at short sentence length with divided attention average scores included. In this case the interaction was not significant at the .05 level.

It will be seen from Figures 14a and 14b that for short sentences, subjects achieved near perfect performance on all recall tasks in either dichotic listening condition. Removal of the spatial cue and subsequent removal of the talker cue resulted in increasingly poorer performance; the extent to which performance decreased, however, varied as a function of recall task. For example, performance on divided attention #1 decreased marginally, while divided attention #2 performance dropped significantly.

For medium sentences, subjects maintained near perfect performance on both the selective attention and divided attention #1 recall tasks in both dichotic listening conditions. Divided attention #2 performance dropped slightly in these listening conditions as sentence length increased from short to medium length. Partial report performance remained essentially the same on the dichotic-different talkers condition, but dropped slightly in the dichotic-same talkers condition. In the monaural-different talkers condition, performance on all recall tasks remained essentially the same as that achieved on short sentences. In the monaural-same talkers condition, scores dropped significantly on all recall tasks as sentence length was increased, except for selective attention which remained essentially the same.

For long sentences, near perfect performance was maintained only on the selective attention task and only in the dichotic listening conditions and monaural-different talkers condition. Performance on both partial report and divided attention #1 dropped slightly in all listening conditions as sentence length was increased from medium to long sentence length, while divided attention #2 performance dropped substantially in both the dichotic listening conditions and monaural-different talkers condition. Interestingly, in the monaural-same talkers condition scores on all tasks dropped slightly as sentence length was increased from medium to long.

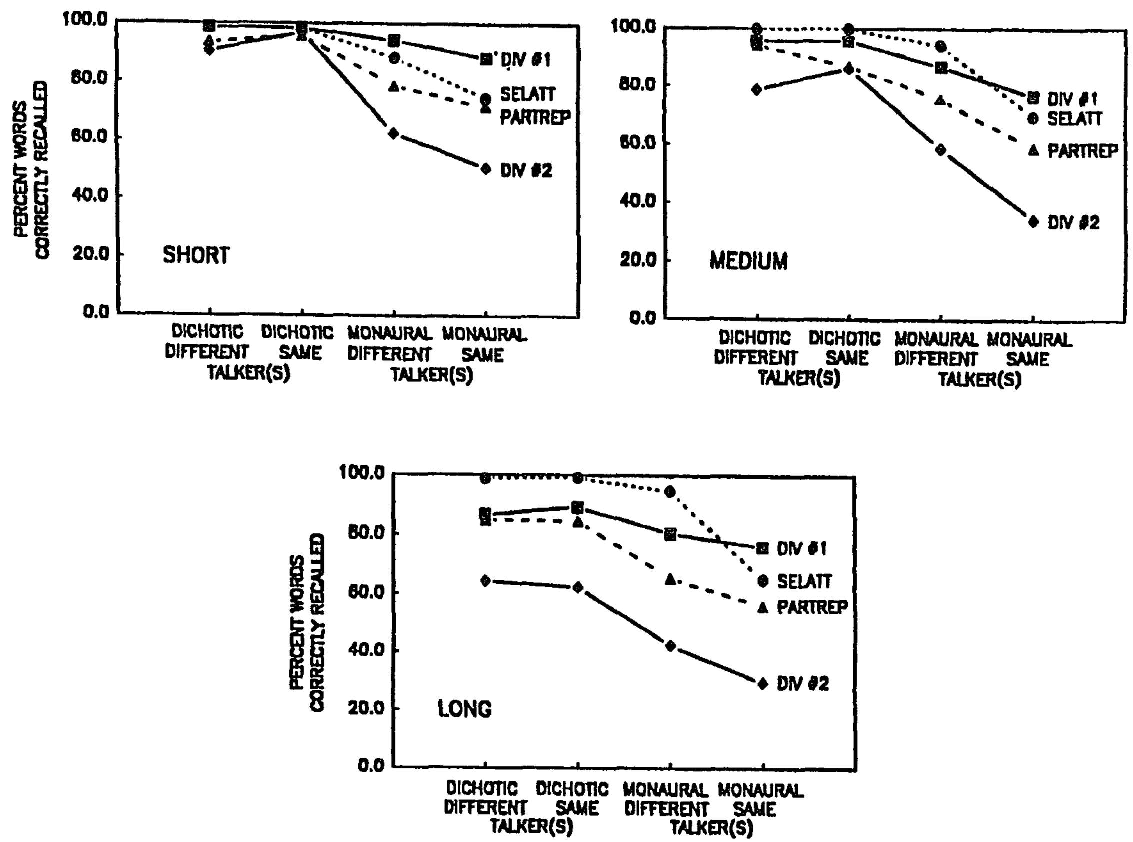

Figure 14a. Group means at all three sentence lengths as a function of listening condition and recall task (divided attention #1 and #2 scores included).

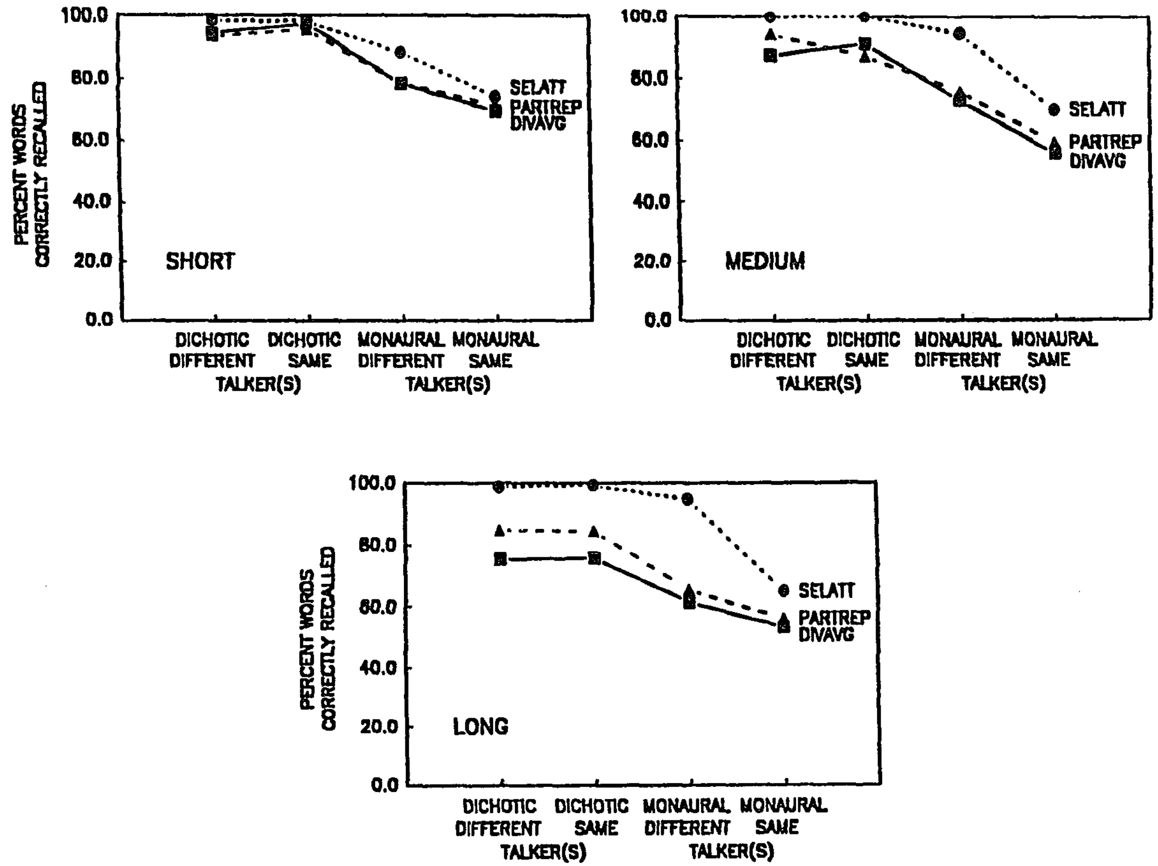

Figure 14b. Group means at all three sentence lengths as a function of listening condition and recall task (divided attention average scores included).

CHAPTER 5: DISCUSSION

Examination of the data revealed that subjects clearly performed best on all recall tasks when the spatial cue was present (i.e., in the dichotic listening conditions). In fact, in most test conditions adding the talker cue when the spatial cue was already present did not significantly improve performance. Perhaps the most impressive finding was that subjects were able to correctly recall more than 90% of the target words for short sentences, regardless of the recall task. Hence, even on the divided attention task subjects were able to process and recall both sentences accurately.

The excellent performance in the dichotic listening conditions might be due to two factors. First, subjects heard the talkers in separate headphones, hence, there was no peripheral masking in either ear (except that due to the noise floor in each recording). Second, Treisman (1964b), and Craik and Lockhart (1972) have suggested that when a spatial cue is present it results in a separation of the perceptual representation of each stimulus. If this assumption is correct, then this would result in decreased mutual interference during processing and, in turn, more accurate performance.

Scores in the monaural-different talkers listening condition (i.e., when the target and competing message were presented in the same earphone but via different talkers) were consistently intermediate between the higher dichotic listening condition scores and the lower monaural-same talker condition scores. This suggests that adding the talker cue when no other distinctive acoustic cue was present facilitated performance. The extent of this improvement, however, was not as great as when the spatial cue was added; this difference in performance may be due to the presence of peripheral masking and greater interference masking in the monaural-different talkers condition.

In the absence of both spatial and talker cues (i.e., when the target and competing message were presented via the same talker and in the same ear), performance did falter. However, the results obtained in this study are better than those reported in earlier studies by Broadbent (1952 a,b), Cherry (1953), Cherry and Taylor (1954), Egan, Carterette and Thwing (1954), and Treisman (1964 a,b) and might be due to a number of underlying factors. First, the use of sentences might have provided the listener, even in the absence of spatial and talker cues, with sufficient acoustic and linguistic cues in which to process and recall much of the target sentence(s). Second, the subject's task in this study probably required less mental effort than that entailed in studies involving shadowing. Hence, acoustic redundancy (such as that provided by the presence of spatial and/or talker cues) might not have been as crucial a factor in this study. Third, unlike the earlier Egan et al. study, subjects in this study were told the topics of both the target and competing sentences.

Knowledge of sentence topic in both the selective attention and partial report tasks gave subjects a basis in deciding which sentence was the designated target (note that the results indicate topic knowledge on the selective attention task was not useful until the subject had initially processed at least part of one or both competing sentences. This will be discussed in depth later in this section).

The degree to which subjects successfully attended to and recalled a spoken target sentence also varied as a function of recall task; that is, performance on some recall tasks was better than on others. As expected, subjects performed best, overall, on the selective attention task. In fact, subjects achieved near perfect performance on this task in both dichotic listening conditions and in the monaural-different talker condition. However, in the absence of spatial and talker cues, selective attention performance dropped sharply and to such an extent that subjects actually performed significantly better on divided attention #1.

Inspection of the data in the monaural-same talker condition revealed that there was no significant difference between overall performance on partial report and selective attention. On further analysis, it was determined that there was no significant difference in performance for these two tasks at short and medium sentence lengths but subjects did perform significantly better on long sentences on the selective attention task. This suggests that, at least for short and medium sentences, in the absence of spatial and talker cues subjects were not able to benefit significantly from prior awareness of the topic of the target sentence. One possible underlying factor is that the necessary contextual information to derive sentence topic can occur anywhere in the sentence. For example, in the following sentence pair the information cuing the listener to sentence topic occurs near the end of both sentences:

1. ANIMALS : Do you want to buy that cute puppy?

2. SEASONS/HOLIDAYS : Did you finish all your shopping for Christmas?

Subjects would need to process both sentences in full before the necessary topic information would be encountered. This would make the subject's task somewhat analogous to the partial report task; subjects would have to process both sentences in full before knowing which one to recall.

If, on the other hand, the necessary information confirming topic designation occurred at the beginning of either sentence, then subjects would not need to attend to and process both sentences to completion. For example, in the following sentence pair the subject would be able to determine the target sentence early on and, subsequently, focus only on that particular sentence.

1. FOOD : Drink your coffee before it gets too cold!

2. CLOTHES : The nightgowns are on sale at the store.

Because subjects had to process a certain amount of sentence context before they could determine the target sentence on the basis of sentence topic, sentence length could have influenced topic derivation. That is, for short and medium sentences subjects might not have been able to determine the target sentence before item completion, therefore, necessitating the processing of both sentences. However, at the longest sentence lengths sufficient sentence context might have allowed subjects to determine the target sentence on the basis of topic before sentence completion, hence, enabling subjects to focus solely on the target sentence from that point on. In turn, this would have resulted in significantly better performance on the selective attention task than on partial report.

When either the spatial or talker cue was present in the selective attention task, subjects performed as well as in the control condition (i.e., presentation of a target sentence in the absence of a competing message). Hence, adding the spatial and/or talker cue appears to have changed the nature of the subject's task from one resembling partial report in the monaural-same talker condition (at least for short and medium sentences) to one of true selective attention in the other listening conditions. That is, only when a distinctive long-term acoustic cue was present were subjects able to selectively attend to only one sentence from the very onset of presentation.

Another interesting finding was the very good performance attained on divided attention #1, with subjects performing slightly better overall on selective attention than on divided attention #1 (90% versus 87.1%, respectively). And, as mentioned earlier, in the monaural-same talker condition (i.e., in the absence of spatial and talker cues) subjects performed best on divided attention #1. In fact, in this listening condition subjects were able to correctly recall approximately 90% of the words from one of the competing sentences at short sentence length and close to 80% of the words at long sentence length. These results suggest that even when spatial and talker cues were removed subjects were able to separate perceptually the two competing sentences quite easily.

The excellent performance on divided attention #1 might have been due simply to subjects having been able to choose which sentence to recall first. Subjects only had to process and recall one sentence accurately to derive high scores on divided attention #1. For example, in the monaural-same talker listening condition subjects did quite poorly on divided attention #2, yet, they did quite well on divided attention #1. Therefore, on the divided attention task, subjects were able to attain high scores on divided attention #1 as long as subjects were able to accurately process and recall at least one sentence.

As mentioned, the excellent performance on divided attention #1 was not without cost since divided attention #2 scores were consistently worse than on any other recall task, especially in the monaural listening conditions. A number of possible factors underlies the poor performance on divided attention #2. First, for whatever reasons, subjects might have latched onto one sentence (eg., on the basis of initial intensity) and then proceeded to process this sentence more accurately and at the expense of the other. Second, if the more completely processed sentence was repeated back first, then the memory trace of the second sentence would have been subject to output interference as well as any short-term memory limitations occurring with the passage of time. Verbal report of the first sentence could have produced output interference in three ways:

1. The subject's vocal production of the first sentence could have interfered with the acoustic memory trace of the second sentence.

2. Recall of the first sentence would have interfered with rehearsal of the second sentence.
3. The word sequence could have affected syntactic and semantic memory of the second sentence.

The literature also indicates that a weak memory trace is more prone to subsequent loss from short-term memory (Gregg, 1986). Therefore, in the absence of spatial and talker cues, a subject listening to competing sentences would not only experience increased difficulty in the initial processing stage (due to increased mutual masking by the competing sentences), but could also be faced with trying to recall weak memory traces fading rapidly from short-term memory. The latter could be especially detrimental to partial report and divided attention #2 performance.

As mentioned in the review of the literature, various studies have shown that spatial and/or talker cues enhance performance in divided attention and partial report tasks (Webster and Thompson, 1954; Poulton, 1956; Treisman, 1970), but it has not been clear whether the enhancement on these tasks is as great as on the selective attention task.

In this study, subjects performed significantly better on the partial report and divided attention tasks when the spatial and/or talker cues were present. Subjects performed best in the dichotic listening conditions, followed by performance in the monaural-different talkers condition. Especially impressive was the high level of performance attained on these two recall tasks in the dichotic listening conditions at short sentence length, with subjects recalling more than 90% of the words correctly. In fact, subjects did as well on partial report and divided attention #2 as on divided attention #1. These scores, in turn, were similar to those achieved on the selective attention task. When sentence length was increased, performance dropped on both the partial report and divided attention tasks (the drop in performance on the divided attention task was due primarily to the large drop on divided attention #2 scores), while performance remained essentially the same on the selective attention task. These findings indicate that when the competing sentences are short the enhancing effect of the spatial cue is as beneficial on the partial report and divided attention tasks as on the selective attention task. Even though subjects had to derive the linguistic content of both competing messages on the partial report and divided attention tasks, subjects were still able to perform as well as on the selective attention task. This suggests that for short sentences the spatial acoustic cue significantly decreased the mental load during processing. The fact that subjects did not perform as well on the partial report and divided attention tasks as sentence length was increased might be due simply to the greater amount of material that had to be processed at the longer sentence lengths. That is, for longer sentences subjects had to process up to a maximum of 28 words on the divided attention tasks, while having to attend to and recall only 14 words (i.e., only one sentence) on the selective attention task. Hence, memory limitations might have contributed to the decline in performance, rather than the initial processing demands of the recall task. One way to examine this assumption would be to have subjects selectively attend to sentences longer than 14 words and then compare the results with those obtained at medium and long sentence lengths on the partial report and divided attention tasks (note this technique would only have validity if the sentences presented on either divided attention task were interleaved, that is, were non-overlapping. Only then would the presentation time on the selective attention task be equal to those on either divided attention task).

It appears that adding only the talker cue enhanced subject performance on all tasks but significantly more so on the selective attention task, even on short sentences. This finding supports an earlier contention. The presence of the talker or spatial cue on the selective attention task alters the nature of the task from one resembling partial report in the monaural-same talker condition to one of true selective attention; hence, subjects were able to process the target sentence as if it had been presented without any competing messages present. On the other hand, adding the talker cue on the partial report and divided attention tasks does not fundamentally alter the recall task. The subject's ability to process the target sentence(s) is enhanced but to a significantly lesser extent than when the spatial cue is added. This suggests that for these recall tasks in the monaural-different talker condition the perceptual distance between the competing sentences is less than when the spatial cue is present, therefore, resulting in greater mutual interference and poorer performance in this listening condition than in either of the dichotic listening conditions.

Another interesting observation was the remarkable similarity between partial report and divided attention average performance in the monaural listening conditions. In only the dichotic listening conditions did performance differ on these two recall tasks, that is, only on long sentences in the dichotic-same talkers condition and on medium and long sentences in the dichotic-different talkers condition. In these test conditions, subjects performed significantly better on partial report.

Two possible mechanisms might underlie this similarity in performance in the monaural listening conditions. First, memory limitations might have influenced the results. Sperling (1960) and Moray, Bates, and Barnett (1965), using alphanumeric characters, found that subjects performed significantly better on partial report versus whole report (divided attention average) only when subjects recalled the stimuli within 1 second post-exposure. In fact, later studies using alphanumeric characters have shown that the partial report advantage is between 250 and 300 milliseconds and is probably attributable to subjects in this task being able to access iconic memory (Massaro, 1976a; Lupker and Massaro, 1979). Because sentence materials involve significantly longer processing times than alphanumeric characters, it is possible that recalling sentence materials is analogous to recalling alphanumeric items after 300 milliseconds exposure. This, in turn, would eliminate any advantage inherent in the partial report task. The fact that subjects performed significantly better on partial report in the dichotic listening conditions for only the longer sentences suggests that if memory limitations affected the results, it was not in the manner described by Sperling and Moray. Their results would have predicted differences, if any were to occur, on the shorter sentences and that partial report and divided attention performance would have been similar on the longest sentences.

The second possible mechanism is based on two assumptions. The first assumption is that the major mental expenditure in both the partial report and divided attention tasks was due to the initial processing rather than in the actual report of either or both sentences. The second assumption is that subjects in the partial report task had a 50/50 chance of being asked to recall the more or less accurately processed sentence. If the two assumptions are correct, then it would be expected that results on the partial report task would be similar to those derived by averaging the scores of the first and second sentences recalled in the divided attention task (i.e., divided attention average). This hypothesis is consistent with the results obtained at short and medium sentence lengths in both monaural listening conditions. However, as mentioned earlier, subjects performed significantly better on the partial report task in the dichotic listening conditions on the longer sentences. It is possible that the primary factor influencing performance on all sentence lengths in the dichotic listening conditions was the initial processing of the competing sentences, but, on long sentences short-term memory limitations may have also impacted on the ability to recall the second sentence on the divided attention task. This assumption is supported by the significantly large drop in divided attention average scores as a result of decreased recall of the second sentence on long sentences.

On the other hand, subjects in the monaural listening conditions performed similarly on both partial report and divided attention average, even on the longest sentences. This might have been due to the greater mental effort required to process sentences in the monaural listening conditions and possibly was the overwhelming factor affecting performance, even on long sentences. Since the initial processing requirements on both the partial report and divided attention recall tasks were identical this hypothesis would help explain why similar results were obtained in the monaural listening conditions.

As expected, the overall ability to repeat words correctly from the target sentence(s) diminished gradually as sentence length was increased. However, this effect was not uniform and depended greatly on the type of recall task and particular listening condition. For example, on the selective attention task, performance remained above 90% across all sentence lengths when the spatial and/or talker cues were present (with performance being near perfect in the dichotic listening conditions). This suggests that the selective attention task was extremely easy and resulted in little mental load when a distinctive long-term acoustic cue was present.

Subjects performed similarly on the partial report and selective attention tasks at short sentence length (except in the monaural-different talkers listening condition). As sentence length increased, performance diverged in favor of the selective attention task, regardless of listening condition. The similarity in performance on these tasks on short sentences in the dichotic listening conditions is probably due to the ease to which the target sentence(s) was processed and recalled. As sentence length was increased, it appears that mental load did not increase significantly on the selective attention task, but did so on the partial report task. And, as mentioned earlier, the similar results on both tasks in the monaural-same talker condition for short sentences might have been due to the subject's task on selective attention actually having been one of partial report. However, at longer sentence lengths subjects were able to use the topic cue to selectively attend to the target sentence to some degree and, hence, achieve higher scores on the selective attention task than on the partial report task.

The significant difference in performance in the monaural-different talkers condition is probably due to the fact that the talker cue in the selective attention task changed the nature of the task from one of partial report to true selective attention, hence, making the recall task significantly easier. Although adding the talker cue in the partial report task did improve performance, it did not alter the task; subjects still had to process both sentences before being notified of the target sentence to recall. As sentence length was increased, performance on these two recall tasks diverged. Selective attention scores remained high, regardless of sentence length, while partial report scores dropped gradually.

The effect of sentence length is also apparent when examining selective attention versus divided attention #1 performance. Collapsing over listening conditions, it will be seen that for short sentences subjects performed significantly better on divided attention #1 than on selective attention, while the reverse pattern of performance occurred on long sentences. Inspection of the data shows that the better performance on divided attention #1 on short sentences was due solely to the higher scores achieved in the monaural-same talker condition. However, when sentence length was increased, scores on divided attention #1 dropped in all listening conditions, while it did so only in the monaural-same talker condition on the selective attention task. These results suggest that selective attention performance, at least for the sentence lengths used in this study, was primarily impacted by listening condition and that when either the spatial or talker cue was present sentence length did not impose a significant mental load. However, this was not the case on the divided attention task where the added load of processing and retaining a second sentence in memory as sentence length was increased, resulted in poorer recall of the first sentence.

There was also an interesting interaction between listening condition and sentence length. Subjects revealed a different pattern of performance as a function of sentence length in the monaural-same talker condition than in any other listening condition. Except for the selective attention task, subjects in the monaural-same talker condition showed a large drop in performance when sentence length was increased from short to medium, while a slight drop occurred as sentence length was increased further. In contrast, in the dichotic listening conditions, as well as in the monaural-different talkers condition, subjects achieved similar mean scores at short and medium sentence length. These means, in turn, were significantly better than those achieved for long sentences. Therefore, on divided attention tasks (including partial report), it appears that one benefit derived from adding spatial and/or talker cues is an increased ability to process and recall longer sentences accurately (i.e., subjects perform similarly on short and medium sentences).

In addition to the main research questions there were a number of side issues of interest. For example, did resolving the methodological inadequacies in the earlier Medwetsky study (1988) lead to different results in this study? Since only the divided attention task (and in only the monaural-same talker condition) was investigated in the pilot study, only those results pertaining to this test condition will be addressed.

Since group means were derived for all twelve sentence lengths in the pilot study, these data had to be reanalyzed for comparisons with those obtained in this study. The results are shown in Appendix L for divided attention #1 and #2 at short, medium and long sentence lengths. It will be seen that overall scores, collapsed across sentence lengths, were significantly higher in the pilot study. However, group means for divided attention #1 were similar in both studies for short sentence. Only on the longer sentences did scores diverge in favor of the first study (by approximately 8 percentage points). On the other hand, performance on divided attention #2 was far superior in the first study. Subjects achieved mean scores that were 30 percentage points higher at short sentence length and 20 percentage points higher at both medium and long sentence lengths. Further analysis of the data shows that the overall pattern of performance was similar in the two studies, even though the absolute values differed significantly. That is, scores on divided attention #1 and #2 dropped significantly as sentence length increased from short to medium but dropped little as sentence length increased from medium to long. Hence, it appears that the more stringent methods used in pairing sentences in this study did reduce overall performance, especially on divided attention #2.

Another issue of interest concerns the number of confusion errors made in the various test conditions (i.e., the percentage of words incorrectly inserted from the competing sentence into the target response). Appendix M shows the percentage of confusion errors in each test condition. The percentage of confusion errors was very low and never exceeded 5% in any test condition and in most test conditions was less than 1%. When errors did occur, they were greatest in the monaural-same talker condition, followed by the dichotic-same talker condition. This suggests that talker identity might be more effective than spatial cues in preventing confusion errors once words have actually been identified during processing.

It should be noted that on divided attention #1 there was a total of only two confusion errors over all listening conditions and none in the monaural-same talker condition. It is likely that on the divided attention task, the sentence the subject chose to recall first was the one processed most accurately and with the least intrusions from the competing sentence.

One last issue concerns the predictability of subject performance across recall tasks. Were there recall tasks in which subject performance was highly correlated? Correlations were examined in only the monaural-same talker condition because this was the most difficult listening condition and the one most likely to show differences among subjects. Pearson product-moment correlation coefficients were calculated, the results shown in a correlation matrix in Appendix N. All correlations, except for the comparison of partial report and divided attention #1, were significant at either the .05 or .01 level. The highest correlations were those obtained for the comparisons of (a) divided attention average and divided attention #2, (b) partial report and divided attention average, and (c) partial report and divided attention #2. These results suggest it is the subject's ability to process a second sentence accurately that most distinguishes subjects from one another.

CHAPTER 6: FOLLOWUP STUDY

During the course of testing, some subjects indicated there had been a number of occasions in which one sentence had been clearly more intelligible than the other when competing sentences had been presented in the same ear. These subjects felt that when they heard both the male and female talkers in the same ear, the male talker was often easier to attend to. In addition, even when both sentences were spoken by the female, there had been a number of instances in which the subjects could only "hear" one sentence. For example, on the selective attention task in the monaural-same talker condition, subjects sometimes stated that they could not correctly repeat any words from the designated sentence and that the competing sentence had been the only one that they could "follow". In addition, on the partial report and divided attention tasks, some subjects stated that they had been able to attend to only one sentence because one sentence had "dominated" the other.

Upon completion of testing, this investigator listened to all of the competing sentence pairs on both the master and test audiocassette tapes, both dichotically and monaurally. On all those presentations in which one sentence appeared to be of better sound quality, a tally was made on the corresponding test sheets. Analysis of the results revealed that in almost all instances in which tallies were entered it was due to the pairing of a sentence from the CUNY laserdisc recording with one of the newly recorded sentences. In addition, in almost all cases this investigator had rated the newly recorded sentence material of being of higher listening quality. This difference in listening quality was most apparent in the monaural listening conditions.

Because these differences in recording quality posed a threat to the validity of the findings reported earlier, it was necessary to determine whether the recordings differed spectrally and, if there were any differences, whether they affected the outcome in the various test conditions.

Method- Followup Study

To determine whether spectral differences existed between the original CUNY laserdisc recording and the newly recorded sentences, sentences from both recordings were selected at random for spectral analysis. Because the process of transfer and storage of sentences from laserdisc to audiocassette test tape could have possibly altered the spectral quality of the sentence material, spectral analyses were made of various sentence items from the (a) original laserdisc recording, (b) master audiocassette tape, and (c) test audiocassette tape. A similar analysis was also carried out for the newly recorded sentences and involved analyzing sentences from the (a) initial PCM videotape recording, (b) master audiocasette tape, and (c) test audiocassette tape.

A high resolution signal analyzer (B&K Type 2033) was used to spectrally analyze the sentences from the various storage media (i.e., laserdisc, videotape, and audiocasette tape). The average power spectrum was calculated using linear averaging over the total duration of the sentence. A sampling rate of 20,000 was used and the average power for 400 points over the frequency range of 0-10 kHz was determined.

The resulting graphs for each sentence were then examined across each recording medium. The graphs showed that the power spectra for each sentence were essentially identical, regardless of the storage media. Hence, any differences between the CUNY sentence sets recordings and the new recordings were not due to the transfer of sentence material from one recording to another.

Since the newly recorded sentences, spoken by the female talker, consisted of different text from those stored on the laserdisc, no direct spectral comparisons of the same sentence could be made. Therefore, an indirect determination of spectral similarity was made; this was done by comparing the power spectrum of a number of laserdisc and newly recorded sentences. These comparisons showed a clearly defined spectral difference between the recordings. Although both recordings revealed a flat spectrum up to 1250 Hz the newly recorded sentences proceeded to drop off at a rate of 6 to 8 dB per octave from 1250 to 5K Hz, while the laserdisc sentences dropped off sharply at a rate of 16 to 22 dB per octave over the same frequency range (Figures 15a and 15b show the power spectrum of one newly recorded sentence and one laserdisc sentence, respectively). This finding suggests that the laserdisc sentences were somehow lowpass filtered and probably accounts for the perceived quality differences that some subjects expressed during testing.

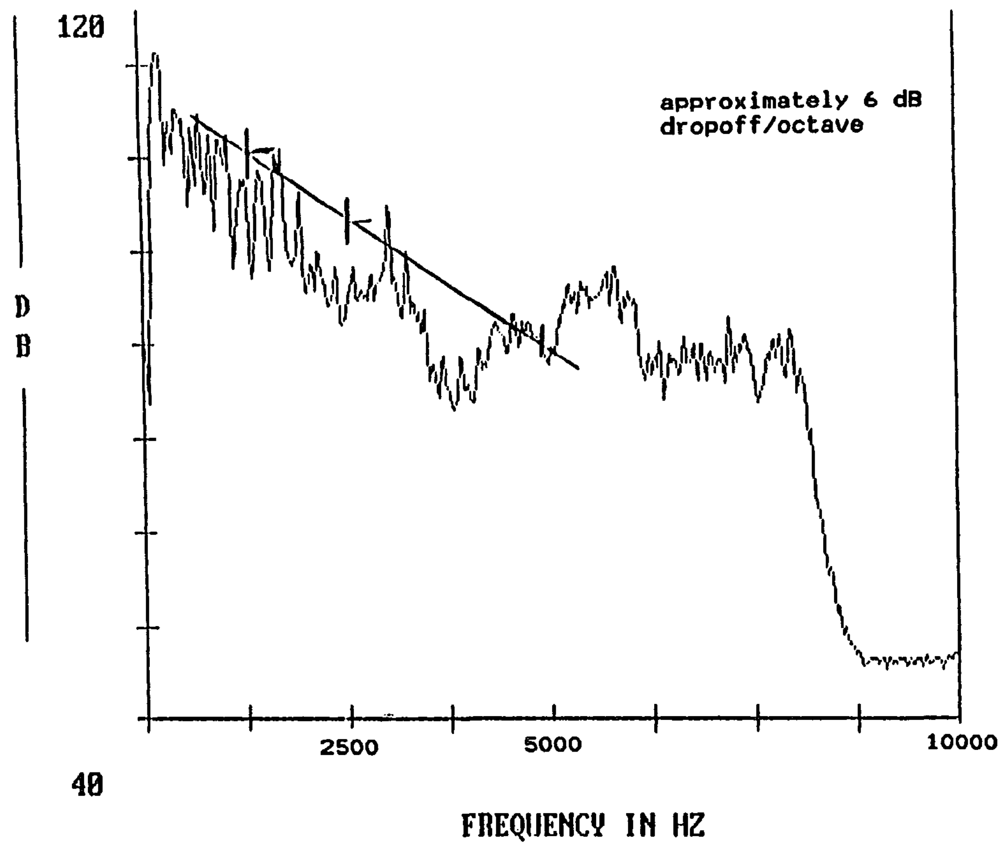

Figure 15a. Power spectrum of one of the newly recorded sentences.

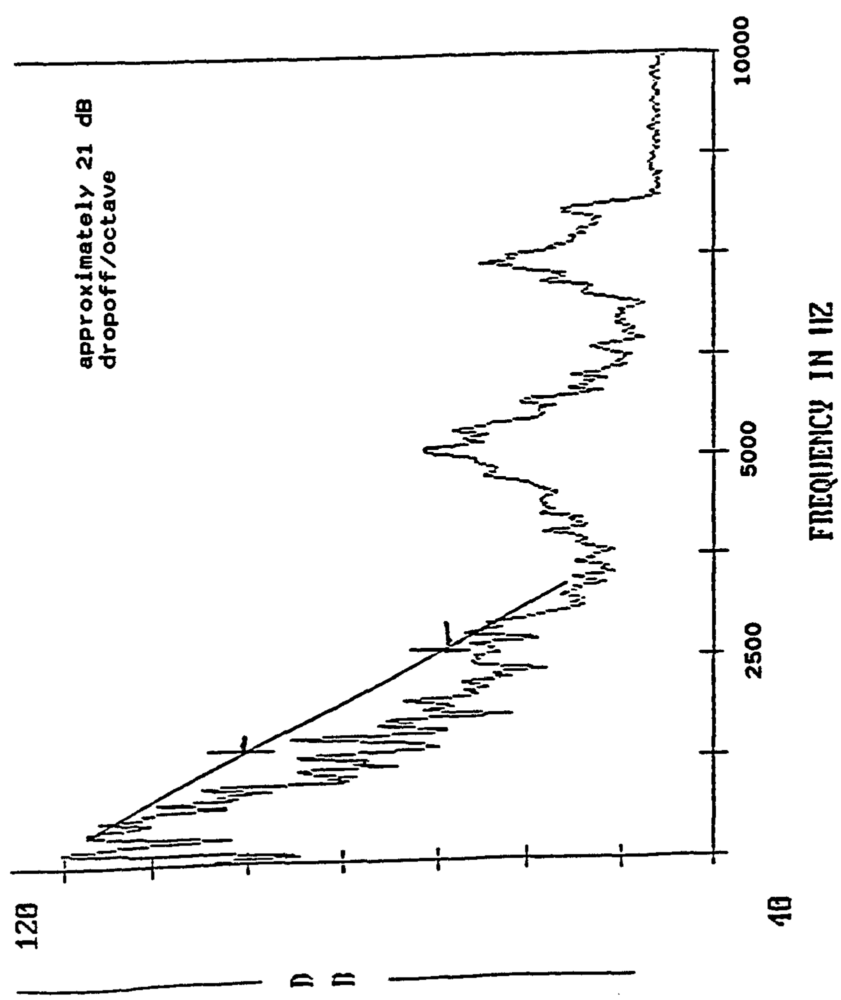

Figure 15b. Power spectrum of one of the old recorded (laserdisc) sentences.

In reviewing the recording conditions, it was determined that microphone placement had differed in the two recording conditions. In the laserdisc recording the microphone had been placed on the talker's collar, while in the new recording the microphone had been placed directly in front of the talker's mouth at a distance of 18 inches away. Subsequent examination of microphone placement by Medwetsky and Boothroyd (1991) confirmed that microphone placements off-axis, that is, not directly in front of the talker's mouth, results in the attenuation of high frequencies.

Ericksen and Yeung (personal communication, 1993) attempted to replicate the same microphone placements used in the two different dissertation recordings (i.e., at the collar and at 18" directly in front of the talker's mouth). Thirty seconds of connected discourse, spoken by a different female talker than the one whose recordings were used in the dissertation, was recorded simultaneously from each microphone placement. The power spectra of these recordings and those used in the dissertation were subsequently analyzed using a Fast Fourier Transform algorithm that integrated the speech energy over a moving 1/3 octave window. The resulting graphs at the corresponding microphone placements were remarkably similar to those examined in this study, except for some minor variations that were possibly due to talker differences. Hence, it appears that the lowpass filtering in the laserdisc recordings is primarily due to the collar placement of the microphone.

The differences in spectral quality between recordings lead to the next question; Did these differences in spectral quality impact on subject performance?

Results- Followup Study

The original data were re-examined in order to determine whether differences in spectral quality impacted on subject performance. Sentences copied from the laserdisc were designated as "old", while the additional sentences recorded for this study were designated as "new". There were two possible sentence recording/listening combinations in the different-talkers listening conditions. These were:

1. Female-Old (F-O) / Male-New (M-N)
2. Female-New (F-N) / Male-New (M-N)

On the selective attention and partial report tasks the pairings listed below indicate the target sentence first, followed by the competing sentence:

	TARGET		COMPETING
1.	Female-Old (F-O)	/	Male-New (M-N)
2.	Female-New (F-N)	/	Male-New (M-N)
3.	Male-New (M-N)	/	Female-New (F-N)
4.	Male-New (M-N)	/	Female-Old (F-O)

Since subjects in the divided attention task were able to choose which sentence to recall first the above pairings indicate which recorded sentence the subjects recalled first and second.

There were four possible recording combinations in any test condition in the monaural-same talker listening condition:

1. Female-Old (F-O) / Female-Old (F-O)
2. Female-New (F-N) / Female-New (F-N)
3. Female-Old (F-O) / Female-New (F-N)
4. Female-New (F-N) / Female Old (F-O)

As mentioned above, in the selective attention and partial report tasks the order of recordings within each pairing represent the target sentence first followed by the competing sentence, while in the divided attention task the order represents the recorded sentences that the subjects recalled first and second.

Because there were an unequal number of items for each recorded pairing across sentence length, correction factors were applied over a number of steps in deriving the group means. First, for each recording combination (in any of the 12 test conditions) the total number of words recalled correctly by all 12 subjects from the target sentence(s) for each sentence length (short, medium, and long) was first calculated. These totals were then divided by the maximum number of words that could have been recalled for each corresponding sentence length over the number of items actually presented. Second, the derived percentages for each sentence length were then multiplied by the maximum number of words that could have been recalled correctly on one sentence list for each corresponding sentence length had there been uniformity of recordings (i.e., 18, 34, and 52 words for short, medium, and long sentence lengths, respectively). Last, the totals derived for all three sentence lengths were then summed and divided by 102 (i.e., the total number of words from one sentence list). The percentages obtained represent the group means for the target sentence(s) in each recording combination.

Table 11 summarizes the group means obtained for each combination of competing sentence recordings in all three recall tasks and four listening conditions. This table also includes the overall group means collapsed over all recording combinations (i.e., the group means reported in the main study) as well as the number of sentence items presented for each recording combination in each test condition.

Table 11. The group means for each recording combination as well as the overall means (collapsed over recording combinations) are shown for each test condition. The numbers in parentheses represent the total number of test items for that particular test condition/recording combination.

Key:

Female (F)	Laserdisc recording (O)
Male (M)	Newly recorded sentences (N)

LISTENING CONDITIONS	RECALL TASKS SELECTIVE ATTENTION	PARTIAL REPORT	DIVIDED ATTENTION AVERAGE	DIVIDED ATTENTION #1	DIVIDED ATTENTION #2
DICHOTIC-DIFFERENT TALKERS					
(F)O-(M)N	98.7 (112)	89.2 (106)	85.7	92.5 (103)	78.8 (103)
(F)N-(M)N	98.7 (34)	89.4 (36)	76.6	87.6 (41)	65.6 (41)
(M)N-(F)N	99.2 (31)	87.9 (40)	85.3	90.7 (20)	79.9 (20)
(M)N-(F)O	99.5 (111)	90.5 (106)	81.9	93.2 (124)	70.5 (124)
Overall Mean	99.1	89.5	82.8	91.8	73.7
DICHOTIC-SAME TALKER					
(F)O-(F)N	98.6 (35)	84.1 (56)	83.8	91.9 (50)	75.7 (50)
(F)O-(F)O	99.3 (189)	88.9 (164)	86.2	94.3 (164)	78.2 (164)
(F)N-(F)N	100.0 (17)	91.3 (17)	85.9	93.6 (19)	78.0 (19)
(F)N-(F)O	99.2 (47)	84.0 (51)	80.0	90.2 (55)	69.8 (55)
Overall Mean	99.3	87.3	84.7	93.0	75.7

Table 11. Continued

LISTENING CONDITIONS	SELECTIVE ATTENTION	PARTIAL REPORT	DIVIDED ATTENTION AVERAGE	DIVIDED ATTENTION #1	DIVIDED ATTENTION #2
	RECALL TASKS				
MONAURAL-DIFFERENT TALKERS					
(F)O-(M)N	85.0 (101)	58.8 (111)	76.9	86.1 (86)	67.7 (86)
(F)N-(M)N	95.5 (44)	76.3 (32)	68.2	84.1 (42)	52.3 (42)
(M)N-(F)N	96.4 (32)	75.7 (36)	61.2	81.1 (32)	41.3 (32)
(M)N-(F)O	98.2 (111)	79.9 (109)	64.4	86.2 (128)	42.6 (128)
Overall Mean	93.6	71.1	68.3	85.1	51.4
MONAURAL-SAME TALKER					
(F)O-(F)N	59.7 (50)	30.3 (51)	74.3	69.7 (15)	78.9 (15)
(F)O-(F)O	63.1 (166)	60.5 (161)	55.4	74.7 (177)	36.1 (177)
(F)N-(F)N	83.2 (19)	59.2 (22)	54.3	74.1 (14)	36.6 (14)
(F)N-(F)O	88.2 (53)	84.3 (54)	57.1	88.7 (82)	25.6 (82)
Overall Mean	68.1	59.7	56.8	78.4	35.2

The group means in those recording combinations in which the target and competing sentences were from equally filtered recordings (i.e., either new versus new or old versus old) were then combined and compared to the overall means obtained in each test condition. These results are shown in Figure 16. It will be seen that the overall group means and the combined equally filtered means were essentially the same regardless of listening condition, with no differences exceeding five percentage points. This indicates that had only one recording, be it the new or the old recordings, been used in this study the results would not have been significantly different from those reported earlier, hence, confirming their validity.

A second issue was whether pairing of sentences of different spectral quality had any affect on performance. Table 12 and Figures 17 and 18 show the overall results obtained when sentences from different recordings were paired on each recall task in the dichotic and monaural listening conditions, respectively.

Figure 17 shows that differences in recording quality had little or no effect on performance in either dichotic listening condition.

Figure 18, on the other hand, shows that recording quality impacted significantly on subject performance on

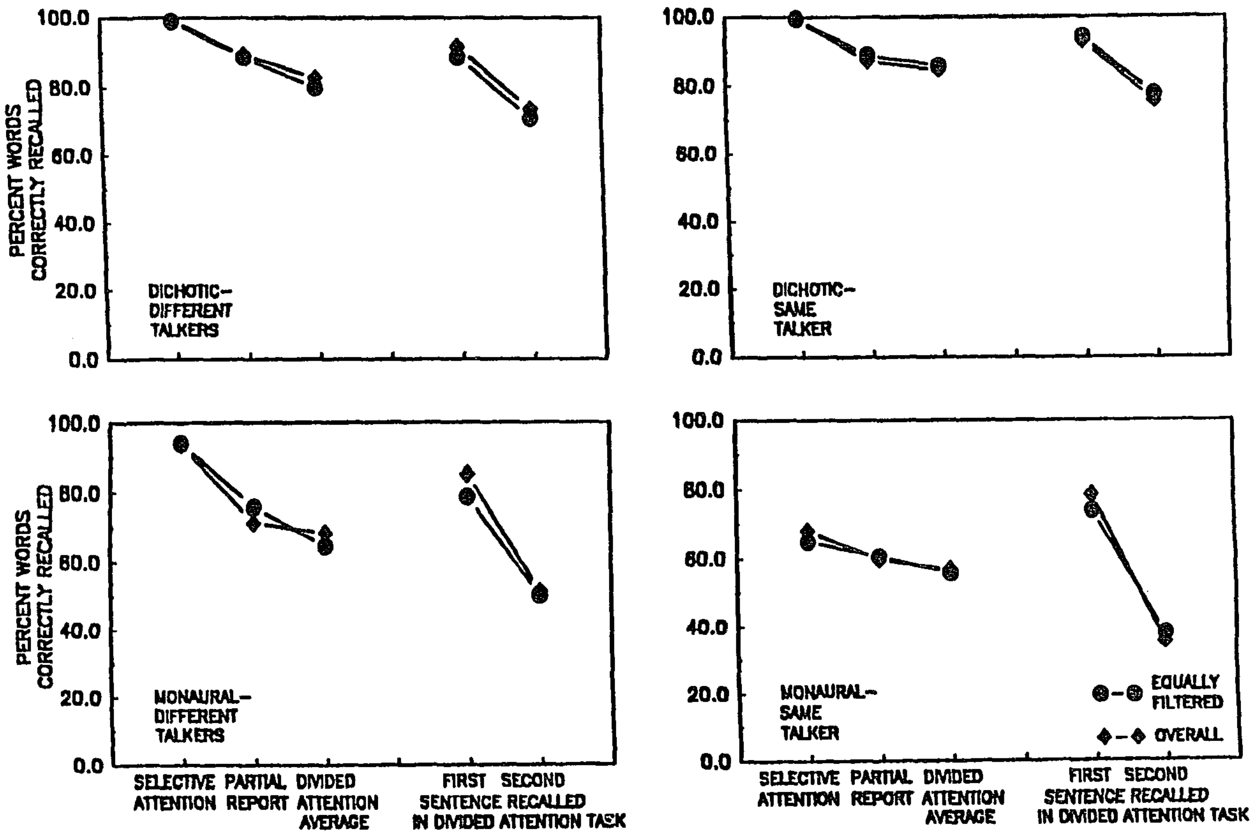

Figure 16. Comparison of group means for competing sentences from equally filtered recordings versus overall means (i.e., collapsed over all recording combinations). Values are shown for all test conditions.

Table 12. The overall means and the "combined" means obtained when collapsing over the unequally filtered listening conditions are shown for each test condition. The numbers in parentheses represent the total number of test items for that particular test condition/recording combination.

Key:

Female (F)	Laserdisc recording (O)
Male (M)	Newly recorded sentences (N)

LISTENING CONDITIONS	RECALL TASKS: SELECTIVE ATTENTION	PARTIAL REPORT	DIVIDED ATTENTION AVERAGE	DIVIDED ATTENTION #1	DIVIDED ATTENTION #2
DICHOTIC- DIFFERENT TALKERS					
(F)O-(M)N	98.7 (112)	89.2 (106)	85.7	92.5 (103)	78.8 (103)
(M)N-(F)O	99.5 (111)	90.5 (106)	81.9	93.2 (124)	70.5 (124)
Combined Mean	99.1	89.9	83.8	92.9	74.7
Overall Mean	99.1	89.5	82.8	91.8	73.7
DICHOTIC- SAME TALKER					
(F)O-(F)N	98.6 (35)	84.1 (56)	83.8	91.9 (50)	75.7 (50)
(F)N-(F)O	99.2 (47)	84.0 (51)	80.0	90.2 (55)	69.8 (55)
Combined Mean	98.9	84.1	81.9	91.0	72.8
Overall Mean	99.3	87.3	84.7	93.0	75.7

Table 12. Continued

LISTENING CONDITIONS	RECALL TASKS SELECTIVE ATTENTION	PARTIAL REPORT	DIVIDED ATTENTION AVERAGE	DIVIDED ATTENTION #1	DIVIDED ATTENTION #2
MONAURAL-DIFFERENT TALKERS					
(F)O-(M)N	85.0 (101)	58.8 (111)	76.9	86.1 (86)	67.7 (86)
(M)N-(F)O	98.2 (111)	79.9 (109)	64.4	86.2 (128)	42.6 (128)
Combined Mean	91.6	69.4	70.7	86.2	55.2
Overall Mean	93.6	71.1	68.3	85.1	51.4
MONAURAL-SAME TALKER					
(F)O-(F)N	59.7 (50)	30.3 (51)	74.3	69.7 (15)	78.9 (15)
(F)N-(F)O	88.2 (53)	84.3 (54)	57.1	88.7 (82)	25.6 (82)
Combined Mean	74.0	57.3	65.7	79.2	52.2
Overall Mean	68.1	59.7	56.8	78.4	35.2

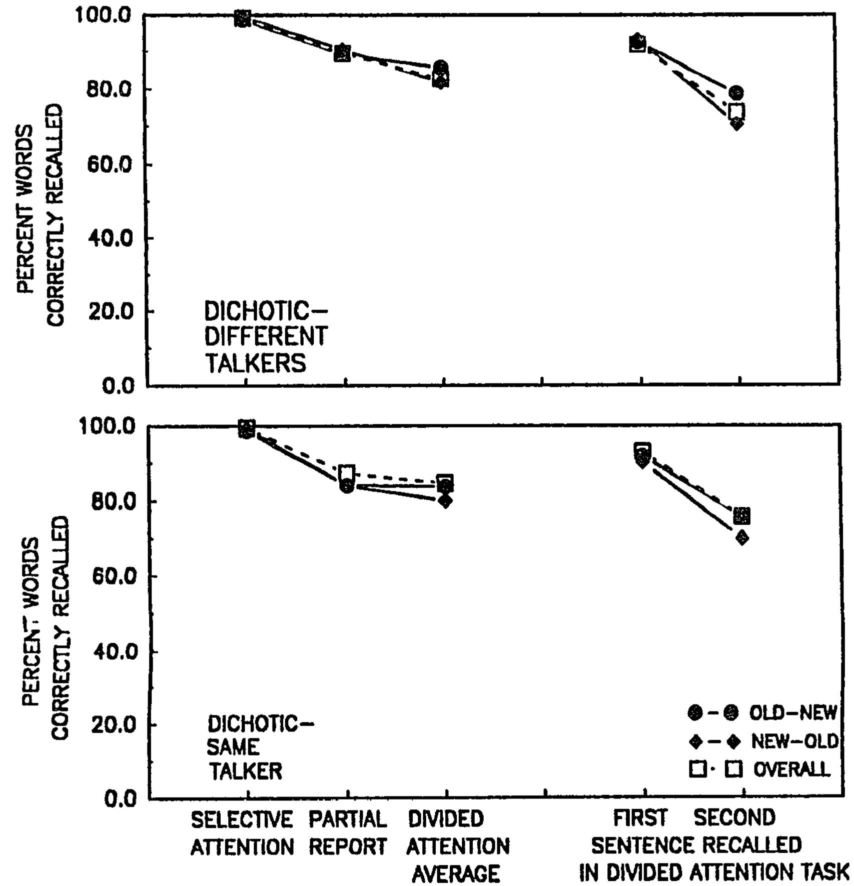

Figure 17. Comparison of overall group means (i.e., collapsed over all recording combinations) versus the means derived when sentences from different recording quality were paired. The values shown are those for the dichotic listening conditions.

almost all recall tasks in the monaural listening conditions; the one exception was in the monaural-different talkers listening condition where subjects performed similarly on the first sentence recalled in the divided attention task (whether the sentence was from the new or old recordings). It will also be seen that the effect of recording quality was much larger in the monaural-same talker condition.

In both the selective attention and partial report tasks, subjects achieved higher scores when the target sentence to be recalled was from the new recording and the competing sentence was from the old laserdisc recording. Results on the divided attention task in both the different and same talker conditions show that subjects achieved a higher divided attention average score when they chose to recall the old sentence first. Although subjects attained a higher divided attention #1 score when they recalled the new sentence first, it resulted in a much larger drop in performance on divided attention #2 (i.e., the difference in scores on divided attention #2 was greater than on divided attention #1).

It is interesting to note that on the divided attention task the percentage of new versus old sentences recalled first differed as a function of listening

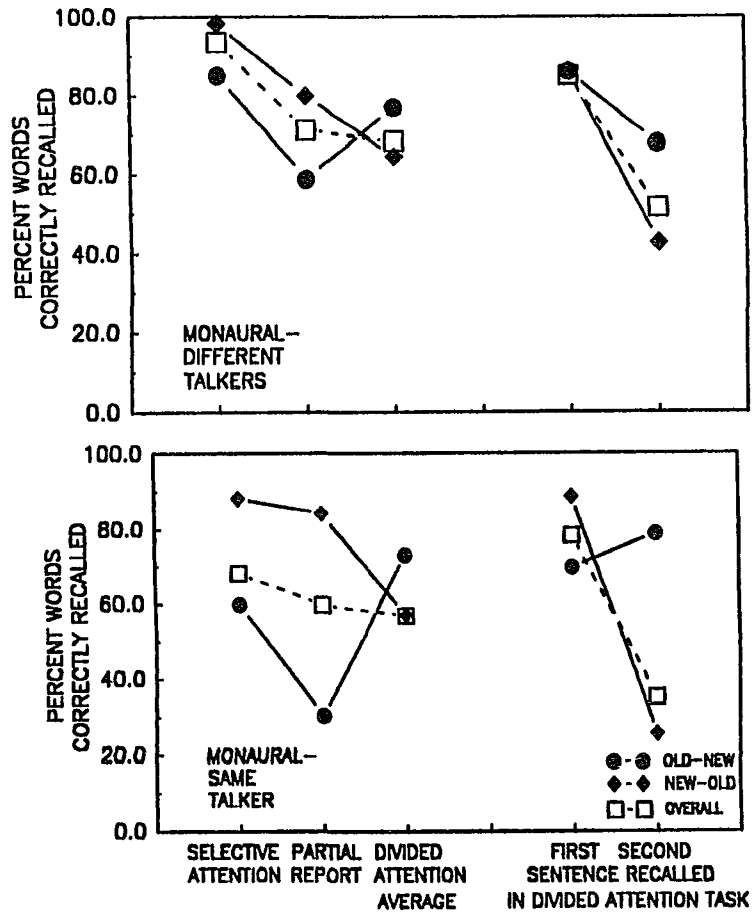

Figure 18. Comparison of overall group means (i.e., collapsed over all recording combinations) versus the derived unequally filtered means (i.e., when sentences from different recording quality were paired. The values shown are those for the monaural listening conditions.

condition. The percentage of items in which new sentences were recalled first in the various listening conditions on the divided attention task are listed below:

1. Dichotic-different talkers (54.6%)
2. Dichotic-same talker (52.4%)
3. Monaural-different talkers (59.8%)
4. Monaural-same talker (85.5%)

Subjects showed a slight preference for recalling the new recorded sentence first in both the dichotic listening conditions and in the monaural-different talkers condition. However, when both the spatial and talker cues were removed, subjects revealed a marked increase in the percentage of new sentences they recalled first (note that this finding is slightly misleading since there were a number of instances in which subjects were unable to recall any words from the old sentence).

The last results to be mentioned involve comparing the overall means reported in the main study to the "combined" means obtained when the means in the unequally filtered listening conditions are collapsed (i.e., when a new recorded sentence was paired with an old laserdisc sentence). The overall and combined means in all test conditions were shown in Table 12 and are also illustrated in Figure 19. These means are remarkably similar, regardless of recall task, in both dichotic listening conditions and in the monaural-different talkers condition. This similarity in performance is also observed on the selective attention and partial report tasks in the monaural-same talker listening condition. This suggests that in these test conditions, whatever improvement in performance occurred when the target was the newly recorded sentence (or in the case of the divided attention task when the sentence was recalled first) was matched by a similar decrement in performance when the target was the old laserdisc sentence (or in the case of the divided attention task when the sentence recalled first was the old sentence).

Only on the divided attention task in the monaural-same talker condition did this pattern of performance deviate; that is, the subjects' combined means on divided attention #2 and, subsequently, on divided attention average were higher than the overall mean. This was due to the fairly accurate performance (78.9%) on divided attention #2 in the unequally filtered condition when subjects chose to recall the new sentence last. This performance is significantly better than that achieved

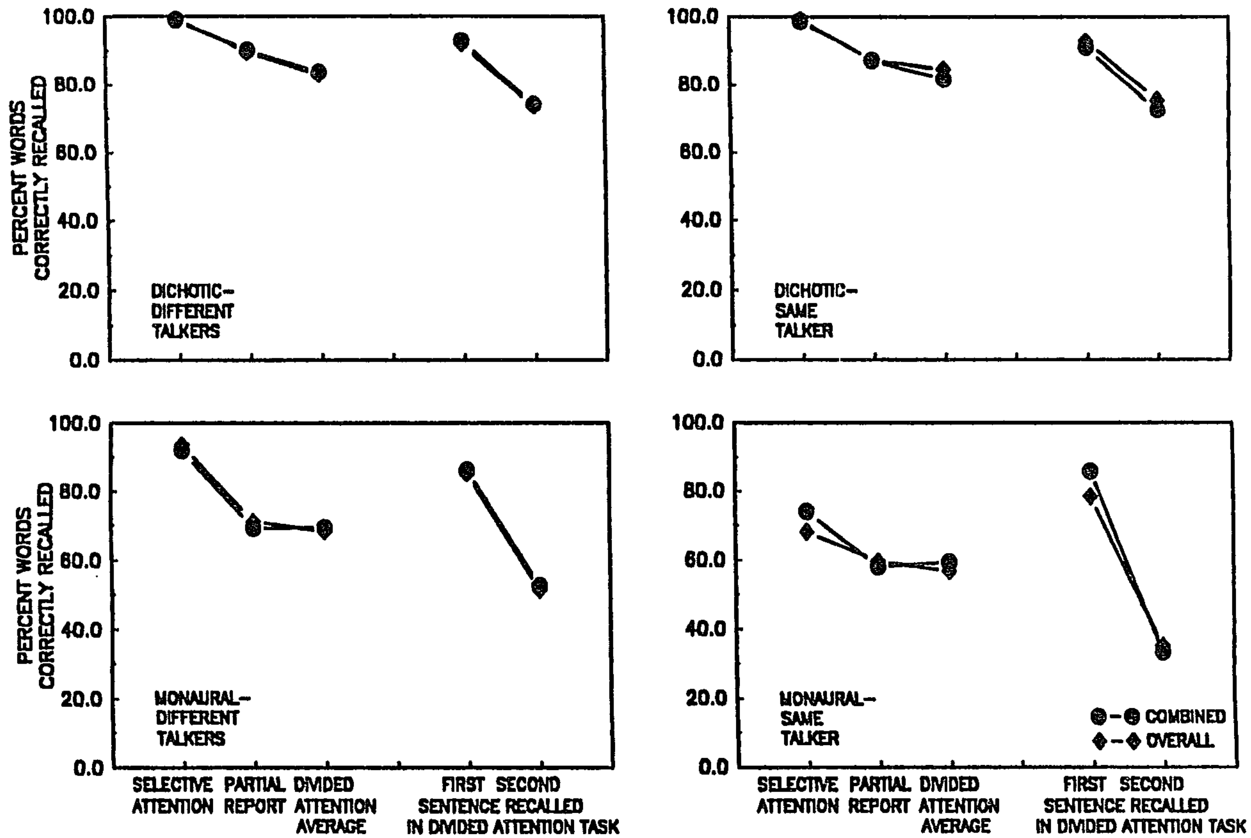

Figure 19. Comparison of overall group means (i.e., collapsed over all recording combinations) versus the combined means (i.e., when the unequally filtered means in each test condition were combined).

in the unequally filtered condition when subjects chose to recall the old sentence last (25.6%) or the divided attention #2 scores in either of the equally filtered conditions (approximately 36% in either condition).

Discussion- Followup Study

Although the two recordings in this study differed in spectral quality it appears that the overall findings would not have been significantly different had only one recording been used. It was also noted that spectral quality had little or no impact on performance in the dichotic listening conditions. That is, subjects performed similarly regardless of which sentence recordings were paired and which sentence recording served as the target(s). And, even though differences in spectral quality affected performance in the monaural listening conditions, any gains evidenced when the target was the newly recorded sentence (or in the case of the divided attention task when subjects chose to recall the new sentence first) was generally counterbalanced by similar decrements in performance when the target sentence was from the old laserdisc (low-passed) recording. There was one exception to this pattern; subjects achieved a significantly higher divided attention average score when they chose to recall the old sentence first, followed by the new sentence. Interpretation of this finding is discussed later on in this section.

These results support an earlier finding by Egan, Carterette and Thwing (1954). In one experiment these researchers examined the effects of high-pass filtering of either the target or competing message in a selective attention task. The messages consisted of continuous discourse that were presented monaurally and spoken by the same talker. Egan et al. found that whatever gains resulted from filtering the interfering message was countered by a parallel drop in performance when the target message was filtered to a similar extent. This study not only supports Egan et. al's findings for selective attention but extends these findings by showing that a similar phenomenon occurs in partial report and divided attention as well.

As mentioned above, differences in spectral quality affected performance in the monaural listening conditions, especially when both the spatial and talker cues were removed. Subjects performed significantly better on both the selective and partial report tasks when the target sentence was from the new recording. One possible reason for this enhancement was that pairing a "new" target sentence with an "old" (low-passed) sentence, relative to sentences paired from the same recording, resulted in a significant number of critical bands with positive S/N ratios. This, in turn, would have resulted in less peripheral masking and improved performance. On the other hand, if the designated target had been from the old recording, then this would have resulted in an increased number of critical bands with negative S/N ratios, hence, greater peripheral masking and poorer performance.

Differences in the spectral quality between recordings also influenced the order in which subjects recalled sentences on the divided attention task in the monaural-same talker listening condition; subjects showed a great tendency to recall the newly recorded sentence first. However, this was not the most effective strategy since subjects achieved higher divided attention average scores when they recalled the new sentence last. These higher scores are probably due to the newly recorded sentences being subject to less peripheral masking; this would result in relatively strong acoustic traces, and, in turn, make these sentences more resistant to decay in short-term memory. This interpretation also helps to explain why subjects recalling the new sentence last in the unequally filtered condition would have achieved higher scores than those attained in the equally filtered conditions. In the equally filtered conditions, there would have been more mutual peripheral masking and weaker acoustic traces of either sentence.

CHAPTER 7: CONCEPTUALIZING THE RESULTS WITHIN THE FRAMEWORK OF AN INFORMATION PROCESSING MODEL

The purpose of this chapter is to review the information processing approach to speech perception and to interpret the results obtained in this study within this framework.

An information processing model attempts to conceptualize the various memory structures and psychological processes presumed to operate between the onset of the stimulus and an individual's response (Massaro, 1975; Hawkins and Presson, 1986). Massaro (1975) defines memory structures as storage components that hold information, while psychological processes are operations that involve the transformation of information from one memory structure to another. Because the listener is limited in the number of units "chunks" he or she can retain in short-term "conscious" memory (i.e., 7 +/- 2 chunks; Miller, 1956), two important processes are engaged. The first process is that of attention- the ability to selectively focus on the stimuli of interest and ignore irrelevant competing stimuli, hence, limiting the amount of input processed to resolution. The second process involves the individual's ability to recode information into ever larger chunks; that is, at successively higher stages in processing, increasingly greater amounts of informational content are retained per unit (Miller, 1957). For example, the letters "C-A-T" or "D-O-G" consist of three chunks of information. However, over time the individual learns to recode the letters into one unit, hence, increase the amount of information contained per chunk.

Figure 20 highlights the author's conceptualization of the main components of an auditory information-processing model as derived from a number of sources (Massaro, 1975; Massaro and Cohen, 1975; Klatzky, 1984; Gregg, 1986; Hawkins and Presson, 1986; Wyer and Srull, 1989). The boxes represent memory structures, while the arrows represent psychological processes.

The acoustic stimulus is first transformed mechanically, hydraulically, and electrically via the middle ear, cochlea, and central auditory nervous system. Featural information such as intensity, frequency, and timing is extracted from the electrical representations. Because recognition of an auditory stimulus is not immediate it must somehow be stored; initially, this is thought to occur in preperceptual auditory storage- often referred to as echoic memory (Massaro, 1975; Massaro and Cohen, 1975; Gregg, 1986; Hawkins and Presson, 1986).

The duration of preperceptual acoustical storage has been investigated by a number of researchers (Massaro, 1970; Massaro, 1972; Massaro and Cohen, 1975; Hawkins and Presson, 1986; Gregg, 1986). Massaro (1970, 1972) did a number of experiments in which subjects had to identify a target stimulus on the basis of either pitch, loudness, or duration. Target stimuli of 20-50 milliseconds duration were followed by masking stimuli at intervals between 0 and 500 milliseconds following the offset of the target (i.e., a backward masking paradigm). The results showed a subject's ability to identify the target stimulus correctly was initially quite poor but rose steadily as the interval was lengthened to 250 milliseconds. After 250 milliseconds, the mask had no deleterious effect on performance. Massaro concluded that presenting a masking stimulus prior to 250 milliseconds post-target offset serves to disrupt the internalization of various physical parameters. In turn, the individual is unable to characterize a stimulus on the basis of pitch, intensity or durational features. Gregg (1986) suggested that up to

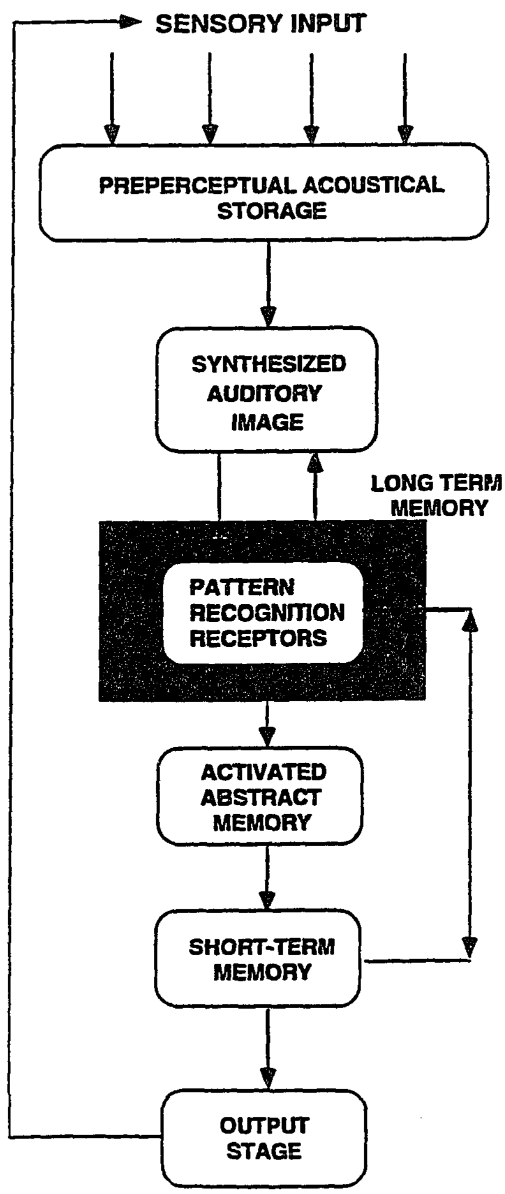

Figure 20. The author's conceptualization of the main components of an auditory information processing model.

250 milliseconds the results are consistent with the target stimulus being represented in an acoustic code. After approximately 250 milliseconds the acoustic trace of the target stimulus decays and is transformed into some other representation.

Massaro (1976b) summarized a number of experiments he conducted in which he showed that the preperceptual auditory store is a buffer with only one central storage channel; that is, inputs to the two ears converge onto one central preperceptual store. In one backward masking study Massaro found that masking stimuli were equally effective up to 250 milliseconds post-target offset, regardless of: (a) physical similarity between target and masker, (b) duration of the masker, (c) whether the masker was presented ipsilaterally or contralaterally to the target stimulus, or (d) whether subjects allocated any attention to the task. For example, in some test conditions the subjects were not told beforehand in which ear the masking stimulus would be presented (i.e., ipsilateral versus contralateral to the target stimulus), while in other conditions the subjects were aware of which ear the masking stimulus would occur. Similar levels of performance were attained up to 250 milliseconds post-target offset, regardless of the attention condition and masker location.

However, this was not true of performance for masking stimuli presented at intervals greater than 250 milliseconds where both factors were observed to affect performance. Thus, it appears that attentional mechanisms and masker location do not exert any influence at the preperceptual auditory storage level.

In the next stage, the featural content within the preperceptual auditory store is combined and transformed into a synthesized percept and stored in synthesized auditory memory (Massaro, 1975). In contrast to preperceptual auditory storage, synthesized auditory memory is organized along separate channels such as spatial location, intonation and intensity, which, in turn, allow the individual to identify the location, pitch, and loudness of a stimulus.

A number of studies have disassociated synthesized auditory memory from the preperceptual auditory store. As mentioned earlier, Massaro (1976b) showed that for intervals up to approximately 250 milliseconds, masking effectiveness depends greatly on the time lapse between target offset and masking onset and not on the physical similarity of the target and masking stimuli. In addition, Massaro showed that attentional mechanisms do not affect performance during this time frame. However, at intervals greater than 250 milliseconds, Massaro found that physical similarity and attentional mechanisms did affect performance. For example, Massaro examined subjects' memory for pitch via a delayed comparison task. The time lapse between target offset and masker onset exceeded 250 milliseconds on this task. Observers were presented with a standard tone, followed by an intervening tone (i.e., the masker), followed by a comparison tone. Subjects had to state whether the comparison tone was the same or different in pitch as the standard tone. Massaro found that masker duration and masker similarity did impact on performance on the delayed comparison task; that is, the longer the masker duration and the greater the physical similarity between the masker and standard tones, the worse the performance. Massaro interpreted these and earlier findings to indicate that masking stimuli, beyond a minimal duration, exert their effects on: (a) preperceptual auditory storage (i.e., at post-offset intervals less than 250 milliseconds) by terminating the processing of the test tone, regardless of physical similarity and attentional mechanisms, and (b) synthesized auditory memory (i.e., at post-offset intervals greater than 250 milliseconds) by influencing the subsequent forgetting of the standard tone, since, only after this time frame do physical similarity and attention affect performance.

The next examples illustrate how synthesized auditory memory can be dissociated from higher order memory traces. Cherry (1953) and Treisman (1970) conducted shadowing studies in which subjects were required to repeat all words from one of two dichotically presented connected speech passages at the same time that these passages were being presented. When subjects were asked on a random basis to recall any of the verbal content from the irrelevant competing message, subjects were unable to do so. However, subjects were able to recall whether the competing passage had consisted of speech and if the passage had been spoken by a male or female. Therefore, subjects were able to recall the intonational patterns and fundamental frequency contours of speech even though they were unable to recall any of the linguistic content.

Massaro (1975) summarized the results from an earlier experiment by Bryden (1971) in order to present evidence of the relative independence of synthesized auditory memory from higher order abstract memory. In Bryden's study, subjects listened to 4 digit pairs presented dichotically at a rate of 2 pairs/second. Subjects were told to attend to items in only one of the ears. One group of subjects was required to recall the attended items first, while a second group was told to recall the unattended items first. Significantly better results were achieved for the attended items, regardless of whether the lists were recalled first or second. Massaro interpreted this to indicate that the attended digits were stored differently than the unattended digits. He concluded that the names of the attended digits were transferred from synthesized auditory memory into a higher order abstract memory, hence, subjects could retrieve the names of the attended digits directly. On the other hand, the names of the unattended digits remained in synthesized auditory memory; subsequent retrieval of the unattended digits required their transfer from synthesized auditory memory to higher order abstract memory. The rapid forgetting of the unattended items indicated that the capacity of synthesized auditory memory was under four items. It should be noted that Massaro's conclusion regarding synthesized auditory memory capacity might actually reflect the capacity of a higher order memory (i.e., activated abstract memory), a topic to be discussed later.

The next stage involves the physchological process known as "pattern recognition". In this process, the synthesized auditory percept is compared to stored knowledge in long-term memory, that is, prototypes, which, in turn, consist of various features or properties (Klatzky, 1984; Glover, Ronning, and Bruning, 1990; Massaro, 1992). Activation of the stored percept appears to be determined by the interaction of a number of factors and include: (a) the strength of the stimulus, (b) the activation threshold of the unit stored in long-term memory (for example, well learned patterns have lower activation thresholds than those involving infrequent stimulation), (c) the linguistic and "world" context preceding/following the stimulus, (d) the subject's expectations, and (e) the amount of focal attention given to that particular stimulus.

Massaro (1987, 1992) proposed that the perceiver processes the stimulus on a number of independent dimensions and that perceptual identification and interpretation results from the best match between the stimulus and the various stored alternatives. Note that the derived percept is not fixed and is subject to review and change depending on the results of continued processing of later information.

Depending on the amount of activation and/or continued attention, the activated patterns can reside momentarily at a pre-conscious level (i.e., at a level still below consciousness) or be accessible to on-line awareness (i.e., working memory). For the purpose of this paper, this pre-conscious state will be called activated abstract memory. There is much evidence supporting the existence of activated abstract memory (for example, the use of subliminal perception to elicit responses without the individual's conscious awareness).

One early study demonstrating the existence of activated abstract memory was that done by Treisman (1960). Subjects listened to connected discourse passages, spoken by the same speaker and presented dichotically. The passages differed in topic. Subjects were told to selectively attend to and shadow the passage heard in one ear and ignore the irrelevant passage in the competing ear. During the course of presentation, the passage being shadowed was switched to the other ear and the irrelevant message switched to the target ear. Treisman found that subjects tended to switch momentarily to the irrelevant ear and to repeat a number of words before switching back to the target ear (i.e., the words in the irrelevant ear were contiguous with the passage heard originally in the target ear and, momentarily, were of a higher probability and a lower activation threshold than the passage now heard in the target ear). In almost all cases, Treisman found that subjects had been oblivious to the switch. Treisman concluded that words presented in the unattended ear can be processed to a semantic level without reaching conscious awareness.

Corteen and Wood (1972) did a study in which subjects were first given a series of trials in which an electric shock was associated with the presentation of city names. The subjects then completed a dichotic listening task in which they shadowed a passage in one ear, while the city names were occasionally embedded in a sequence of unrelated words in the other "nonattended" ear. Galvanic skin responses (GSR) were taken during the dichotic listening study. Corteen and Wood found large GSRs for the presentations of city names even though subjects were oblivious to the words presented in the unattended ear. This suggests that the meanings of the unattended items had been activated without awareness.

Another compelling demonstration of the automaticity of processing for highly familiar words is illustrated by the "Stroop" phenomenon (Stroop, 1935; cited in Klatzky, 1984). Stroop asked subjects to name the color of ink in which words were printed and measured their naming time. When the words themselves were of a different color (for example, the word blue printed in a red background), Stroop found that color-naming times increased, relative to those obtained when neutral words were used. This occurred even when subjects were told to ignore the written words. Hence, the reading of the word was automatic (i.e., without attention) and interfered with the naming of the color.

The above studies indicate that incoming stimuli can be processed to meaning without attentional allocation and without reaching consciousness.

Much confusion exists regarding the relative time domains of synthesized auditory memory and activated abstract memory. For the purpose of this paper the time course of these two memory constructs will be combined and discussed under the heading of "perceptual memory" (Massaro, 1975). In discussing the time course of perceptual memory we need to differentiate between the amount of time normally required to activate stored patterns from long-term memory versus the maximum duration of perceptual memory (i.e., the duration in which an activated perceptual trace can remain in memory without any attention being devoted to it).

Studies of event related potentials (ERP), specifically that of the P300, have been used to measure the processing demands of various tasks as well as providing us with additional information regarding various cognitive processes. The P300 is usually elicited using the "oddball" paradigm. In this paradigm, the subject is told to attend to an infrequently occurring task-relevant stimulus and to ignore the irrelevant stimulus. Attention to the oddball stimulus has been shown to elicit an evoked potential at approximately 300 milliseconds after stimulus onset, while frequently occurring stimuli or inattention to the oddball do not elicit the P300. The subject's response task can vary, depending on the variable the researcher wishes to examine. An example of one type of experiment has involved subjects counting the number of instances in which words have belonged to an infrequently occurring semantic category. To accomplish this task, the subject must first recognize the word, determine the category to which that word belongs, and then increase the count if the word belongs to the infrequent category. Perceptually, the stored patterns corresponding to the stimuli must not only be activated from long-term memory but, in turn, they must also be processed to short-term memory (i.e., the activated trace must reach the level of awareness). The latency of the P300 on this task has been shown to occur in the range of 300 to 750 milliseconds, depending on the task difficulty and, in turn, the attentional efforts required on the task (Gopher and Donchin, 1986). Since the P300 occurs only when the subject has determined that a particular target word belongs to the designated semantic category, this finding would suggest that subjects must have processed the target stimulus to short-term memory before the P300 could be elicited. Because perceptual memory occurs earlier in time than short-term memory, stored patterns must be activated at even shorter intervals than those evidenced by the P300.

A number of studies have looked at the maximum duration in which items presented in the non-attended channel are still accessible for recall. In one study, Treisman (1964b) presented identical but asynchronous messages, one to each ear. Subjects were required to shadow the message coming in one ear. Treisman varied the delay between the messages arriving in the shadowed and unattended ears. Treisman found that most subjects identified the rejected message as being identical to the attended message when the attended message led the rejected message by as much as 5 seconds. However, when the rejected message led in time the two messages had to be brought significantly closer together, to approximately 1.5 seconds, before subjects identified the two passages as being identical. It is likely that when the attended material was presented first, it resulted in relatively strong memory traces that were easily triggered by the subsequent presentation of identical material in the unattended channel. However, presenting the material initially to the unattended channel is probably a better indicator of the maximum duration of perceptual memory because it reflects how long an activated trace can remain in memory without any allocation of attention.

Glucksberg and Cowen (1970) conducted a dichotic listening task, whereby, subjects shadowed prose in one ear and after delays ranging from 0.3 to 20.3 seconds the subjects were asked to recall single digits embedded in prose in the unattended ear. Performance decreased significantly from 0 to 5 seconds delay with no memory for the nonattended material after 5 seconds. Glucksberg and Cohen concluded the data indicated that verbal material presented auditorily to the nonattended channel persists briefly but then fades rapidly from memory. Thus, it appears from this study and the Treisman (1964b) study that stimuli can persist in perceptual memory up to five seconds post-offset.

As mentioned earlier, Massaro (1975), based on the earlier work by Bryden (1971) regarding attended versus unattended items, concluded that the capacity of synthesized auditory memory was less than four items. However, it is likely that subjects on this task had actually processed the unattended digits to the level of activated abstract memory. If this assumption is correct, then this would suggest that the capacity of the perceptual memory span (be it synthesized auditory memory or activated abstract memory) is less than four items and is less than the capacity of short-term memory.

The last storage stage, prior to the subject initiating a response, is that of short-term memory- also known as working memory. Short-term memory is thought to be the stage where information that has been processed from incoming stimuli or been retrieved from long-term memory is accessible to the individual (i.e., within the individual's awareness). Factors influencing the information that is stored as well as the span of apprehension (i.e., the maximum number of units retained) include: (a) attentional allocation, (b) rehearsal (i.e., strategies that maintain items and slow down its decay in working memory),

(c) articulatory difficulty of input, (d) familiarity of material, and (e) accuracy and efficiency of retrieval from long-term memory (Miller, 1956; Massaro, 1975; Broadbent, 1984; Klatzky, 1988). As mentioned earlier, Miller (1956) has shown that the adult short-term memory span for familiar material is on the order of 7 +/- 2 units; it should be noted that the memory span for unfamiliar material is significantly lower. The larger memory span in short-term memory (versus perceptual memory) is probably due to the conscious utilization of rehearsal strategies in recycling and maintaining the images.

Some additional concepts need to be defined before the results from this study can be interpreted within the framework of an information processing model. These include: limited-capacity processor, attentional allocation, and mental workload. Numerous researchers have proposed that the human perceiver has a limited capacity in which to process incoming stimuli (Miller, 1956; Broadbent, 1958; Kahneman, 1973). The importance of attentional allocation is that it allows the human perceiver to focus selectively on a limited amount of information at any one point in time, hence, maximizing the extent to which the target information will be processed and stored. Only the information that is deemed relevant will be attended to and processed.

Mental workload refers to the amount of mental energy expended on a task (Kahneman, 1973; Gopher and Donchin, 1986). Numerous factors determine the amount of workload expended, including: (a) the human perceiver's familiarity with the task, (b) the amount of information to be processed over a specific time frame, (c) the discriminability of the stimulus, and (d) the amount of "noise" embedded in the stimulus. Hence, the extent to which mental energy must be expended as well as the perceiver's capacity to process information will determine whether the task will be completed in entirety.

The following discussion represent the author's conceptualization of the processes thought to occur when a subject is asked to listen to two competing sentences and is engaged in either a selective attention, divided attention, or partial report task.

Figure 21 details the processes thought to take place in the selective attention task. The first process, regardless of recall task, involves the transduction of the acoustic representation of both competing sentences into sensory input. Featural content is extracted and stored in preperceptual acoustic storage. As mentioned earlier, Massaro (1976b) has shown that attention does not influence the primary reception process, hence, attentional allocation does not influence what is stored in preperceptual acoustical storage.

In the next stage, synthesized auditory images are generated. These are then compared with pattern recognition receptors (prototypes) in long-term memory. Attentional allocation to the target sentence increases the likelihood that corresponding stored patterns will be activated from long-term memory (however, other factors such as priming, familiarity of stimulus and emotional importance of input can also influence the activation of stored patterns). Continued focusing of attention on the target sentence results in the transfer of items from perceptual to short-term memory (i.e., items become accessible for recall). On the other hand, any activated representations in the unattended channel soon decay from perceptual memory.

As noted in the results section (Chapter 4), subjects on the selective attention task were able to achieve near perfect performance in both dichotic listening conditions

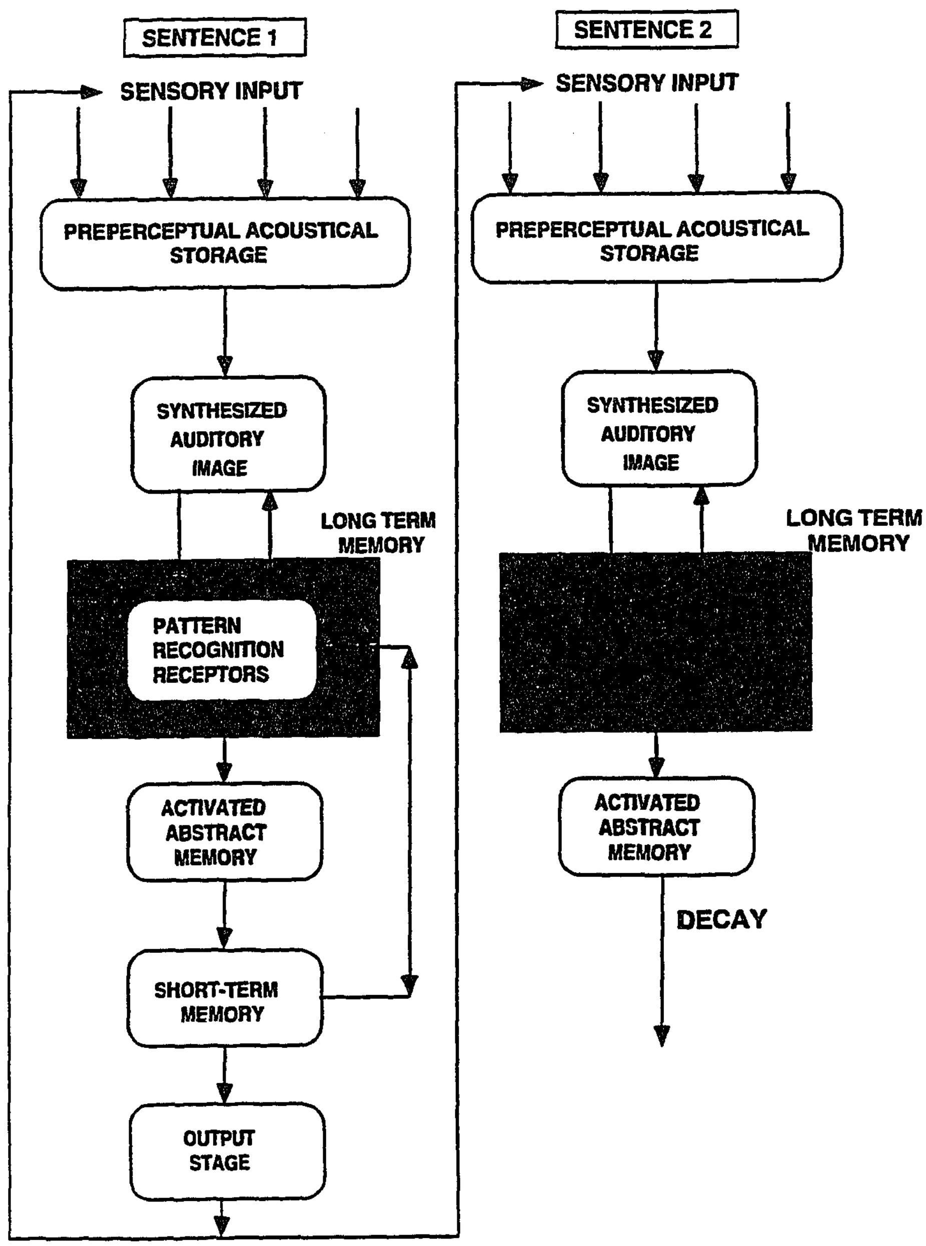

Figure 21. The memory constructs and processing stages thought to occur in the selective attention task.

and in the monaural-different talkers listening condition. In both dichotic listening conditions subjects had to focus their attention only to the target ear and ignore what was heard in the other ear. The listening task was slightly more difficult in the monaural-different talkers condition; subjects had to allocate their attention to one ear and separate perceptually the target and competing sentence on the basis of talker cues. As a result, peripheral masking was introduced in this listening condition. Nevertheless, the presence of the talker cue allowed subjects to overcome the peripheral masking and to disambiguate the target from the irrelevant sentence quite easily. Although this listening condition probably increased the mental workload it did not affect performance, as measured by the percentage of words repeated correctly.

On the other hand, subjects performed significantly poorer on the selective attention task in the monaural-same talker listening condition. This is probably due to a combination of factors. First, this listening condition would have resulted in a high degree of peripheral masking. This would have led to incomplete feature extraction and, ultimately, the generation of incomplete synthesized auditory images. In addition, this listening condition would have resulted in the least perceptual distance between incoming stimuli and, in turn, maximum interference masking. Second, the ensuing ambiguities would have made it difficult, if not impossible, to match all incoming stimuli with stored prototypes, hence, resulting in increased processing time and mental effort. Third, it is likely that many of the activated stored patterns resulted in weak perceptual traces, subsequently, making them more prone to masking and decay. Last, subjects had to process both sentences until sufficient linguistic context had been derived before they could determine the target sentence on the basis of topic; only then, could subjects focus solely on the target sentence. Therefore, subjects had to process a greater amount of information than in the other listening conditions.

The fact that subjects were able to selectively attend to and recall a significant proportion of the target sentence, even in the absence of talker and spatial cues, indicates that the remaining short-term spectral and suprasegmental acoustic cues allowed for some feature extraction and, in turn, activation of some stored patterns. It is likely that these activated patterns then primed closely associated neuronal networks (i.e., they lowered the activation thresholds of other closely associated stored patterns) and made it easier for those stored patterns to be activated by later incoming stimuli. In addition, linguistic context would have allowed subjects to fill in many of the missing details.

Figure 22 details the processes thought to occur on the divided attention task. The divided attention task engages essentially the same processing and memory stages used to recall a target sentence on the selective attention task, except that both competing sentences must now be recalled. This necessitates the subject having to recall one sentence, while holding the second sentence in memory, and, then recall the second sentence. Repeating the first sentence likely interferes with storage of the second sentence by preventing the individual from using rehearsal strategies and by introducing some auditory and linguistic interference. The fact that subjects were able to recall almost all words of the second sentence on short sentences in both dichotic listening conditions suggests that rehearsal is probably more crucial in the recall of longer sentences since they are more prone to decay.

One question that needs to be addressed at this point is: at what level of memory is the second sentence stored during recall of the first sentence? We know that subjects

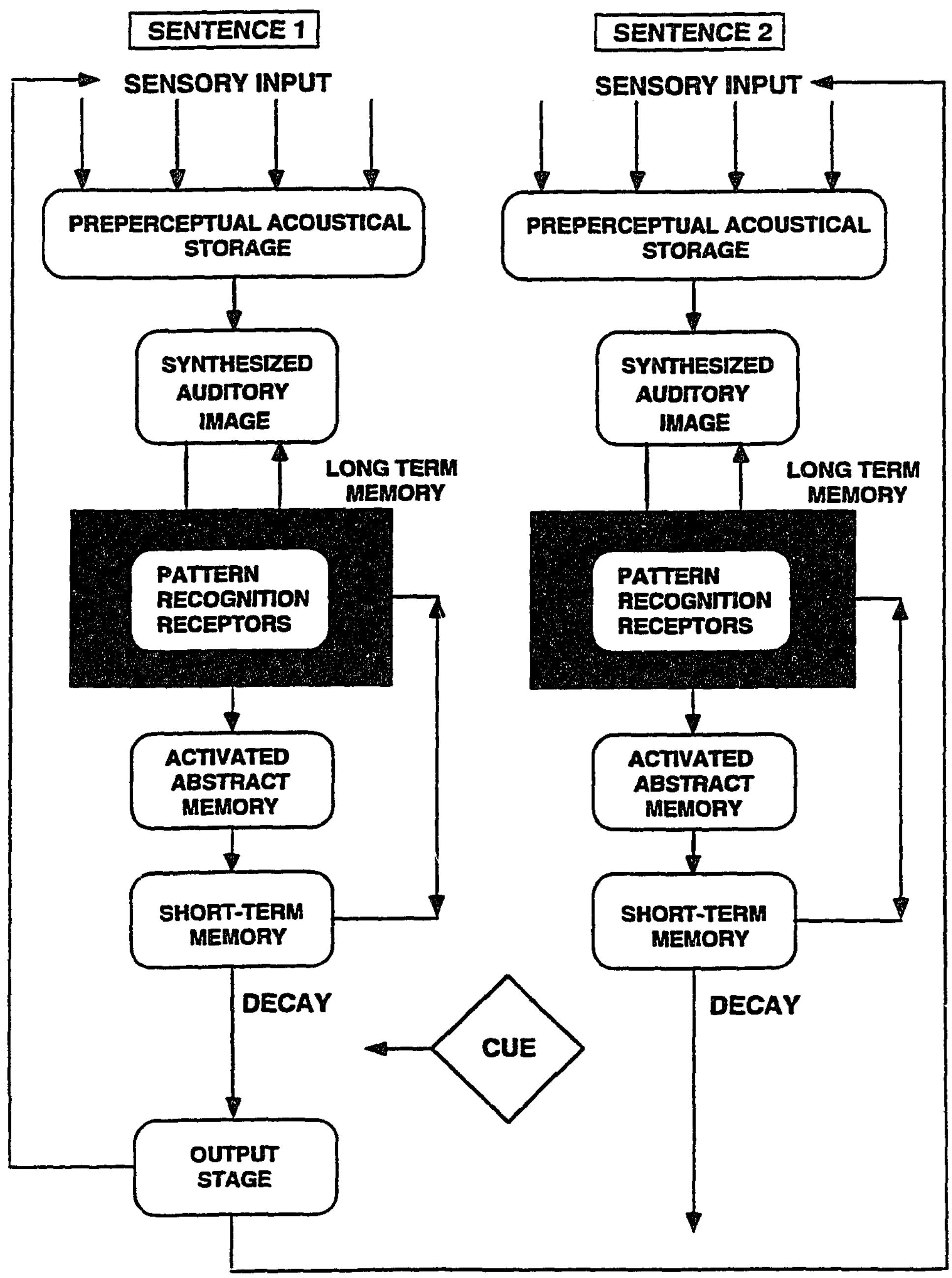

Figure 23. The memory constructs and processing stages thought to occur in the partial report task.

could not have maintained the second sentence in sensory memory since its duration is on the order of 250 milliseconds and sentences varied from one to six seconds in duration. It is also unlikely that individuals retained sentence information at the level of synthesized auditory memory. At this level the information is stored in units of combined acoustic features, thus, making it unlikely that these units can be grouped into larger chunks. In addition, subjects would have been unable to retain sentences longer than 4 or 5 words in synthesized auditory memory since the maximum storage capacity for synthesized auditory memory is less than 4 units. On the other hand, activated abstract memory entails the activation of stored patterns in long-term memory. These activated patterns are likely associated with other stored patterns, via neuronal associations, and can possibly be chunked into larger sized units. Hence, it appears that both sentences on the divided attention task had to have been processed to at least the level of activated abstract memory.

The next question is the degree to which both competing sentences were processed during actual presentation. Any one of a number of scenarios could have occurred. First, subjects processed all words in both sentences to activated abstract memory. They then focused their attention to one sentence, subsequently, transferring the activated traces to short-term memory for recall. After recalling the first sentence, the subjects then turned their attention to the second sentence, still held in perceptual memory, for subsequent transfer to working memory and eventual recall. One problem with this scenario is that for medium and long sentences, subjects would have had to maintain at least a total of 6-8 chunks of information in perceptual memory, an amount that would have exceeded its capacity.

A second possibility is that subjects focused their attention solely to one sentence during the presentation, transferring the words on-line to short-term memory. Subjects proceeded to recall this sentence first and, subsequently, switched their attention to the other ear for the purpose of retrieving information from activated abstract memory.

A third alternative is that subjects attended to and processed the words in real time from both sentences to short-term memory. They then proceeded to recall one sentence, while holding the other sentence in short-term memory, then recalled the second sentence.

In an attempt to address this issue, this researcher asked five subjects after the study to indicate, via introspection, how they processed and recalled sentences on the divided attention task in the dichotic-different talkers condition. The subjects indicated that they listened to and recognized words from both sentences during the course of presentation. This suggests that subjects were dividing their attention and processing both sentences on-line to short-term memory. It should also be noted that some of these subjects indicated they often missed at least some words from one or both sentences during the presentation and attempted to fill in the missing information upon completion of the presentation.

A number of other findings on the divided attention task have pertinence to information processing theory. First, in both dichotic listening conditions subjects were able to recall at least 90% of the words from both sentences, even for medium sentences (i.e., 7 to 10 words long). Hence, subjects were quite capable of attending to and processing separate acoustic streams (either in parallel, or, via switching back and forth between streams). Second, subjects were able to recall at least 75% of the words from at least one sentence in the same talker-same ear listening condition, regardless of sentence length. Therefore, subjects had sufficient short-term acoustic and linguistic information to disambiguate the two acoustic streams and to process at least one sentence quite accurately to short-term memory; however, this occurred at the expense of processing and recalling the second sentence.

Figure 23 details the processes engaged in partial report. These processes are essentially the same as those involved in divided attention with one major difference. That is, once subjects have been cued to the target sentence upon completion of presentation, they are then able to allocate all resources to recalling the target sentence and the second sentence is allowed to decay from memory.

In summary, from an information processing perspective the importance of the talker and, especially, the spatial cue, in a competing sentence task is that both cues appear to enhance the extraction of acoustic features as well as increase the perceptual distance between the two incoming acoustic streams. In turn, this facilitates the process by which stored prototypes are matched with incoming stimuli, ultimately leading to decreased processing time and memory load on the task. The fact that subjects are still able to recall a significant proportion of words from the target sentence(s), even in the absence of these cues, highlights the subject's ability to reconstruct sentences on the basis of the remaining short-term acoustic and linguistic cues.

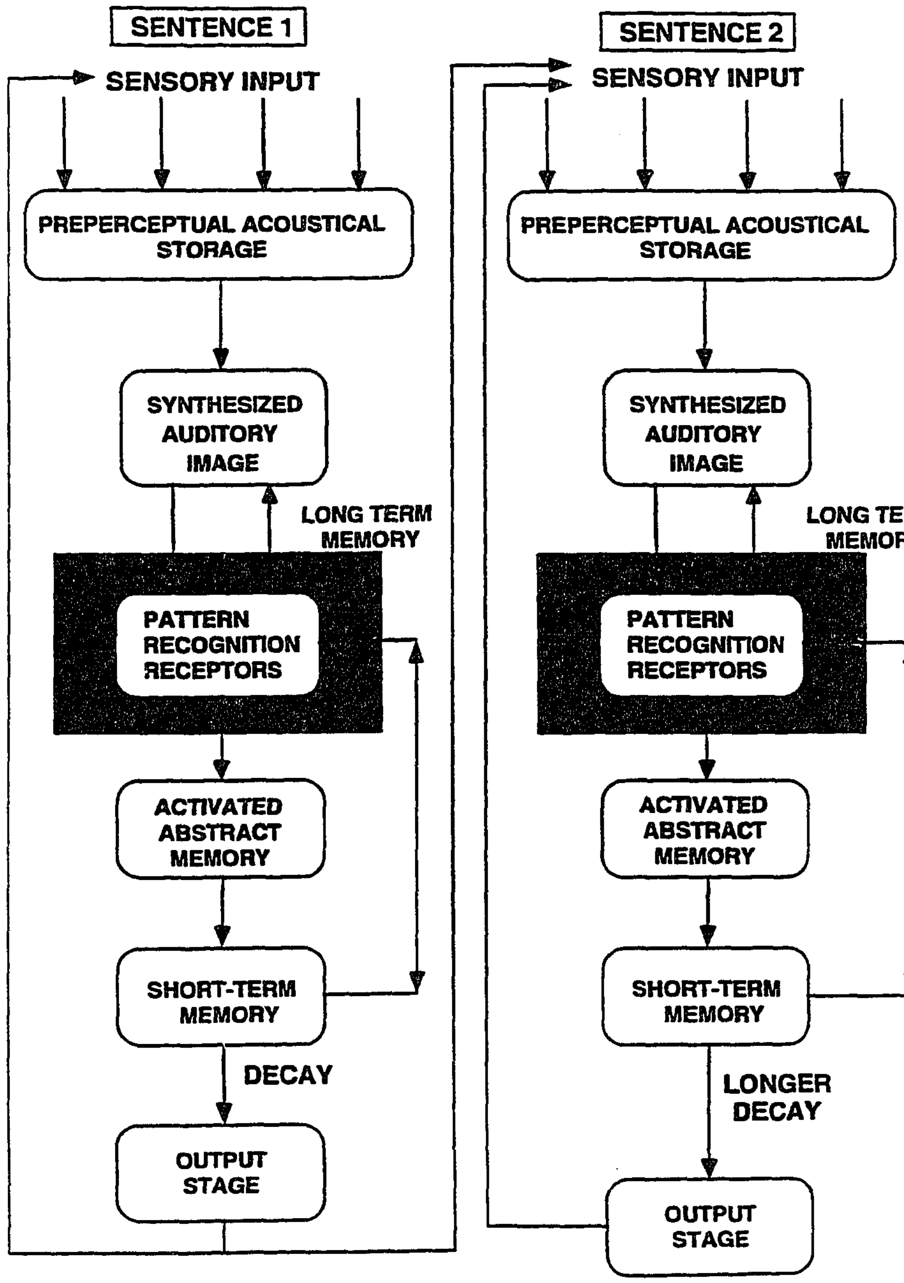

Figure 22. The memory constructs and processing stages thought to occur in the divided attention task.

CHAPTER 8: SUMMARY, CONCLUSIONS AND FUTURE RESEARCH

The purpose of this study was to assess the importance of both talker and spatial cues in three different auditory attention tasks (selective attention, partial report and divided attention). Sentence materials were used to increase the generalizability to everyday listening situations. Subjects listened to two sentences presented from: (a) different talkers in different ears, (b) the same talker in different ears, (c) different talkers in the same ear, and (d) the same talker in the same ear.

Subjects performed best on all recall tasks when the spatial cue was present; in fact, adding the talker identity cue, when the spatial cue was already present, resulted in little or no improvement in performance in most test conditions. Overall performance dropped slightly when the spatial cue was removed; however, subjects still achieved very accurate performance when only the talker cue was present. This suggests that adding the talker cue facilitated performance when no other distinctive acoustic cue was present, but, the extent of this improvement was not as great as when the spatial cue was present. In the absence of both spatial and talker cues, performance did falter. Nevertheless, subjects were still able to recall a significant portion of each sentence, especially on short sentences.

The degree to which subjects successfully attended to and recalled a target sentence(s) also varied as a function of recall task. On the selective attention task, subjects achieved near perfect performance, regardless of sentence length, when either acoustic cue was present. In the absence of either acoustic cue, performance dropped significantly. The absence of both the spatial and talker cues appears to have fundamentally altered the subject's task. That is, when either acoustic cue was present, subjects were able to focus their attention on the target sentence from the onset of presentation. In the absence of these cues, subjects had no way knowing which sentence was the target, hence, they had to process both sentences until they derived enough linguistic evidence for determining the topic of the target sentence (this made the subject's task somewhat analogous to that of partial report and helps to account for the similarity in performance at the shorter sentence lengths). From only that point on, could subjects focus solely on the target sentence.

Subjects also performed significantly better on the partial report and divided attention tasks when either the spatial and/or talker cue(s) were present. In fact, on short sentences, subjects achieved near perfect performance on both of these tasks. Increasing the sentence length, however, resulted in a gradual decrease in performance. This pattern contrasts with that observed on the selective attention task; that is, when either the spatial and/or talker cue was present on the selective attention task, subjects maintained near perfect performance, regardless of sentence length. Because subjects had to process twice as many words on both the partial report and divided attention tasks, as compared to the selective attention task, the decrease in performance with increased sentence length may simply reflect the increased memory load.

Another interesting finding was that when spatial and talker cues were removed on the divided attention task, subjects were still able to repeat the first sentence very accurately, even on long sentences. This suggests that subjects were able to separate perceptually the two competing sentences quite easily on the basis of the linguistic context and the remaining short-term acoustic cues. However, this was not without cost since subjects consistently performed poorest on divided attention #2 (i.e., in the recall of the second sentence) than on any other recall task.

In summary, the results in this study support many of the earlier findings by earlier researchers. That is, subjects performed best when the spatial cue was present. In the absence of the spatial cue, adding the talker cue facilitated performance, although not the same extent as the spatial cue. In the absence of both acoustic cues, performance dropped significantly, however, subjects were still able to repeat a significant portion of the target message(s), especially on short sentences. The results in the monaural-same talker condition are much better than those reported earlier and is probably due to the use of competing sentence stimuli in this study versus those studies which either used impoverished linguistic stimuli, such as digits and nonsense syllables, or employed more mentally demanding tasks, such as, shadowing.

Because the competing stimuli in this study consisted of sentence material, the main findings from this study can be generalized to everyday listening situations. That is, individuals listening in natural situations to competing messages not only have access to spatial and talker cues but also to the linguistic context and short-term spectral cues present in spoken language.

Topics for possible future research

This study examined performance under listening conditions that represent the extremes for both spatial separation and talker cues; that is, only under earphones can a target message be completely isolated from a competing message. In everyday listening situations, an individual must attend to acoustic signals consisting of a mixture of both the target and competing sounds. Therefore, it is likely that the benefits of the spatial cue are not as dramatic in everyday life as has been shown in this study. It is also not known whether the benefits derived when competing sentences are spoken by talkers from different genders would hold or diminish when the competing talkers were of the same gender.

Subjects were able to recall at least one sentence remarkably well on the divided attention task (divided attention #1) in the absence of spatial and talker cues. However, because subjects had to recall both sentences on the divided attention task it is not known whether the divided attention #1 score, when both the spatial and talker cues have been removed, represents the listener's maximum ability in separating competing sentences perceptually. An additional test condition, whereby, subjects are asked to recall only the sentence of their choice on the divided attention task (i.e., unencumbered of trying to store and recall a second sentence) would be a better indicator of this ability.

The results regarding the pairing of sentences with different spectral quality needs to explored in a more systematic fashion. For example, what is the relationship between recall of the target sentence and the degree of filtering of the competing sentence and do similar functions occur for low- and high-pass filtering?

It would also be interesting to examine performance in each test condition over a large number of trials. Conclusions in this and in other studies have been usually based on a few replications. It is possible that performance would improve significantly in some of the more difficult test conditions if subjects had more experience in these novel listening conditions.

Last, this study examined the ability of normal listening subjects to attend to and recall target sentences on a variety of attention tasks and listening conditions. These results provide us with a baseline by which individual and group performance in both hearing impaired and learning disabled populations can be compared. The information gleaned from such studies would not only provide us with further information about disordered listening processes but also with useful information that could be used in the development of management strategies.

Appendix A. Items (and instructions) on the Edinburgh Handedness Inventory.

INSTRUCTIONS

Please indicate your preferences in the use of hands in the following activities by putting + in the appropriate column. Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, put ++. If in any case you are really indifferent put + in both columns.

Some of these activities require both hands. In these cases the part of the task, or object, or which hand preference is wanted is indicated in brackets.

Please try to answer all the questions and only leave a blank if you have no experience at all with the object or task.

	LEFT	RIGHT
1. Writing		
2. Drawing		
3. Throwing		
4. Scissors		
5. Toothbrush		
6. Knife (without fork)		
7. spoon		
8. Broom (upper hand)		
9. Striking a match		
10. Opening a box (lid)		

To find the laterality quotient, add up the number of + signs in each column. Subtract the number of + signs under Left from the number under Right, divide by the total number, and multiply by 100.

Appendix B. One list from the CUNY Topic Sentence Test.

Set 9:

Topic	Number of Words		Sentence
Food	11	1.	The desserts at that restaurant are very good but very expensive.
Family	3	2.	She's my daughter.
Work	6	3.	He doesn't like his new boss.
Clothes	13	4.	I bought three pairs of shoes and a pair of boots last week.
Animals	4	5.	Let the dog out.
Homes	9	6.	Move the couch to the wall facing the window.
Sports/ Hobbies	11	7.	If you want to take good pictures, take a photography class.
Weather	7	8.	Wear a heavy sweater since it's cold.
Health	14	9.	Do you go to a gym to exercise, or do you exercise at home?
Seasons/ Holidays	8	10.	Have you finished all your Christmas shopping yet?
Money	5	11.	Can I pay by cheque?
Music	10	12.	Do you think he'll play the piano at the party?

Appendix C. The number of question/statement sentence pairs and the mean duration, collapsed over sentences, for each sentence length. These are shown for the female/female (F/F) and female/male (F/M) sentence sets.

Sentence Lengths	F/F Q	F/F S	F/F Mean Dur.	F/M Q	F/M S	F/M Mean Dur.	(F/F)-(F/M) Diffs.
3	3	9	1.16	1	11	1.18	-.02
4	3	9	1.38	4	8	1.37	.01
5	2	10	1.62	3	9	1.60	.02
6	3	9	1.95	1	11	1.88	.07
7	5	7	2.20	5	7	2.14	.06
8	5	7	2.42	4	8	2.42	.00
9	5	7	2.65	3	9	2.67	-.02
10	4	8	3.03	3	9	3.03	.00
11	4	8	3.33	3	9	3.43	-.10
12	5	7	3.78	2	10	3.74	.04
13	4	8	3.88	3	9	3.94	-.06
14	5	7	4.36	1	11	4.36	.00
Totals	48	96		33	111		
Means	4.0	8.0	2.65	2.8	9.2	2.65	.00
SD	1.0	1.0		1.3	1.3		.03

Appendix D. The text for all sentence pairs in the Female/Female (FF) and Female/Male (F/M) sets. The number following FF or FM represents the number of words in each sentence.

FF3 SENTENCE TEXT

1	HEALTH	Where's the nurse?#3
2	ANIMALS	Where's your dog?
3	HEALTH	Brush your teeth.#3
4	ANIMALS	Feed the dog.
5	HOMES	Lock the door.#3
6	MONEY	Here's a quarter.
7	FAMILY	She's my daughter.#3
8	SEASONS/HOLIDAYS	Mow the lawn.
9	HEALTH	Take your medicine!#3
10	SEASONS/HOLIDAYS	Decorate the cake!
11	MUSIC	Play that song.#3
12	SEASONS/HOLIDAYS	Carve the turkey.
13	FAMILY	Where's your sister?#3
14	HOMES	Where's the bathroom?
15	SPORTS/LEISURE	Where's the football?#3
16	CLOTHES	Where's my jacket?
17	WORK	Here's my office.#3
18	FOOD	I like peas.
19	FOOD	Cake is sweet.#3
20	MUSIC	It's my guitar.
21	SPORTS/LEISURE	I like baseball.#3
22	MUSIC	Record the concert!
23	CLOTHES	Polish your shoes!#3
24	WORK	Hire a secretary!

FF4 SENTENCE TEXT

1	SEASONS/HOLIDAYS	What day is Easter?#4
2	SPORTS/LEISURE	Does he still run?
3	HOMES	Does the roof leak?#4
4	CLOTHES	Is that coat new?
5	WORK	I quit my job.#4
6	WEATHER	Put on your raincoat.
7	WORK	The office is busy.#4
8	CLOTHES	That's my new dress.
9	WORK	Don't be late today.#4
10	FAMILY	The baby is crying.
11	FOOD	The dip is spicy.#4
12	WEATHER	It will snow today.
13	HEALTH	She has a fever.#4
14	MUSIC	Turn the radio off.
15	WEATHER	How much snow fell?#4
16	HEALTH	Have you had headaches?
17	CLOTHES	I dyed the shoes.#4
18	HOMES	I waxed the floor.
19	SEASONS/HOLIDAYS	Please wrap the presents!#4
20	CLOTHES	Buy those snow boots!
21	FAMILY	Feed the baby, please!#4
22	WORK	The typewriter is broken.
23	SEASONS/HOLIDAYS	Mail your Christmas cards.#4
24	MONEY	That place is expensive.

FF5 SENTENCE TEXT

1	FOOD	Give the dog a bone!#5
2	SPORTS/LEISURE	Pass the ball to him!
3	MUSIC	Do you play the guitar?#5
4	MONEY	How much is the bill?
5	HEALTH	He should floss his teeth.#5
6	FOOD	She never eats red meat.
7	CLOTHES	Hang up your good suit.#5
8	ANIMALS	I never saw a bear.
9	FAMILY	Is your sister in school?#5
10	CLOTHES	Where are my new pants?
11	SPORTS/LEISURE	I like to play tennis.#5
12	ANIMALS	That dog likes to run.
13	SEASONS/HOLIDAYS	We marched on Columbus day.#5
14	ANIMALS	Goldfish are easy to keep.
15	HOMES	We're looking for an apartment.#5
16	MONEY	We'll pay the telephone bill.
17	SPORTS/LEISURE	Cancel the match for tomorrow!#5
18	HEALTH	She has the chicken pox.
19	HOMES	Wash and dry the dishes.#5
20	MUSIC	The drummer was too loud.
21	WEATHER	It's very warm out tonight.#5
22	WORK	Don't take a long lunch.
23	FAMILY	Visit your grandmother on Sunday.#5
24	HOMES	The kitchen needs new wallpaper.

FF6 SENTENCE TEXT

1	ANIMALS	Did you buy a flea collar?#6
2	SPORTS/LEISURE	Do you like to go fishing?
3	SEASONS/HOLIDAYS	Put these lights on the tree.#6
4	ANIMALS	Take the dog for a walk.
5	HOMES	How many bedrooms do you have?.#6
6	CLOTHES	Can I borrow your red sweater?
7	SPORTS/LEISURE	How many laps did he swim?#6
8	ANIMALS	When did your dog get sick?
9	HEALTH	Cover your mouth when you cough.#6
10	CLOTHES	This shirt shrunk in the wash.
11	MUSIC	I really like that new album.#6
12	FAMILY	No one likes to change diapers.
13	HOMES	They bought a new carpet yesterday.#6
14	WORK	Type that letter before you leave!
15	FAMILY	Help your sister with her homework!#6
16	MONEY	I think I have some change.
17	ANIMALS	Don't pet that big black dog.#6
18	FOOD	Eat all of your green vegetables!
19	HEALTH	Smoking is bad for your lungs.#6
20	MUSIC	Put your albums where they belong.
21	SEASONS/HOLIDAYS	I like New Year's Eve parties.#6
22	ANIMALS	The dog barked too loudly yesterday.
23	HEALTH	Take these pills every eight hours!#6
24	SEASONS/HOLIDAYS	I always eat alot on Thanksgiving.

FF7 SENTENCE TEXT

1	CLOTHES	Did you buy a bathing suit yet?#7
2	WORK	Did your boss give you a raise?
3	WORK	When will you be taking your vacation?#7
4	FOOD	Can you bake the chocolate cake tonight?
5	WORK	How long have you been employed there?#7
6	FOOD	When should we have the awards dinner?
7	FOOD	Do you want gravy on your potatoes?#7
8	FAMILY	Does he still live with his parents?
9	SEASONS/HOLIDAYS	We're going to the beach on Sunday.#7
10	FOOD	The bread was not very fresh today.
11	WEATHER	Put snow tires on the car today.#7
12	MUSIC	Dancers have a good sense of rhythm.
13	MONEY	She's taken out a lot of loans.#7
14	WORK	She is going on a job interview.
15	WORK	Where are the employee time cards now?#7
16	WEATHER	Is it snowing or raining right now?
17	SPORTS/LEISURE	Take your baseball glove to the game.#7
18	HOMES	Polish the furniture in the living room.
19	WEATHER	Take a sweater in case it's chilly.#7
20	SEASONS/HOLIDAYS	Let the children stay up for Halloween.
21	HEALTH	I really don't like to get injections.#7
22	SPORTS/LEISURE	Sharpen your skates before you play hockey!
23	MUSIC	She's the one who gives singing lessons.#7
24	HOMES	Fix the oil burner before winter arrives.

FF8 SENTENCE TEXT

1	FOOD	When did you learn how to bake bread?#8
2	MUSIC	Have you ever thought of making a record?
3	WORK	Make sure you get to work on time.#8
4	WEATHER	It is going to be very windy today.
5	MONEY	Has the charge account been paid off yet?#8
6	SEASONS/HOLIDAYS	How will you celebrate the Fourth of July?
7	FAMILY	Make sure you call your brother this week.#8
8	HEALTH	I know a doctor who makes house calls.
9	HOMES	Where did you get all that new furniture?#8
10	SPORTS/LEISURE	Did your father teach you to play chess?
11	CLOTHES	Did you buy those shoes in that store?#8
12	FAMILY	Are you going to visit your parents tomorrow?
13	SEASONS/HOLIDAYS	Will you clean the house before spring comes?#8
14	WORK	Do you have to take many business trips?
15	ANIMALS	My parakeet got out of the new cage.#8
16	FOOD	Make sure that you don't overcook the shrimp.
17	CLOTHES	Mend your shirt and socks by next week.#8
18	HOMES	She just moved into a three room apartment.
19	CLOTHES	Buy that bathing suit because it fits you.#8
20	ANIMALS	Give the ducks some bread from your sandwich.
21	HOMES	The garden needs to be replanted next spring.#8
22	SPORTS/LEISURE	You can see deer near my country house.

23	SPORTS/LEISURE	She loves to knit while she's watching television.#8
24	FAMILY	Please put the baby's pictures in mother's album!

FF9 SENTENCE TEXT

1	SEASONS/HOLIDAYS	Do you go to the beach during the summer?#9
2	FOOD	Do you want to have a barbecue this evening?
3	MONEY	Do you get paid once or twice a month?#9
4	FOOD	How long does it take to roast a turkey?
5	FOOD	Did you warm up the baby's bottle of milk?#9
6	WORK	Does your boss give you a bonus every year?
7	WORK	Are you learning a lot on your new job?#9
8	SEASONS/HOLIDAYS	Will you be going on vacation in the spring?
9	SPORTS/LEISURE	Try to keep your knees bent while you're skiing.#9
10	SEASONS/HOLIDAYS	We need to renovate the beach house this summer.
11	HEALTH	If she is not careful, she'll get a sunburn.#9
12	MONEY	The value of the dollar fell with the deficit.
13	CLOTHES	How much did they charge you for the alterations?#9
14	MONEY	Is there a minimum balance for a checking account?
15	SPORTS/LEISURE	Clean the filter in the pool before they swim.#9
16	HOMES	Take the penthouse apartment if you like the view!
17	WEATHER	Be careful driving on the bridge when it's windy.#9
18	MONEY	I have to call the bank about my statement.

19 MONEY	I always mail in my loan payments on time.#9
20 CLOTHES	Buy yourself a new coat for the cold months.
21 HOMES	We are really excited about looking for a house.#9
22 ANIMALS	We saw alot of deer while driving last night.
23 ANIMALS	Walk the horses and clean their stalls before dinner!#9
24 FOOD	Let the grill get really hot before you barbecue.

FF10 SENTENCE TEXT

1	MUSIC	Do you think he'll play the piano at the party?#10
2	CLOTHES	What should I wear to the party next Saturday night?
3	FOOD	Let's go out to lunch instead of eating at home.#10
4	WEATHER	The days have been cool for this time of year.
5	HOMES	Where are the screens for the front and back windows?#10
6	SEASONS/HOLIDAYS	Do you want to go Christmas shopping with me today?
7	ANIMALS	We went to the lake and fed the baby ducks.#10
8	FOOD	I like to drink my coffee with lots of milk.
9	SEASONS/HOLIDAYS	Put up the Christmas lights before it gets too cold.#10
10	MONEY	Take out a loan before the interest rate goes up.
11	ANIMALS	Do snakes eat only mice or do they eat plants?#10
12	WEATHER	How many inches of rain fell during the summer months?
13	MUSIC	Tell him that we want to buy his concert tickets!#10
14	FAMILY	You have to let your children make their own mistakes.
15	ANIMALS	My cat was chasing the bird all around the yard.#10
16	MONEY	Check the limit on your charge account before you buy!
17	HEALTH	Did he get sick from eating some bad food yesterday?#10
18	HOMES	Did the repairman come to fix the washing machine today?

19	WORK	The supervisor will be upset if those reports are late.#10
20	SPORTS/LEISURE	We're going to buy season tickets for the football games.
21	FAMILY	Our relatives are flying in tonight for the surprise party.#10
22	WORK	When you want to quit give them two weeks notice.
23	FAMILY	My friend will not spend another weekend with her nephew.#10
24	HEALTH	Don't scratch your rash or it will just become worse!

FF11 SENTENCE TEXT

1	HEALTH	When is the best time of day to exercise or run?#11
2	WORK	Do you know who will take over when our boss retires?
3	MUSIC	Do you know what time the folk concert starts this evening?#11
4	WEATHER	Will you go to the beach even if it's still cloudy?
5	HOMES	Where did you buy all that new furniture for the house?#11
6	SPORTS/LEISURE	How many miles a day do you run before a marathon?
7	ANIMALS	Did your landlord give you any trouble about having a dog?#11
8	FAMILY	Have you and your fiancee set a date for the wedding?
9	FAMILY	My brother and his two children are coming to visit me.#11
10	FOOD	We go out to eat dinner at least once a week.
11	CLOTHES	Sew that button on the sport shirt before you lose it!#11
12	ANIMALS	The bee stung the little girl while she was picking flowers.
13	HEALTH	When he went to the dentist, he had his teeth cleaned.#11
14	WORK	Quit your job if you are not satisfied with your salary.
15	CLOTHES	The store is having a sale on all their bathing suits.#11
16	MUSIC	He plays the bass in a jazz band every Monday night.
17	SEASONS/HOLIDAYS	Be careful if you use fireworks on the Fourth of July.#11
18	HOMES	All the furniture should be covered before the painter arrives today.

19 WEATHER	Put both cars in the garage before it starts to snow!#11
20 MUSIC	Don't stand so close to the microphone when you are singing.
21 WORK	If you work for an airline you get great travel benefits.#11
22 HEALTH	She told me to take this medicine for my upset stomach.
23 HOMES	Polish the furniture and wax the floors before our guests arrive!#11
24 MONEY	It's better to pay with cash than to use credit cards.

FF12 SENTENCE TEXT

1	CLOTHES	Did you know that she made her own dress for the wedding?#12
2	WEATHER	Does it look as if the sun is trying to come out?
3	WORK	How many years of school did it take to become a nurse?#12
4	FAMILY	When was the last time that you went to visit your parents?
5	FOOD	I was so hungry this morning, that I ate a huge breakfast.#12
6	FAMILY	Don't forget to take your little sister to her ballet lessons today!
7	MONEY	Did the cashier ring up the correct price on those two items?#12
8	FOOD	Do you want fried chicken or do you want pizza for dinner?
9	HEALTH	Children get sick more often when they start to go to school.#12
10	CLOTHES	The store is having a great sale on all winter coats today.
11	ANIMALS	Did you know that baby seals are often killed for their skins?#12
12	CLOTHES	Who bought you that beautiful green blouse that you were wearing yesterday?
13	HOMES	Can we keep the old curtains and replace just the window shades?#12
14	FAMILY	Did your brothers and sisters come to visit you on your birthday?
15	CLOTHES	Do your laundry so that you have a clean shirt for tomorrow.#12
16	FAMILY	It's hard to believe that she has four daughters and three sons.
17	SEASONS/HOLIDAYS	Make sure that all the children wear costumes to the Halloween party.#12
18	SPORTS/LEISURE	Both of the teams' offense and defense were wonderful in the game.

19	HOMES	My friends bought an old house and are starting to renovate it.#12
20	WEATHER	I'm not going to work tomorrow if it snows a lot tonight.
21	WORK	Don't make so many personal telephone calls while you are at work.#12
22	MONEY	Remember to get travelers checks before you go on vacation next week.
23	WEATHER	Always take your sunglasses with you when you drive on sunny days.#12
24	SEASONS/HOLIDAYS	Make sure you remember to buy your boyfriend a Valentine's Day gift.

FF13 SENTENCE TEXT

1	FOOD	What should we make for dinner when our friends come to visit us?#13
2	SEASONS/HOLIDAYS	Do you think you'll go to the mountains for your vacation this year?
3	HEALTH	Her leg was put in a cast when she went to the hospital.#13
4	MONEY	Don't use your credit card if you can't pay the bill on time.
5	SPORTS/LEISURE	Did you ever think about trying to sell some of our better paintings?#13
6	MUSIC	Do you think you would enjoy going to see an opera with me?
7	MONEY	Don't spend so much or you'll never be able to buy that car.#13
8	WORK	He got a promotion at work and now he doesn't want to leave.
9	HEALTH	It is not a good idea to chew gum because it causes cavities.#13
10	WEATHER	Listen to the news tonight to find out if they predict more rain.
11	FOOD	Take the steaks out of the freezer and put them on the counter.#13
12	ANIMALS	Don't forget to take the cat and her kittens to the vet today.
13	WEATHER	Don't drive your car during the storm because the streets are very icy!#
14	ANIMALS	It was really very easy to teach the parrot how to say hello.
15	MUSIC	He asked me to go to the concert with him next Saturday night.#13
16	WORK	Make sure the new boss is introduced to all of the office employees!
17	WORK	Will your husband be taking any extra time off for vacation this year?#1
18	FAMILY	Who takes care of your children when they get home from school early?

19 CLOTHES	I bought three pairs of shoes and a pair of boots last week.#13
20 MONEY	The rate of inflation went down this year while the mortgage rate increased.
21 ANIMALS	Did you see any interesting birds when you went bird watching last week?#13
22 CLOTHES	Did your friend have that pretty silk dress custom made for the party?
23 MONEY	I'm getting a big tax return this year so I'm buying a car.#13
24 HEALTH	Don't drink alcohol while you are pregnant because it's harmful to your baby.

FF14 SENTENCE TEXT

1	ANIMALS	How many whales did you see when you went on the whale watching boat?#14
2	MUSIC	Did you know that they both get season tickets for the opera every year?
3	WORK	It's important to make a good impression when you go on a job interview.
4	WEATHER	The wind was so strong yesterday that it blew the branches off the tree.
5	HEALTH	When will you finally go to the dentist to have that loose filling checked?#14
6	SEASONS/HOLIDAYS	Have they bought all the food and drinks for the barbecue on Memorial Day?
7	FOOD	Peel and cut all these potatoes if you want me to make french fries!#14
8	WORK	Get a key made for both of the offices that you will be using.
9	MONEY	You have to keep one hundred dollars in this bank account for six months.#14
10	FAMILY	You have to invite all of your aunts and uncles to the wedding reception.
11	SPORTS/LEISURE	Do you use live bait when you fish or do you prefer plastic lures?#14
12	MUSIC	Do you still like to play the violin or have you given it up?
13	MUSIC	Is anybody planning to go to the rock concert in the park next Saturday?#14
14	HEALTH	Do you go to a gym to exercise, or do you exercise at home?
15	WEATHER	Will it rain this weekend or is it supposed to be clear and sunny?#14
16	HOMES	Are you going to hire someone to paint the apartment before you move in?
17	HEALTH	If you want to lower your risk for heart disease and cancer, don't smoke!#14
18	FOOD	Don't eat that cake because I baked it to take to the birthday party.

19	SPORTS/LEISURE	He couldn't play in the football game because he sprained his ankle in practice.#14
20	WORK	At the meeting, our boss listened to our complaints and promised to take action.
21	SEASONS/HOLIDAYS	Make sure the ushers arrive on time for the midnight mass on Christmas Eve.#14
22	WEATHER	The thunder and lightning during the storm last night woke up all of us.
23	MUSIC	Buy those records you want now while the store is having a big sale.#14
24	ANIMALS	The children threw peanuts to the monkeys during their class trip to the zoo.

FM3 SENTENCE TEXT

1	FAMILY	That's her brother.#3
2	FOOD	Frost the cake.
3	FOOD	Wash the fruit!#3
4	WORK	Call your boss.
5	WEATHER	It's hot today.#3
6	MONEY	Get some cash!
7	WEATHER	What's the humidity?#3
8	WORK	Where's your office?
9	HEALTH	I am sick.#3
10	CLOTHES	I need pants.
11	HOMES	Rents are high.#3
12	SEASONS/HOLIDAYS	Give her flowers.
13	SPORTS/LEISURES	Finish the race.#3
14	CLOTHES	Tie your shoelaces.
15	HEALTH	See your doctor.#3
16	SPORTS/LEISURE	He swims fast.
17	HEALTH	My throat hurts.#3
18	CLOTHES	Sneakers are comfortable.
19	CLOTHES	My zipper broke.#3
20	WORK	Filing is boring.
21	MUSIC	Practice the guitar.#3
22	WORK	Computers save time.
23	SEASONS/HOLIDAYS	The flowers bloomed.#3
24	FAMILY	My grandfather died.

FM4 SENTENCE TEXT

1	FOOD	Have you eaten yet?#4
2	ANIMALS	Where's the new puppy?
3	SPORTS/LEISURE	Throw me the ball.#4
4	ANIMALS	Let the dog out.
5	MONEY	Did the check clear?#4
6	FAMILY	How's your brother doing?
7	SPORTS/LEISURE	Do you like camping?#4
8	WEATHER	Has it started raining?
9	SPORTS/LEISURE	Can she ice skate?#4
10	HOMES	Is the basement clean?
11	HEALTH	Get the flu shot.#4
12	MONEY	Don't spend so much.
13	FAMILY	My mother is working.#4
14	FOOD	I want french fries.
15	MONEY	Keep all the change.#4
16	SEASONS/HOLIDAYS	Buy a Halloween costume.
17	ANIMALS	That snake is long.#4
18	HOMES	Clean the kitchen first.
19	MONEY	Don't cash that check.#4
20	SEASONS/HOLIDAYS	Summer is finally here.
21	FAMILY	I have ten cousins.#4
22	FOOD	That pizza smells great.
23	SEASONS/HOLIDAYS	Vote on Election Day.#4
24	SPORTS/LEISURE	She likes watching basketball.

FM5 SENTENCE TEXT

1	HOMES	They bought a new house.#5
2	SPORTS/LEISURE	They like to go fishing.
3	MUSIC	Have you heard her sing?#5
4	HOMES	What color is your bathroom?
5	MONEY	Can I pay by check?#5
6	SEASONS/HOLIDAYS	Can you build a snowman?
7	CLOTHES	Do the ski gloves fit?#5
8	MONEY	Does he get an allowance?
9	HOMES	Buy a new garage door.#5
10	CLOTHES	Iron all of your shirts.
11	FOOD	Please turn on the coffee.#5
12	HEALTH	Don't take so much aspirin.
13	WEATHER	Get out the snow shovel!#5
14	HEALTH	Alcohol can damage your liver.
15	WEATHER	Warm yourself by the fire!#5
16	FOOD	Make my steak well done.
17	MUSIC	Buy that record for him.#5
18	FAMILY	My father has two jobs.
19	MUSIC	Those albums are very old.#5
20	SPORTS/LEISURE	I play tennis every Tuesday.
21	WEATHER	The sun is finally shining.#5
22	WORK	Finish that report this afternoon.
23	SEASONS/HOLIDAYS	We'll plant roses this spring.#5
24	WEATHER	It's very windy outside today.

FM6 SENTENCE TEXT

1	CLOTHES	I need to buy a suit.#6
2	FAMILY	My nephew is having a party.
3	WORK	She had to bring her resume.#6
4	CLOTHES	I need to buy new boots.
5	FOOD	She forgot to preheat the oven.#6
6	SPORTS/LEISURE	The tennis match was rained out.
7	ANIMALS	How many cats do you have?#6
8	FAMILY	When is your aunt getting married?
9	HOMES	Meet me at my house later.#6
10	MUSIC	Don't play your radio that loud.
11	WEATHER	It's going to be sunny tomorrow.#6
12	MUSIC	He started to take singing lessons.
13	HEALTH	Our teacher was sick all week.#6
14	SEASONS/HOLIDAYS	People eat too much on Thanksgiving.
15	WORK	He doesn't like his new boss.#6
16	FAMILY	My sister has a new boyfriend.
17	SPORTS/LEISURE	Throw him a few good pitches.#6
18	FOOD	She baked a big apple pie.
19	SPORTS/LEISURE	Make sure your running shoes fit.#6
20	SEASONS/HOLIDAYS	Give her candy on Valentine's Day.
21	CLOTHES	Button your jacket because it's cold!#6
22	SEASONS/HOLIDAYS	Make reservations for the Easter cruise!
23	HEALTH	Remember to take all your vitamins.#6
24	WORK	Computers make typing reports much easier.

<u>FM7 SENTENCE TEXT</u>

1	CLOTHES	Where did you buy your new hat?#7
2	FAMILY	Are your cousins invited to the wedding?
3	CLOTHES	Where did he buy that gray suit?#7
4	FOOD	Do you want a toasted English muffin?
5	ANIMALS	Pick up the rabbit by it's neck!#7
6	HEALTH	My doctor said I'll be better soon.
7	MONEY	He put his savings into the bank.#7
8	SEASONS/HOLIDAYS	We're going trick or treating on Halloween.
9	FOOD	Do you cook big dinners every night?#7
10	HOMES	Can the plumber fix the leaking faucet?
11	ANIMALS	Please don't give the dog that bone.#7
12	WEATHER	Take the dog out before it snows.
13	FAMILY	Did you remember to call your grandmother?#7
14	MUSIC	Did anyone sing at your wedding reception?
15	ANIMALS	Don't let the dog off his leash.#7
16	HEALTH	You have to start losing some weight.
17	FAMILY	When is your sister's plane arriving today?#7
18	SPORTS/LEISURE	Did the basketball game go into overtime?
19	MONEY	Don't spend so much on new clothes!#7
20	MUSIC	He plays chamber music on Wednesday nights.
21	WEATHER	Wear a heavy sweater since it's cold.#7
22	HOMES	Clean the guest bedroom before next weekend.
23	CLOTHES	This tailor always fits clothes very well.#7
24	HEALTH	Take your vitamins every morning after breakfast.

FM8 SENTENCE TEXT

1	FOOD	Don't add too much salt to the soup.#8
2	CLOTHES	Iron that blouse before you go to school.
3	WEATHER	Did you see the full moon last night?#8
4	MONEY	How much does your car insurance cost you?
5	MUSIC	Where are all the rock and roll albums?#8
6	HEALTH	How is your friend recovering from the accident?
7	ANIMALS	Do you want to buy that cute puppy?#8
8	SEASONS/HOLIDAYS	Have you finished all your Christmas shopping yet?
9	SPORTS/LEISURE	Put all the golf clubs in the cart.#8
10	WORK	My friend was just fired from his job.
11	HEALTH	Go to the doctor and get a physical.#8
12	FOOD	Cut some tomatoes and cucumbers for the salad.
13	WEATHER	The reservoir is dry because of the drought.#8
14	SEASONS/HOLIDAYS	There is always a parade for Memorial Day.
15	MUSIC	Have you seen the new musical on Broadway?#8
16	MONEY	Do you always balance your checkbook every month?
17	FOOD	Drink your coffee before it gets too cold!#8
18	CLOTHES	The store is having a sale on nightgowns.
19	WORK	Mail that package before you take a break!#8
20	MUSIC	The free concerts in the park are wonderful.

21 SEASONS/HOLIDAYS	Buy champagne for the New Year's Eve party.#8
22 WEATHER	Many businesses are closed because of the snowstorm.
23 HOMES	The store delivered the new washer and dryer.#8
24 FAMILY	Help your grandmother and grandfather clean the yard!

FM9 SENTENCE TEXT

1	MUSIC	Would you like to go to a rock concert?#9
2	HEALTH	Did you break your wrist or was it sprained?
3	CLOTHES	How much is that black dress in the window?#9
4	FAMILY	Is your nephew having a birthday party next week?
5	SEASONS/HOLIDAYS	I like going to the mountains in the fall.#9
6	WORK	Next time, don't come back from lunch so late.
7	HEALTH	Did your leg take a long time to heal?#9
8	FAMILY	Where are the newlyweds going to spend their honeymoon?
9	WEATHER	I heard that there will be rain this Sunday.#9
10	HOMES	We're going to paint the guest bedroom next week.
11	HOMES	Move the couch to the wall facing the window.#9
12	ANIMALS	Close the windows before you open the bird cage.
13	SPORTS/LEISURE	Don't try to run unless you have good shoes.#9
14	MONEY	I lost my checkbook so I closed the account.
15	HEALTH	The only way to diet is not to eat.#9
16	FAMILY	Remember to take your sister to the airport tomorrow.
17	MUSIC	I like to listen to the stereo at home.#9
18	HOMES	The elevator in my apartment building broke last night.

19 ANIMALS	The cats keep each other company during the day.#9
20 HEALTH	Crash diets can really make a person very sick.
21 ANIMALS	Please don't go that close to the lion's cage.#9
22 HEALTH	All my friends seem to be catching summer colds.
23 MUSIC	The jazz festival in the mountains was very enjoyable.#9
24 WORK	You should have your resume printed instead of xeroxed.

FM10 SENTENCE TEXT

1	MUSIC	Do you know of a good band for the party?#10
2	MONEY	Do you think we should buy him a savings bond?
3	HOMES	Clean the basement if you want to have that party.#10
4	MUSIC	The concert we went to last night was too loud.
5	FOOD	Make sure you wash the fruit before you eat it.#10
6	HOMES	Her apartment is big so she shares it with roommates.
7	SPORTS/LEISURE	Did you hear the score of last night's baseball game?#10
8	MUSIC	Did you tape the concert they broadcast on the radio?
9	HEALTH	You should see a doctor about your chronic back problem.#10
10	CLOTHES	Buy yourself a new jacket now while they're on sale.
11	SPORTS/LEISURE	Were the two football players hurt during the last play?#10
12	HEALTH	How often do you go for a complete physical examination?
13	ANIMALS	Give the cat some food before you go out tonight.#10
14	CLOTHES	Remember to use bleach when you wash that white underwear.
15	WORK	Finish all the filing by the end of the day.#10
16	CLOTHES	Take the dress back and buy something that you like.
17	CLOTHES	He needed new soles on three pairs of his shoes.#10
18	MUSIC	Do not be late for band practice next Saturday afternoon!

19	FAMILY	Try to visit your mother at least once a week.#10
20	SPORTS/LEISURE	The football field is right next to the baseball field.
21	HOMES	We had all the floors scraped and polished this weekend.#10
22	WEATHER	We couldn't fly home yesterday because of the big snowstorm.
23	MUSIC	The rock concerts on the pier have been very successful.#10
24	FOOD	Defrost the freezer first, then go do your grocery shopping.

FM11 SENTENCE TEXT

1	HOMES	Did it take you a long time to find an apartment?#11
2	MUSIC	Did you buy new speakers when you bought the new turntable?
3	SPORTS/LEISURE	We used to collect rocks and shells when we were young.#11
4	MUSIC	Don't forget to buy the tickets for the concert next week.
5	MONEY	Do you need a social security number to open an account?#11
6	CLOTHES	When can you take my dress to the tailor for alterations?
7	HOMES	I think we should replace the carpeting in the living room.#11
8	CLOTHES	Don't wear your new boots today because the streets are slushy.
9	ANIMALS	Is it very difficult to take care of all those fish?#11
10	FOOD	Do you eat bacon and eggs for breakfast every Sunday morning?
11	WEATHER	This past summer was the hottest one that I can remember.#11
12	SEASONS/HOLIDAYS	Don't wait until the last minute to do your Christmas shopping.
13	SPORTS/LEISURE	I bought new cross country skis to take on my trip.#11
14	HOMES	Vacuum the rugs and polish the furniture before the party tonight.
15	FAMILY	Tell your father to mail your brother and sister's letter today!#11
16	SPORTS/LEISURE	Don't fool around on the high diving board because it's dangerous!
17	FAMILY	My grandfather's house is only a few blocks away from here.#11
18	SEASONS/HOLIDAYS	The school will be closed for Washington's Birthday and Lincoln's Birthday.

19 CLOTHES	It's okay to dress casually for the party this Saturday night.#11
20 MONEY	Have twenty dollars taken from your paycheck for savings each week.
21 HEALTH	You have to exercise as well as diet to lose weight.#11
22 WEATHER	The weather forecast for tomorrow calls for sunshine and low humidity.
23 HEALTH	Remember to get plenty of rest and drink lots of fluids.#11
24 FOOD	The desserts at that restaurant are very good but very expensive.

FM12 SENTENCE TEXT

1	FOOD	The french fries would have been better if they weren't so greasy.#12
2	HEALTH	Give the insurance forms to the dentist when you go next week.
3	WORK	Is your new job closer to your house than the old one?#12
4	SPORTS/LEISURE	Did you get to see any of the gymnastics competition last week?
5	SPORTS/LEISURE	Will they be able to go skiing with us today or tomorrow?#12
6	SEASONS/HOLIDAYS	Why do leaves always change color before they fall off the trees?
7	HOMES	Some of their mail is lost because they don't have a mailbox.#12
8	FAMILY	Take these cookies with you when you go to visit your grandfather.
9	ANIMALS	Take the dog to the vet every year for it's rabies shot.#12
10	MONEY	Many of my friends had to take out school loans this year.
11	FOOD	Don't forget to serve the cheese and crackers when the guests arrive.#12
12	WORK	The supervisor said we have to finish the filing by next week.
13	CLOTHES	Take off your wet boots and raincoat before you enter the house!#12
14	HOMES	Remember to lock all the doors and windows before you go away.
15	ANIMALS	It's not a good idea to go that close to the pigeons.#12
16	MUSIC	Please turn down the stereo before the neighbors start complaining about it.
17	WORK	My commute each morning is just a little bit over an hour.#12
18	SEASONS/HOLIDAYS	It seems like we haven't had a decent spring in several years.

19 MUSIC	Get tickets for the ballet next week before they are sold out!#12
20 ANIMALS	I saw an interesting television show about the wild animals in Africa.
21 HEALTH	If you want to live a healthy life, avoid eating fatty foods!#12
22 MONEY	My friend's wedding reception will cost five thousand dollars, including the band.
23 SPORTS/LEISURE	If you want to take good pictures, take a few photography classes.#12
24 FAMILY	My grandmother and grandfather are celebrating their fiftieth wedding anniversary this month.

FM13 SENTENCE TEXT

1	ANIMALS	Don't let the dog and cat in the same room because they'll fight.#13
2	HEALTH	More people seem to catch colds in the winter than in the summer.
3	HOMES	Don't forget to take out the garbage before you go to work today.#13
4	HEALTH	If you still have fever tomorrow make sure you go to the doctor.
5	MONEY	I would like to buy a new television but they are too expensive.#13
6	SEASONS/HOLIDAYS	You better be very careful when you go trick or treating on Halloween.
7	CLOTHES	Where should we go to buy some fabric and patterns to make dresses?#13
8	WORK	Was the business meeting successful or do you have to meet again tomorrow?
9	SPORTS/LEISURE	Clean your paint brushes after using them or else they will be ruined.#13
10	CLOTHES	Put all your winter suits in storage and take out your spring suits.
11	FAMILY	Is the bride planning to keep her maiden name or take her husband's?#13
12	FOOD	Would you prefer to have toast, blueberry muffins or rolls with your coffee?
13	FAMILY	Are all their children planning to come to the family reunion next week?#13
14	HOMES	Would you ever consider building an extra room or two onto the house?
15	MUSIC	When she played the scales, we noticed that the piano was badly tuned.#13
16	WEATHER	Make sure you dress warmly on days when the temperature drops below freezing.
17	SPORTS/LEISURE	She was on the swimming team and the track team while in college.#13
18	MUSIC	The opera singer lost her voice just before her performance on opening night.

19 HOMES	We are trying, but it's difficult to find an apartment we can afford.#13
20 MUSIC	Please make sure that you practice a lot before your next piano lesson.
21 WORK	Remember to keep all your receipts when you go on a business trip.#13
22 FOOD	We had roast beef, baked potatoes with sour cream and broccoli for dinner.
23 SPORTS/LEISURE	Please make sure the darkroom is locked after you finish developing your pictures!#13
24 HOMES	Please repair the crack in the sidewalk before someone has a serious accident!

FM14 SENTENCE TEXT

1	FOOD	Please get the groceries out of the car and put them away for me.#14
2	MONEY	Make sure that you don't forget to send your tax returns in on time.
3	ANIMALS	Cats are easy to take care of because you don't have to walk them.#14
4	HOMES	My new summer house at the beach needs to be painted before it's used.
5	MONEY	What type of investment plan did they think would be the best for you?#14
6	SPORTS/LEISURE	How long did it take you to learn how to crochet those beautiful blankets?
7	MUSIC	Make sure the members of the band know the rehearsal times for next week.#14
8	CLOTHES	That suit is very expensive but I think the style is perfect for you.
9	FAMILY	My mother will not allow pets in our house since my brother has allergies.#14
10	SPORTS/LEISURE	I went camping with my friends last week and we forgot the tent poles.
11	WORK	Take the job only if you feel that the work will be more challenging.#14
12	FOOD	We decided to make hamburgers and hot dogs for the barbecue this Sunday afternoon.
13	ANIMALS	My landlord won't let me have a dog but I can have a cat.#14
14	HEALTH	Remember to take your medicine every four hours and rest in bed all day.
15	HOMES	We wanted to put new shutters on our house but it was too expensive.#14
16	MONEY	Always check with your broker before you decide to buy any stocks or bonds.

17 FOOD	The new restaurant will serve a price fixed meal with dessert and coffee included.#14
18 HOMES	We decided to paint the living room light blue and the dining room yellow.
19 CLOTHES	Get your new pants shortened or you won't be able to wear them Saturday.#14
20 WORK	Clean out the desk and rearrange the files tonight before the new secretary arrives!
21 FOOD	Each family will bring a special dish to the pot luck dinner on Saturday.#14
22 FAMILY	Make sure the children wash their faces and brush their teeth before their bedtime!
23 WORK	It's difficult for me to leave the office on time during our busy season.#14
24 FAMILY	Every spring we have a big picnic with all my aunts, uncles and cousins.

Appendix E. The sentences presented in the control condition.

Set 1

1. I went to the eye doctor for glasses.#8
2. Light the candle in the pumpkin before the children come.#10
3. Did the hurricane cause extensive damage?#6
4. When you're in London, make sure you eat fish and chips.#11
5. His mother sat up all night to make his ghost costume for Hallloween.#13
6. Did her secretary move the files to her office?#9
7. Bears are big.#3
8. Which do you like to listen to, classical music or show tunes?#12
9. I bought aspirin at the drug store.#7
10. Have the poodle trimmed tomorrow.#5
11. Do orange and grapefruit trees thrive in tropical climates, or in more moderate ones?#14
12. Are the roads icy?#4

Set 2

1. Wear sunglasses while skiingto cut down on glare.#9
2. Isn't this coffee too sweet?#5
3. Did you know that a lot of cities have parades on Thanksgiving?#12
4. Did you hire an architect or did you design your new apartment by yourself?#14
5. Has spring arrived?#3
6. Wholesale shoes are less expensive than retail.#7
7. Don't play that tape.#4
8. Does Labour Day always fall on the first Monday of September?#11
9. Are children allowed to eat candy on Halloween?#8
10. The trains were slow so I arrived late to work.#10
11. Call your grandmother and ask her if she needs anything from the store.#13
12. Did the gardener prune the trees?#6

Appendix F. The number of words correctly recalled by each subject for all sentence lengths (from 3 to 14 words long) in both trials of the control and 12 test conditions (i.e., 4 listening conditions x 3 recall tasks). The total number of words correct out of 102 words, as well as the means (in %) for each condition are also shown. The number of words incorrectly recalled from the competing sentence are shown in superscript.

Key:

Left ear (L)	Right Ear (R)
Dichotic-different (D-D)	Dichotic-same (D-S)
Monaural-different (M-D)	Monaural-same (M-S)

Subject #1

PRACTICE SESSIONS

LENGTH	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL	MEAN %
TRIAL1-L	3	4	5	6	7	8	9	10	11	12	13	13	101	99.0
TRIAL2-R	3	4	5	6	7	8	9	10	11	12	13	13	101	99.0

SELECTIVE ATTENTION

	TRIAL 1 = LEFT				TRIAL 2 = RIGHT			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	1	2
4	4	4	4	4	4	3	4	4
5	5	5	5	2^{2}	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	6	6	7	7	7	2
8	8	8	8	8	8	8	8	8
9	9	9	9	8	9	9	9	9
10	10	10	10	6	10	10	10	10
11	11	11	11	1^{1}	11	11	11	10
12	12	12	12	10	12	12	12	8
13	12	13	13	11	13	12	13	7^{5}
14	14	14	13	14	14	13	14	8
TOTAL	101	102	100	79	102	99	100	79
MEAN	99.0	100.0	98.0	77.5	100.0	97.1	98.0	77.5

PARTIAL REPORT

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	2	3	3	3	3	3	1	3
4	2	4	2	1	4	4	4	1
5	5	3	5	2	5	5	5	2
6	6	6	6	6	5	6	6	6
7	5	3	5	4	7	7	7	6
8	7	8	5 [1]	4	8	2 [1]	8	5 [2]
9	9	9	6	9	9	4 [1]	3	9
10	7	9	6	7	10	0 [10]	0 [9]	3
11	11	8	11	0	11	11	7	6 [2]
12	9	10	7	5	12	11	10	2 [1]
13	7	12	12	9	9 [1]	13	6	13
14	7	13	10	3 [1]	10	11 [1]	13	12
TOTAL	77	88	78	53	93	77	70	68
MEAN	75.5	86.4	76.5	52.0	91.2	75.7	68.6	66.7

DIVIDED ATTENTION #1

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	2 [1]	3	2
4	4	4	4	4	4	4	3	4
5	5	5	5	3	5	5	5	5
6	5	6	6	1	6	6	5	6
7	7	7	6	5	7	7	5	7
8	6	8	8	8	8	8	8	7
9	6	9	7	5	8	9	8	7
10	7	10	4	3	10	10	9	7
11	7	8 [3]	6	6	10	11	11	8
12	10	7	12	7	11	12	12	10
13	6	13	9	10	12	13	13	10
14	12	14	13	7	6	13	14	10
TOTAL	78	94	83	62	90	100	96	83
MEAN	76.5	92.2	81.4	60.8	88.2	98.0	94.1	81.4

DIVIDED ATTENTION #2

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	1	3	2 [1]	3	3
4	4	4	3	2	4	4	4	3
5	5	5	4	5	5	5	0	3
6	3	5	4	3	6	6	6	5
7	3	7	3	0	7	7	7	1
8	8	8	6	1	8	7	3	8
9	6	6	4	4	3	3 [6]	5	4
10	9	4	8	0 [4]	4	4	7	2 [1]
11	5	6 [3]	6	6	6	6	7	4
12	6	8	4	8	9	11	5	5
13	5	5	6	0 [2]	1	4	8	0
14	4	9	6	0	2 [2]	3	7	5
TOTAL	61	70	57	30	58	62	62	43
MEAN	59.8	68.6	55.9	29.4	56.9	60.8	60.8	42.2

Subject #2

PRACTICE SESSIONS

LENGTH	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL	MEAN %
TRIAL1-R	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0
TRIAL2-L	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0

SELECTIVE ATTENTION

	TRIAL 1 = RIGHT				TRIAL 2 = LEFT			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	1	2
4	4	4	4	4	4	4	4	4
5	5	5	0	5	5	5	5	5
6	6	5	6	0	6	6	6	6
7	7	7	7	5	7	7	7	7
8	8	8	8	8	8	8	8	8
9	9	9	9	5	9	9	6	4
10	10	10	10	10	10	10	7	9
11	10	11	11	7 2	11	11	6 5	11
12	12	12	12	4 3	12	12	12	5
13	13	13	13	9	13	13	13	11 2
14	14	13	12	14	14	14	14	8
TOTAL	101	100	95	74	102	102	91	81
MEAN	99.0	98.0	93.1	72.5	100.0	100.0	89.2	79.4

PARTIAL REPORT

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	2	3
5	5	5	4	5	5	5	3	5
6	6	6	1 [1]	6	6	6	6	4
7	7	7	5	1	7	7	6	6
8	8	7	6	6	8	8	7	6
9	9	9	2	6	9	9	3	2
10	10	9	10	8	9	10	7	6
11	9	6	11	4 [2]	10	10	8	10
12	12	6	9	12	11	12	10	12
13	8	12	4	0	5 [3]	6 [1]	13	7 [4]
14	11	14	11	6	14	13	9	14
TOTAL	92	86	70	61	91	93	77	78
MEAN	90.2	84.3	68.6	59.8	89.2	91.2	75.5	76.5

DIVIDED ATTENTION #1

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	2	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	3	5
6	6	6	6	6	6	6	4	6
7	7	7	7	7	6	7	7	7
8	8	8	7	4	8	8	8	8
9	9	9	9	7	9	9	9	6
10	10	10	9	5	10	10	10	10
11	10	11	11	11	11	11	11	7
12	10	12	12	12	12	12	10	10
13	13	13	12	10	13	13	9	10
14	14	12	11	12	12	14	9	6
TOTAL	99	100	96	86	99	102	86	82
MEAN	97.1	98.0	94.1	84.3	97.1	100.0	84.3	80.4

DIVIDED ATTENTION #2

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	2	3	3	3	3	2
4	4	4	2	2	4	4	4	4
5	5	5	4	0	5	5	2	2
6	6	6	6	6	6	6	4	0
7	7	7	1	1	6	7	7	7
8	8	8	7	5	7	8	7	2
9	9	9	7	7	8	8	4	3 [3]
10	3	9	3	1 [1]	10	9	9	5
11	6	6	0	2	10	10	10	9
12	9	5 [1]	0 [1]	6	12	9	0	1
13	12	1	5	5	5	6	0	0
14	3	1	6	8	7	9	11	7
TOTAL	75	64	43	46	83	84	61	42
MEAN	73.5	62.8	42.2	45.1	81.3	82.4	59.8	41.2

Subject #3

PRACTICE SESSIONS

LENGTH	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL	MEAN %
TRIAL1-L	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0
TRIAL2-R	3	4	5	6	7	8	9	10	11	12	13	13	101	99.0

SELECTIVE ATTENTION

	TRIAL 1 = LEFT				TRIAL 2 = RIGHT			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	4	5	5	5	5	5
6	6	6	6	3 2	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	5
9	9	9	9	9	9	9	9	5 1
10	10	10	10	8	10	10	10	10
11	11	11	11	8	11	11	11	10
12	12	12	12	6	12	12	12	5
13	13	13	13	0	13	13	13	3
14	14	14	13	13	14	14	14	13
TOTAL	102	102	100	74	102	102	102	76
MEAN	100.0	100.0	98.0	72.6	100.0	100.0	100.0	74.5

PARTIAL REPORT

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	3	3
3	3	2	3	1	2	3	3	2
4	4	4	1	4	4	4	4	1 [1]
5	5	5	2	4	4	5	5	1 [1]
6	6	6	4	6	5 [1]	6	6	6
7	7	7	5	2	7	7	7	6
8	8	8	8	8	8	8	8	7
9	8	6	7	0 [4]	9	0 [8]	9	1 [3]
10	9	10	2	8	10	10	10	7
11	10	10	11	1	11	11	8	7
12	9	9	1	12	9	11	8 [1]	10
13	12	12	9	4	10	8 [3]	10	10
14	10	11	13	0	14	10	0	12
TOTAL	91	90	66	50	93	83	78	70
MEAN	89.2	88.2	64.7	49.0	91.2	81.4	76.5	68.6

DIVIDED ATTENTION #1

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	3	2
4	4	4	4	4	4	3	4	4
5	5	5	5	5	4	5	5	3
6	6	6	6	6	6	6	6	6
7	7	5	7	6	7	7	7	7
8	7	7	5	8	8	8	8	7
9	9	9	9	8	8	9	9	7
10	9	9	4	4	10	10	10	8
11	10	10	5	9	8	10	9	5
12	9	6	12	12	10	9	10	11
13	13	13	3	6	12	13	13	10
14	14	14	9	14	9	13	13	8
TOTAL	96	91	72	85	89	96	97	78
MEAN	94.1	89.2	70.6	83.3	87.3	94.1	95.1	76.5

DIVIDED ATTENTION #2

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	2	2 [1]
4	4	4	0	0	4	4	1	3
5	2	5	4	1	5	5	3	0
6	4	6	2	4	6	5	2	3
7	5	0	6	3	4	7	6	1
8	0	8	8	7	6	8	5	4 [1]
9	9	1	4	3	2	9	3 [4]	7 [1]
10	10	10	6	0 [3]	3	8	0	1
11	9	11	3	1	7	6	0	1
12	10	3	3	0	8	7 [2]	1	6
13	5	2	6	0	13	4	0	4
14	1	2	3	1	0	5	8	12 [2]
TOTAL	62	55	48	23	61	71	31	44
MEAN	60.8	53.9	47.1	22.5	59.8	69.6	30.4	43.1

Subject #4

PRACTICE SESSIONS

LENGTH	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL	MEAN %
TRIAL1-R	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0
TRIAL2-L	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0

SELECTIVE ATTENTION

	TRIAL1 = RIGHT				TRIAL 2 = LEFT			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	1	3	3	3	3
4	4	4	3	4	4	4	4	1
5	3	5	5	5	5	5	1	0
6	6	6	4	0	5	6	5 1	6
7	7	7	7	6	7	7	7	6
8	8	8	3	8	8	8	8	3
9	9	9	9	2 2	9	9	9	2 3
10	10	10	10	2	10	10	9	10
11	11	11	11	2 1	11	11	8	6 1
12	12	10	12	4	12	12	5	2
13	12	12	13	2 2	11	13	8	11
14	13	14	12	13	14	14	9	6
TOTAL	98	99	92	49	99	102	76	56
MEAN	96.1	97.1	90.2	48.0	97.1	100.0	74.5	54.9

PARTIAL REPORT

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	0	2	3	3	3	3
4	4	4	2	3	4	4	3	1
5	3	5	0	4	5	5	4	0
6	6 [4]	6	0	6	4	6	5	1 [1]
7	5	3	7	0 [5]	7	7	5	1
8	8	8	3	0	8	8 [1]	0	3
9	9	9	0	0	6	9	7 [1]	5
10	9	10	3	2	9	8	6	8
11	10	10	2	9	11	11	3	6 [3]
12	10	9 [1]	3	5 [1]	12	8	0	5 [5]
13	11	9 [2]	9	0 [2]	12	12	2	2
14	10	12	7	5	13	12	8 [3]	1
TOTAL	88	88	36	36	94	93	46	36
MEAN	86.3	86.3	35.3	35.3	92.2	91.2	45.1	35.3

DIVIDED ATTENTION #1

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	4	5	4	5	5	4
6	6	6	5	2	6	6	6	3
7	7	4	4	3 [2]	7	7	5	4
8	8	8	8	3	8	8	4	8
9	9	9	3	8	9	9	6	3
10	6	10	7	7	10	9	6	8
11	11	10	9	11	11	10	9	11
12	12	12	3	5	12	9	12	12
13	9	9	6	7	13	13	10	10
14	12	13	6	10	10	8	12	14
TOTAL	92	93	62	68	97	91	82	84
MEAN	90.2	91.2	60.8	66.7	95.1	89.2	80.4	82.4

DIVIDED ATTENTION #2

	TRIAL #1					TRIAL #2			
	D-D	D-S	M-D	M-S		D-D	D-S	M-D	M-S
3	3	3	0	0		3	3	0	0
4	4	4	1	0		4	4	1	3
5	5	5	2	0		2	5	5	0
6	4	6	4	0	4	6	6	5	0
7	7	5	5	0	1	6	7	6	0
8	8	6	1	0	1	5	6	2	1
9	9	9	7	0		3	9	8	0
10	5	7	4	0		6	10	0	5
11	5	9	1	1		4	6	3	0
12	10	10	0	6		9	11	6	1
13	11	7	2	0		13	2	4	2
14	6	13	14	4	1	2	11	7	0
TOTAL	77	84	41	11		63	80	47	12
MEAN	75.5	82.4	40.2	10.8		61.8	78.4	46.1	11.8

Subject #5

PRACTICE SESSIONS

LENGTH	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL	MEAN %
TRIAL1-L	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0
TRIAL2-R	3	4	5	6	7	8	8	10	11	12	13	14	102	100.0

SELECTIVE ATTENTION

	TRIAL1 = LEFT					TRIAL 2 = RIGHT				
	D-D	D-S	M-D	M-S		D-D	D-S	M-D	M-S	
3	3	3	3	3		3	3	1	2	
4	4	4	4	4		4	4	4	4	
5	5	5	5	0		5	5	5	5	
6	6	6	6	0		6	6	6	3	
7	7	7	7	3		7	7	7	6	
8	8	8	8	5	1	8	8	8	7	
9	9	9	9	2		9	9	9	8	
10	10	10	10	8		10	10	10	8	
11	11	11	11	9		11	11	11	8	
12	12	12	12	12		12	12	12	8	3
13	13	13	13	1		13	13	13	7	2
14	14	14	14	10		14	14	12	12	
TOTAL	102	102	102	57		102	102	98	78	
MEAN	100.0	100.0	100.0	55.9		100.0	100.0	96.1	76.5	

PARTIAL REPORT

	TRIAL #1 D-D	TRIAL #1 D-S	TRIAL #1 M-D	TRIAL #1 M-S	TRIAL #2 D-D	TRIAL #2 D-S	TRIAL #2 M-D	TRIAL #2 M-S
3	3	3	3	0	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	4	5	5	5	5	5
6	6	6	6	6	6	6	2 1	6
7	7	7	7	5 1	7	7	7	7
8	8	8	5	8	8	5 1	8	8
9	9	3 3	5	5	6	8	5 1	8
10	10	10	9	10	10	10	10	9
11	11	9	7	3	11	10	11	11
12	12	12	11	12	12	12	12	8 3
13	13	13	12	11	11	13	9	11
14	14	10	6 3	13	10	12	13	8
TOTAL	102	90	79	82	93	95	89	88
MEAN	100.0	88.2	77.5	80.4	91.2	93.1	87.2	86.3

DIVIDED ATTENTION #1

	TRIAL #1 D-D	TRIAL #1 D-S	TRIAL #1 M-D	TRIAL #1 M-S	TRIAL #2 D-D	TRIAL #2 D-S	TRIAL #2 M-D	TRIAL #2 M-S
3	3	3	3	3	3	3	3	2
4	4	4	4	4	4	4	4	2
5	5	5	5	5	5	5	5	5
6	6	5	6	6	6	5	6	5
7	7	7	7	6	7	5	7	7
8	8	8	8	7	8	8	8	7
9	9	9	7	7	9	9	9	8
10	9	10	10	4	10	10	10	10
11	11	11	9	10	11	11	11	7
12	12	11	11	12	12	12	12	9
13	13	13	12	10	13	13	9	11
14	11 1	14	14	9	14	14	13	7
TOTAL	98	100	96	83	102	99	97	80
MEAN	96.1	98.0	94.1	81.4	100.0	97.1	95.1	78.4

DIVIDED ATTENTION #2

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	2	2 [2]
4	4	4	4	4	4	4	1	3
5	5	5	5	3	5	5	4	0
6	6	6	6	6	6	6	4	3
7	7	6	7	3	7	7	0	5
8	8	8	6	8	8	6	8	8
9	9	5	0	8	7	9	6	3
10	10	9	10	8 [1]	10	10	5	10
11	10	11	5	9	8	8	9	7 [2]
12	11	11 [2]	10	11	12	10	12	10
13	12	12	7	7 [2]	9	7	8	1 [3]
14	8 [1]	8	8	3	12	12	9	12
TOTAL	93	88	71	73	91	87	68	64
MEAN	91.2	86.3	69.6	71.6	89.2	85.3	66.7	62.7

Subject #6

PRACTICE SESSIONS

LENGTH	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL	MEAN %
TRIAL1-R	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0
TRIAL2-L	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0

SELECTIVE ATTENTION

	TRIAL1 = RIGHT					TRIAL 2 = LEFT				
	D-D	D-S	M-D	M-S		D-D	D-S	M-D	M-S	
3	3	3	3	3		3	3	0	1	
4	4	4	4	4		4	4	4	4	
5	5	5	5	3		5	5	5	5	
6	6	6	6	6		6	6	5	6	
7	7	7	7	7		7	7	7	7	
8	8	8	8	7		8	8	8	5	
9	9	9	9	9		9	9	9	4	
10	10	10	10	0		10	10	10	10	
11	11	11	11	7	4	11	11	11	7	1
12	12	11	12	9		12	12	12	11	1
13	13	13	13	12		13	13	13	5	8
14	14	14	14	12		14	14	14	14	
TOTAL	102	101	102	79		102	102	98	79	
MEAN	100.0	99.0	100.0	77.5		100.0	100.0	96.1	77.5	

PARTIAL REPORT

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	3	3
4	4	4	3	3	3	4	4	4
5	5	5	4	0	4	3	5	5
6	1	6	6	6	6	6	6	6
7	7	7	7	7	7	5	7	6
8	8	7	8	0	8	8	8	8
9	9	9	6	7	9	9	9	9
10	10	10	10	8	9	8 1	10	9
11	5	9	11	10 1	11	11	9	4 3
12	12	10	6	12	10 1	12	12	11
13	11	8	13	13	13	11 1	4 5	13
14	11	10	10	0	10	6	10	7
TOTAL	86	88	87	69	93	86	87	85
MEAN	84.3	86.3	85.3	67.7	91.2	84.3	85.3	83.3

DIVIDED ATTENTION #1

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	3	2
3	3	3	3	3	3	3	3	3
4	4	4	4	2	4	4	4	4
5	5	5	5	5	5	5	5	3
6	5	6	6	6	6	6	6	6
7	7	6	7	7	7	7	7	7
8	7	8	5	6	8	8	8	6
9	9	5	9	6	9	9	8	4
10	9	10	9	10	9	7	1	10
11	4	8	11	9	7	11	11	9
12	10	10	12	11	12	11	12	9
13	0	13	12	11	13	10	12	12
14	5	14	10	14	13	12	11	7
TOTAL	68	92	93	90	96	93	88	80
MEAN	66.7	90.2	91.2	88.2	94.1	91.2	86.3	78.4

DIVIDED ATTENTION #2

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	0	3	3	3	3
4	4	4	4	4	3	4	0	4
5	5	5	1	5	5	5	5	5
6	6	5	3	6	6	6	6	4
7	7	5	7	5	7	7	0	5
8	5	7	0	3	6	8	7	0
9	7	2	0	7	9	9	8	6
10	0	6	0	0	9	7	5 1	2
11	11 1	9	11	0	7	11	1	11
12	11	8	0 1	9	12	10	9	12
13	0	10	9	8	10	0 2	8	12
14	8	9	0	2	12	7	7	9
TOTAL	67	73	38	49	89	77	59	73
MEAN	65.7	71.6	37.3	48.0	87.3	75.5	57.8	71.6

Subject #7

PRACTICE SESSIONS

LENGTH	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL	MEAN %
TRIAL1-L	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0
TRIAL2-R	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0

SELECTIVE ATTENTION

	TRIAL1 = LEFT				TRIAL 2 = RIGHT				
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S	
3	3	3	3	1	3	3	3	2	1
4	4	4	4	4	4	4	4	0	
5	3	5	5	5	5	5	5	0	5
6	6	6	6	6	6	6	6	4	2
7	7	7	7	5	7	7	7	2	
8	8	8	8	8	8	8	5	8	
9	9	9	9	9	9	9	9	4	6
10	10	10	10	10	10	10	10	10	
11	11	11	11	11	11	11	11	11	
12	12	12	12	10	12	12	12	6	
13	13	13	13	7	13	13	13	13	
14	14	14	14	9	13	14	14	11	
TOTAL	100	102	102	85	101	102	99	71	
MEAN	98.0	100.0	100.0	83.3	99.0	100.0	97.1	69.6	

PARTIAL REPORT

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	4	4	5	5	5	5
6	6	6	5	0 3	6	6	6	6
7	7	4 3	4	0	7	7	7	6
8	8	7	5	2	8	8	7	8
9	9	5 1	8	0	9	9	5 1	6
10	9	10	9	9	10	10	9	3
11	9	10	11	4	11	11	10	11
12	10	11	9	0	12	12	10	7
13	10	12	13	9	9	12	9	5 7
14	14	9	8	11	14	14	11	13
TOTAL	94	86	83	46	98	101	86	77
MEAN	92.2	84.3	81.4	45.1	96.1	99.0	84.3	75.5

DIVIDED ATTENTION #1

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	2	3	3	3	2
4	4	4	4	4	4	4	3	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	5	4	6
7	6	7	7	6	7	7	7	7
8	8	8	8	8	8	6	7	7
9	9	9	9	4	6	9	9	9
10	9	10	8	10	10	10	10	10
11	11	8	6	6	9	11	11	8
12	12	12	12	12	12	10	12	7
13	13	12	7	10	13	10	12	8
14	13	13	13	14	12	14	13	11
TOTAL	99	97	88	87	95	94	96	84
MEAN	97.1	95.1	86.3	85.3	93.1	92.2	94.1	82.4

DIVIDED ATTENTION #2

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	0	3	3	3	3
3	3	3	3	0	3	3	3	2
4	4	4	4	4	4	3	4	2
5	5	5	3	1	5	5	5	0
6	3	6	5	0	6	5	6	5
7	7	7	6	6	7	7	7	7
8	8	8	8	8	8	8	8	7
9	9	9	5	0	5 3	7	9	9
10	9	8	9	3	10	4	10	4
11	9	10	9	10	9	9	11	7
12	12	11	10	9	12	12	10	7
13	12	6	3	10	11	13	10	6
14	9	9	0	1	13 1	11	11	1 6
TOTAL	90	86	65	52	93	87	94	57
MEAN	88.2	84.3	63.7	51.0	91.2	85.3	92.2	55.9

Subject #8

PRACTICE SESSIONS

LENGTH	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL	MEAN %
TRIAL1-R	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0
TRIAL2-L	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0

SELECTIVE ATTENTION

	TRIAL1 = RIGHT					TRIAL 2 = LEFT				
	D-D	D-S	M-D	M-S		D-D	D-S	M-D	M-S	
3	3	3	2	3		3	3	3	3	
4	4	4	1	1		4	4	4	4	
5	5	5	0	3		5	5	5	4	
6	6	6	6	3	1	6	6	4	6	
7	7	7	7	7		7	7	7	7	
8	8	8	8	1	2	8	8	8	3	
9	9	9	9	3		9	9	9	8	
10	10	10	10	10		10	10	10	10	
11	11	11	11	1		11	11	11	3	
12	12	12	10	12		12	12	12	11	
13	13	13	13	0		13	13	13	6	1
14	14	14	14	0		14	14	14	8	
TOTAL	102	102	91	44		102	102	100	73	
MEAN	100.0	100.0	89.2	43.1		100.0	100.0	98.0	71.6	

PARTIAL REPORT

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	3	3
3	3	3	0	0	3	3	3	3
4	4	4	4	4	4	1	4	2
5	5	5	5	2	5	5	2	5
6	3	5	5	0	6	6	0	6
7	6	7	7	0	7	7	2	4
8	8	7	0	4 1	8	7	6	8
9	9	9	6	6	8	8	7	0
10	10	9	10	10	8	10	7	0
11	10	9	10	0	9	11	5	11
12	10	12	11	4	12	10	1	12
13	7 2	2 8	12	2	11	13	7 2	6 4
14	11	4 2	3	11	12	10	7	0
TOTAL	86	76	73	43	93	91	51	57
MEAN	84.3	74.5	71.6	42.2	91.2	89.2	50.0	55.9

DIVIDED ATTENTION #1

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	2	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	1	7	7	7	7
8	8	8	8	7	8	8	8	8
9	9	9	6	9	9	9	8	7
10	10	10	9	3	10	10	10	10
11	9	11	9	11	11	11	11	8
12	12	12	12	6	12	8	12	12
13	13	13	10	13	13	10	5	6
14	14	11	7	14	12	14	14	13
TOTAL	100	99	86	81	100	95	93	89
MEAN	98.0	97.1	84.3	79.4	98.0	93.1	91.2	87.3

DIVIDED ATTENTION #2

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	2	3	0	0	2	3	2	2
4	4	4	2	0	3	4	1	2
5	5	5	0	0	5	5	1	0
6	5	6	0	3	6	6	0	6
7	5	7	0	0	6	7	5	0
8	8	8	0	0	8	8	5	8
9	8	7	2	0	6	9	2	1 1
10	9	8	4	0	9	7	10	3
11	10	9	3	0	10	7	1	0 5
12	6	12	0	3	5 1	3	2	2
13	7	3	1	0	12	2	0	7
14	0	9	0	3	6	10	10	0
TOTAL	69	81	12	9	78	71	39	31
MEAN	67.6	79.4	11.8	8.8	76.5	69.6	38.2	30.4

Subject #9

PRACTICE SESSIONS

LENGTH	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL	MEAN %
TRIAL1-L	3	4	5	6	7	8	9	10	11	12	13	13	101	99.0
TRIAL2-R	3	4	5	6	7	8	9	10	11	11	13	14	101	99.0

SELECTIVE ATTENTION

	TRIAL1 = LEFT				TRIAL 2 = RIGHT			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	2	3	3	3	3
4	4	4	2	4	4	4	4	4
5	5	5	4	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	5	7	7	7	2
8	8	8	8	8	8	8	8	8
9	9	9	9	5	9	9	6	6
10	10	10	7	10	10	10	8	0
11	11	11	11	6 [1]	11	11	11	2 [2]
12	11	12	11	9	12	12	12	6
13	13	13	13	12	13	13	13	12
14	14	14	14	14	14	14	14	13
TOTAL	101	102	95	86	102	102	97	67
MEAN	99.0	100.0	93.1	84.3	100.0	100.0	95.1	65.7

PARTIAL REPORT

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	2	3	3	3	3	2
4	4	4	4	4	4	3	1	4
5	5	5	5	3	5	5	5	5
6	5	6	6	0	6	6	4	6
7	6	7	3	2 [3]	7	7	7	7
8	8	8	8	3	8	8	8	8
9	9	9	9	0	9	6	3	8
10	9	9	10	9	9	10	7	2 [4]
11	10	10	9	2	10	11	10	6
12	5	12	5	8 [2]	11	12	4 [1]	11
13	7 [3]	13	9	8	12	9	9	12
14	9	13	6	3	13	13	4	12
TOTAL	80	99	76	45	97	93	65	83
MEAN	78.4	97.1	74.5	44.1	95.1	91.2	63.7	81.4

DIVIDED ATTENTION #1

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	2	3
4	4	4	1	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	3	6	6	6	6	6
7	7	7	7	7	7	7	6	2
8	8	8	6	4	8	8	8	7
9	8	9	9	2	9	9	9	9
10	8	10	10	10	10	8	10	10
11	11	11	11	9	10	11	6	11
12	9	12	7	7	12	9	12	11
13	3	12	6	12	13	13	5	10
14	12	12	14	12	13	9	6	6
TOTAL	84	99	82	81	100	92	79	84
MEAN	82.4	97.1	80.4	79.4	99.0	90.2	77.5	82.4

DIVIDED ATTENTION #2

	TRIAL #1					TRIAL #2				
	D-D	D-S	M-D	M-S		D-D	D-S	M-D	M-S	
3	0	3	3	3		3	3	2	0	
4	4	4	3	4		3	4	4	4	
5	5	5	5	1		5	5	0	5	
6	6	6	6	1		6	6	6	0	
7	7	7	4	7		7	7	6	2	1
8	8	8	8	3		3	7	8	1	1
9	9	9	0	3	1	7	9	8	8	
10	10	10	4	0		10	6	2	2	
11	11	8	2	2		7	11	4	0	
12	4	12	7	2	2	10	12	4	1	
13	7	9	7	5		6	5	8	3	
14	13	12	3	0		8	8	13	2	1
TOTAL	84	93	52	31		75	83	65	28	
MEAN	82.4	91.2	51.0	30.4		73.5	81.4	63.7	27.5	

Subject #10

PRACTICE SESSIONS

LENGTH	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL	MEAN %
TRIAL1-R	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0
TRIAL2-L	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0

SELECTIVE ATTENTION

	TRIAL1 = RIGHT				TRIAL 2 = LEFT			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	0	0	3	3	3	1 [1]
4	4	4	4	4	4	4	4	4
5	5	5	5	0	5	5	5	4
6	6	6	6	6	6	6	4	0
7	7	7	1	4	7	7	4	2
8	8	8	5	2	8	8	6	4
9	8	9	9	5	9	9	9	9
10	10	10	10	5	10	10	10	4 [1]
11	11	11	5	7	11	9	11	10
12	12	12	7	10	12	12	12	12
13	13	13	12	7	10	13	12	4
14	14	14	14	5	14	14	12 [2]	3
TOTAL	101	102	76	55	99	100	92	57
MEAN	99.0	100.0	74.5	53.9	97.1	98.0	90.2	55.9

PARTIAL REPORT

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	1	1	2	3	3	2 [1]
4	4	3	1	3	4	4	4	0
5	5	5	1	3	5	5	5	1
6	6	1 [3]	6	6	4	6	4	3
7	7	7	7	3	7	5	7	4
8	8	4	8	0	8	2	8	5
9	9	9	3 [3]	1	3	7	9	7
10	10	10	8	9	9	8	10	6
11	11	6	11	7	10	8 [1]	5	0
12	4	12	4	12	11	11	1 [1]	12
13	12	10	10	12	13	11	13	4 [1]
14	14	10	0	2	13	6	7	0
TOTAL	93	80	60	59	89	76	76	44
MEAN	91.2	78.4	58.8	57.8	87.3	74.5	74.5	43.1

DIVIDED ATTENTION #1

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	3	2
4	4	4	4	4	4	4	4	2
5	5	5	5	3	5	5	5	3
6	5	6	6	4	5	6	5	6
7	7	7	7	2	7	6	6	2
8	8	8	8	8	8	8	5	3
9	9	9	8	9	9	8	6	5
10	8	7	10	2	8	6	8	10
11	10	11	11	3	11	10	11	9
12	9	12	9	3	12	12	12	5
13	12	13	12	8	13	13	10	13
14	12	12	6	7	9	12	12	12
TOTAL	92	97	89	56	94	93	87	72
MEAN	90.2	95.1	87.3	54.9	92.1	91.2	85.3	70.6

DIVIDED ATTENTION #2

	TRIAL #1					TRIAL #2				
	D-D	D-S	M-D	M-S		D-D	D-S	M-D	M-S	
3	1	3	0	3		3	3	1	3	
4	3	4	2	0	1	4	4	0	3	
5	5	5	5	5		5	5	2	1	3
6	3	3	5	3		0	6	0	4	
7	7	7	1	0		3	4	7	0	
8	0	8	5	0		5	8	7	0	4
9	3	3	2	3		9	1	7	0	2
10	0	10	10	3	1	5	9	10	0	
11	5	10	0	0		10	7	6	2	
12	8	9	10	0		0	2	5	4	
13	5	8	0	1		11	6	0	2	
14	1	10	4	0	1	0	0	2	2	
TOTAL	41	80	44	18		55	55	47	21	
MEAN	40.2	78.4	45.1	17.6		53.9	53.9	46.1	20.6	

Subject #11

PRACTICE SESSIONS

LENGTH	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL	MEAN %
TRIAL1-L	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0
TRIAL2-R	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0

SELECTIVE ATTENTION

	TRIAL1 = LEFT				TRIAL 2 = RIGHT			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	2	3	3	3	2
4	4	4	2	3	3	4	4	4
5	5	4	4	3	5	5	5	5
6	6	6	6	1	6	6	4	6
7	7	7	7	7	7	7	7	6
8	8	8	8	7	8	8	8	1
9	9	9	9	0 2	9	8	9	5
10	10	10	10	5	10	10	10	0
11	11	11	9	8	11	11	11	5 1
12	12	12	12	12	12	12	5	11
13	13	13	13	13	13	13	13	5
14	14	14	14	11	12	14	14	13
TOTAL	102	101	97	72	99	101	93	63
MEAN	100.0	99.0	95.1	70.6	97.1	99.0	91.2	61.8

PARTIAL REPORT

	TRIAL #1 D-D	TRIAL #1 D-S	TRIAL #1 M-D	TRIAL #1 M-S	TRIAL #2 D-D	TRIAL #2 D-S	TRIAL #2 M-D	TRIAL #2 M-S
3	3	3	1	2 [1]	3	3	3	3
4	4	4	4	3	4	4	4	3
5	5	5	4	4	5	5	5	4 [1]
6	6	6	6	2	6	6	6	0
7	7	7	7	1	6	7	5	6
8	8	7	3 [1]	2	8	8	7	[illegible]
9	9	4	9	1	8	7	8	9
10	7	10	10	9	9	10	10	5
11	11	9	11	0	10	7	11	10
12	12	11	12	8	9	11	12	4
13	11	13	13	2	11	7	10	8
14	14	13	11	2	13	14	11	13
TOTAL	97	92	91	36	92	89	92	73
MEAN	95.1	90.2	89.2	35.3	90.2	87.3	90.2	71.6

DIVIDED ATTENTION #1

	TRIAL #1 D-D	TRIAL #1 D-S	TRIAL #1 M-D	TRIAL #1 M-S	TRIAL #2 D-D	TRIAL #2 D-S	TRIAL #2 M-D	TRIAL #2 M-S
3	1	3	0	3	3	3	1	3
3	3	3	3	3	3	3	0	2
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	1
6	6	6	4	6	6	4	6	6
7	7	7	6	1	7	7	7	7
8	8	8	8	7	8	8	7	8
9	9	9	4	4	9	9	8	8
10	10	10	7	4	10	10	7	9
11	11	11	4	6	10	11	11	10
12	11	11	9	12	12	12	11	9
13	10	12	12	10	13	12	13	7
14	9	11	14	14	12	9	5	13
TOTAL	93	97	80	76	99	94	84	84
MEAN	91.2	95.1	78.4	74.5	97.1	92.2	82.4	82.4

DIVIDED ATTENTION #2

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	3	3	3	3	2
4	4	4	1	4	4	4	3	3
5	5	5	5	0	5	4	3	3
6	6	5	4	2	5	6	4	6
7	7	7	5	7	6	6	3	1
8	7	8	7	6	7	7	6	0
9	9	9	9	0	9	9	6	2
10	10	10	3	1	8	10	7 1	3 1
11	11	5	8	1	7	11	8	5
12	12	7	6	0	8	10	10	7
13	9	11	4	0	13	12	11	2
14	14	5	6	2	10	7	3	0
TOTAL	97	79	61	26	85	89	67	34
MEAN	95.1	77.5	59.8	25.5	83.3	87.3	65.7	33.3

Subject #12

PRACTICE SESSIONS

LENGTH	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL	MEAN %
TRIAL1-R	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0
TRIAL2-L	3	4	5	6	7	8	9	10	11	12	13	14	102	100.0

SELECTIVE ATTENTION

	TRIAL1 = RIGHT				TRIAL 2 = LEFT			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	2	3	1	3	3	3	3
4	4	1	4	0	4	4	4	4
5	5	5	1	5	5	5	5	2
6	6	6	5	6	6	6	6	2
7	7	7	7	5	7	7	1	3
8	8	8	6	8	8	8	8	8
9	9	9	9	9	9	9	7	2 2
10	10	10	10	10	9	10	10	0
11	11	11	11	3	11	11	11	9
12	12	12	11 1	7 3	12	12	12	12
13	12	12	11	13	13	13	12	3
14	14	14	14	4	13	14	14	14
TOTAL	101	97	92	71	100	102	93	62
MEAN	99.0	95.1	90.2	69.6	98.0	100.0	91.2	60.8

PARTIAL REPORT

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	0	2 [1]	3	3	3	2
4	4	4	1	2	4	4	4	3
5	5	4	2 [2]	5	5	5	5	4
6	5	4	6	6	4	6	5	1
7	7	7	7	6	7	7	7	4
8	7	7	4	2	8	8	8	4
9	6	9	9	9	7	9	1	3 [6]
10	9	10	4	9	10	5	9	0
11	11	11	6	0	11	11	3	9
12	12	12	3	0	10	12	7	7 [1]
13	8	12	9	12	8	13	10	9
14	13	14	2	8	11	14	10	13
TOTAL	90	97	53	61	88	97	72	59
MEAN	88.2	95.1	52.0	59.8	86.3	95.1	70.6	57.8

DIVIDED ATTENTION #1

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	3	3	3	2	3	3	3	3
4	4	4	4	4	4	4	4	3
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	1
7	7	7	4	6	6	7	7	4
8	8	8	8	8	8	8	8	8
9	9	9	6	3	8	8	7	8
10	10	7 [1]	10	10	10	10	10	10
11	10	5	5	9	11	7	6	11
12	10	8	8	6	11	8	9	12
13	13	4	9	9	12 [1]	13	10	11
14	4	12	13	11	13	11	14	8
TOTAL	89	78	81	79	97	90	89	84
MEAN	87.3	76.5	79.4	77.5	95.1	88.2	87.3	82.4

DIVIDED ATTENTION #2

	TRIAL #1				TRIAL #2			
	D-D	D-S	M-D	M-S	D-D	D-S	M-D	M-S
3	1	3	3	2	3	2	0	0 [2]
4	4	3	0	1	4	3	1	0
5	5	5	0	1	5	5	5	0
6	6	6	3	6	4	6	5	0
7	7	6	7	2	7	7	3	0
8	7	5	3	2	5	8	1	0
9	6	9	0	0	9	5	6	1
10	8 [2]	10	0	1	4	9	5	1
11	8	6	9	4	10	9	6	0
12	10	6 [2]	4	8	11	6	2	0
13	7 [2]	13	6	0	11	9 [2]	9	4
14	3	0	6	9	11	14	0	6
TOTAL	72	72	41	36	84	83	43	12
MEAN	70.6	70.6	40.2	35.3	82.4	81.4	42.2	11.8

Appendix G. Subject's scores for each sentence length have been arbitarily collapsed to derive three sentence scores. These sentence scores have been derived by averaging the subject's scores over sentence lengths of: 3-6 words (short), 7-10 words (medium), and 11-14 words (long). The group means, standard deviations and standard errors are also shown.

SELECTIVE ATTENTION

	DICHOTIC-DIFFERENT			DICHOTIC-SAME		
SUBJECT	SHORT	MEDIUM	LONG	SHORT	MEDIUM	LONG
1	100.0	100.0	99.0	97.2	100.0	98.0
2	100.0	100.0	99.0	97.2	100.0	99.0
3	100.0	100.0	100.0	100.0	100.0	100.0
4	91.7	100.0	96.0	100.0	100.0	97.0
5	100.0	100.0	100.0	100.0	100.0	100.0
6	100.0	100.0	100.0	100.0	100.0	99.0
7	94.4	100.0	99.0	100.0	100.0	100.0
8	100.0	100.0	100.0	100.0	100.0	100.0
9	100.0	100.0	99.0	100.0	100.0	100.0
10	100.0	98.5	97.0	100.0	100.0	98.0
11	97.2	100.0	98.0	97.2	98.5	100.0
12	100.0	98.5	98.0	88.9	100.0	99.0
MEAN	98.6	99.8	98.8	98.4	99.9	99.2
SD	2.8	0.6	1.2	3.1	0.4	1.0
SE	0.8	0.2	0.4	0.9	0.1	0.3

SELECTIVE ATTENTION

SUBJECT	MONAURAL-DIFFERENT			MONAURAL-SAME		
	SHORT	MEDIUM	LONG	SHORT	MEDIUM	LONG
1	94.4	98.5	99.0	88.9	83.8	69.0
2	86.1	91.2	93.0	83.3	82.4	69.0
3	97.2	100.0	99.0	91.7	86.8	58.0
4	77.8	91.2	78.0	55.6	57.4	46.0
5	94.4	100.0	98.0	58.3	69.1	67.0
6	88.9	100.0	100.0	88.9	72.1	77.0
7	100.0	95.6	100.0	61.1	82.4	78.0
8	69.4	100.0	98.0	75.0	72.1	41.0
9	91.7	88.2	99.0	97.2	64.7	74.0
10	86.1	79.4	85.0	52.8	51.5	58.0
11	86.1	100.0	91.0	72.2	45.6	78.0
12	86.1	85.3	96.0	63.9	66.2	65.0
MEAN	88.2	94.1	94.7	74.1	69.5	65.0
SD	8.1	6.7	6.6	15.0	12.7	11.7
SE	2.3	1.9	1.9	4.3	3.7	3.4

PARTIAL REPORT

	DICHOTIC-DIFFERENT			DICHOTIC-SAME		
SUBJECT	SHORT	MEDIUM	LONG	SHORT	MEDIUM	LONG
1	88.9	91.2	76.0	94.4	61.8	89.0
2	100.0	98.5	80.0	100.0	97.1	79.0
3	91.7	97.1	85.0	97.2	82.4	82.0
4	88.9	89.7	89.0	100.0	91.2	83.0
5	100.0	95.6	94.0	100.0	85.3	91.0
6	80.6	98.5	83.0	94.4	92.6	77.0
7	100.0	98.5	89.0	100.0	88.2	91.0
8	91.7	94.1	82.0	88.9	94.1	71.0
9	97.2	95.6	77.0	97.2	94.1	93.0
10	91.7	89.7	88.0	83.3	76.5	74.0
11	100.0	91.2	91.0	100.0	88.2	85.0
12	91.7	89.7	84.0	91.7	91.2	99.0
MEAN	93.5	94.1	84.8	95.6	86.9	84.5
SD	5.8	3.5	5.3	5.1	9.3	8.0
SE	1.7	1.0	1.5	1.5	2.7	2.3

	MONAURAL-DIFFERENT			MONAURAL-SAME		
SUBJECT	SHORT	MEDIUM	LONG	SHORT	MEDIUM	LONG
1	88.9	58.8	76.0	66.7	69.1	50.0
2	72.2	67.6	75.0	91.7	60.3	65.0
3	77.8	82.4	60.0	69.4	57.4	56.0
4	47.2	45.6	34.0	55.6	27.9	33.0
5	86.1	82.4	81.0	91.7	88.2	77.0
6	94.4	95.6	75.0	83.3	79.4	70.0
7	94.4	79.4	81.0	80.6	52.9	60.0
8	63.9	66.2	56.0	61.1	47.1	46.0
9	83.3	80.9	56.0	75.0	57.4	62.0
10	69.4	88.2	51.0	52.8	51.5	49.0
11	91.7	86.8	91.0	58.3	60.3	47.0
12	72.2	72.1	50.0	69.4	54.4	58.0
MEAN	78.5	75.5	65.5	71.3	58.8	56.1
SD	13.6	13.4	16.0	12.8	14.7	11.4
SE	3.9	3.9	4.6	3.7	4.3	3.3

DIVIDED ATTENTION #1

SUBJECT	DICHOTIC-DIFFERENT SHORT	DICHOTIC-DIFFERENT MEDIUM	DICHOTIC-DIFFERENT LONG	DICHOTIC-SAME SHORT	DICHOTIC-SAME MEDIUM	DICHOTIC-SAME LONG
1	97.2	86.8	74.0	97.2	100.0	91.0
2	100.0	98.5	95.0	100.0	100.0	98.0
3	97.2	95.6	85.0	97.2	94.1	88.0
4	97.2	94.1	90.0	100.0	94.1	84.0
5	100.0	98.5	97.0	94.4	97.1	99.0
6	97.2	95.6	64.0	100.0	88.2	89.0
7	100.0	92.6	95.0	97.2	97.1	90.0
8	100.0	100.0	96.0	100.0	100.0	90.0
9	100.0	95.6	83.0	100.0	97.1	89.0
10	94.4	94.1	88.0	100.0	86.8	95.0
11	100.0	100.0	88.0	94.4	100.0	89.0
12	100.0	97.1	84.0	100.0	94.1	68.0
MEAN	98.6	95.7	86.6	98.4	95.7	89.2
SD	1.8	3.5	9.3	2.1	4.3	7.6
SE	0.5	1.0	2.7	0.6	1.2	2.2

SUBJECT	MONAURAL-DIFFERENT SHORT	MONAURAL-DIFFERENT MEDIUM	MONAURAL-DIFFERENT LONG	MONAURAL-SAME SHORT	MONAURAL-SAME MEDIUM	MONAURAL-SAME LONG
1	94.4	80.9	90.0	77.8	72.1	68.0
2	86.1	97.1	85.0	100.0	79.4	78.0
3	100.0	86.8	74.0	91.7	80.9	75.0
4	94.4	63.2	67.0	77.8	64.7	80.0
5	100.0	97.1	91.0	88.9	82.4	75.0
6	100.0	79.4	91.0	88.9	82.4	82.0
7	91.7	95.6	86.0	94.4	89.7	76.0
8	100.0	92.7	80.0	97.2	76.5	83.0
9	80.6	95.6	67.0	100.0	75.0	78.0
10	97.2	85.3	83.0	75.0	60.3	60.0
11	86.1	79.4	79.0	86.1	70.6	81.0
12	100.0	88.2	74.0	80.6	83.8	77.0
MEAN	94.2	86.8	80.6	88.2	76.5	76.1
SD	6.5	9.6	8.3	8.5	8.1	6.2
SE	1.9	2.8	2.4	2.5	2.3	1.8

DIVIDED ATTENTION #2

SUBJECT	DICHOTIC-DIFFERENT SHORT	DICHOTIC-DIFFERENT MEDIUM	DICHOTIC-DIFFERENT LONG	DICHOTIC-SAME SHORT	DICHOTIC-SAME MEDIUM	DICHOTIC-SAME LONG
1	91.7	70.6	38.0	94.4	67.6	52.0
2	100.0	85.3	64.0	100.0	95.6	47.0
3	86.1	57.4	53.0	97.2	75.0	40.0
4	86.1	72.1	60.0	100.0	86.8	69.0
5	100.0	97.1	82.0	100.0	88.2	79.0
6	97.2	73.5	71.0	97.2	75.0	64.0
7	91.7	92.7	87.0	94.4	85.3	81.0
8	88.9	86.8	56.0	100.0	89.7	55.0
9	88.9	89.7	66.0	100.0	92.7	77.0
10	66.7	47.1	40.0	91.7	73.5	52.0
11	97.2	92.7	84.0	94.4	97.1	68.0
12	88.9	77.9	71.0	91.7	86.8	63.0
MEAN	90.3	78.6	64.3	96.8	84.4	62.3
SD	8.6	14.6	15.3	3.2	9.1	12.7
SE	2.5	4.2	4.4	0.9	2.6	3.7

SUBJECT	MONAURAL-DIFFERENT SHORT	MONAURAL-DIFFERENT MEDIUM	MONAURAL-DIFFERENT LONG	MONAURAL-SAME SHORT	MONAURAL-SAME MEDIUM	MONAURAL-SAME LONG
1	75.0	63.2	49.0	69.4	29.4	28.0
2	75.0	66.2	32.0	52.8	45.6	38.0
3	47.2	55.9	24.0	44.4	38.2	25.0
4	50.0	48.5	37.0	8.3	8.8	14.0
5	80.6	61.7	68.0	66.7	77.9	60.0
6	69.4	39.7	45.0	86.1	41.2	63.0
7	91.7	91.2	64.0	38.9	64.7	51.0
8	16.7	41.2	17.0	36.1	17.7	15.0
9	80.6	58.8	48.0	50.0	38.2	15.0
10	41.7	72.1	27.0	61.1	8.8	11.0
11	72.2	67.6	56.0	63.9	29.4	17.0
12	47.2	36.8	42.0	27.8	10.3	31.0
MEAN	62.3	58.6	42.4	50.5	34.2	30.7
SD	20.6	14.9	15.1	20.1	20.9	17.7
SE	6.0	4.3	4.4	5.8	6.0	5.1

DIVIDED ATTENTION AVERAGE

SUBJECT	DICHOTIC-DIFFERENT SHORT	DICHOTIC-DIFFERENT MEDIUM	DICHOTIC-DIFFERENT LONG	DICHOTIC-SAME SHORT	DICHOTIC-SAME MEDIUM	DICHOTIC-SAME LONG
1	94.4	78.7	56.0	95.8	83.8	71.5
2	100.0	91.9	79.5	100.0	97.8	72.5
3	91.7	76.5	69.0	97.2	84.6	64.0
4	91.7	83.1	75.0	100.0	90.5	76.5
5	100.0	97.8	89.5	97.2	92.7	89.0
6	97.2	84.6	68.0	98.6	81.6	76.5
7	95.8	92.7	91.0	95.8	91.2	85.5
8	94.4	93.4	76.0	100.0	94.9	72.5
9	94.4	92.7	75.0	100.0	94.9	83.0
10	80.6	70.6	64.0	95.8	80.2	73.5
11	98.6	96.3	86.0	94.4	98.6	78.5
12	94.5	87.5	77.5	95.8	90.5	65.5
MEAN	94.4	87.2	75.5	97.6	90.1	75.8
SD	5.0	8.2	9.9	2.0	6.0	7.2
SE	1.4	2.4	2.9	0.6	1.7	2.1

SUBJECT	MONAURAL-DIFFERENT SHORT	MONAURAL-DIFFERENT MEDIUM	MONAURAL-DIFFERENT LONG	MONAURAL-SAME SHORT	MONAURAL-SAME MEDIUM	MONAURAL-SAME LONG
1	84.7	72.1	69.5	73.6	50.8	48.0
2	80.6	81.6	58.5	76.4	62.5	58.0
3	73.6	71.3	49.0	68.1	59.6	50.0
4	72.2	55.9	52.0	43.1	36.8	47.0
5	90.3	79.4	79.5	77.8	80.2	67.5
6	84.7	59.6	68.0	87.5	61.8	72.5
7	91.7	93.4	75.0	66.7	77.2	63.5
8	58.3	66.9	48.5	66.7	47.1	49.0
9	80.6	77.2	57.5	75.0	56.6	46.5
10	69.4	78.7	55.0	68.1	34.6	35.5
11	79.2	73.5	67.5	75.0	50.0	49.0
12	73.6	62.5	58.0	54.2	47.1	54.0
MEAN	78.2	72.7	61.5	69.4	55.4	53.4
SD	9.0	10.0	9.8	11.1	13.4	9.9
SE	2.6	2.9	2.8	3.2	3.9	2.9

Appendix H1a. Summary of one-way repeated measure analyses of variance, in the arcsine data, for the main effect of recall task (selective attention, partial report, divided attention #1, divided attention #2) at each level of listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same).

Listening Condition	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
Dichotic-	1.2368	3	0.4123	54.92	<.0001
Different	0.2477	33	0.0075		
Dichotic-	1.2525	3	0.4275	76.71	<.0001
Same	0.1796	33	0.0054		
Monaural-	1.9111	3	0.6370	78.02	<.0001
Different	0.2695	33	0.0082		
Monaural-	1.3993	3	0.4664	62.20	<.0001
Same	0.2475	33	0.0075		

Appendix H1b. Summary of one-way repeated measure analyses of variance, in the arcsine data, for the main effect of recall task (selective attention, partial report, divided attention average) at each level of listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same).

Recall Task	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
Dichotic-	0.7531	2	0.3765	76.96	<.0001
Different	0.1076	22	0.0049		
Dichotic-	0.8046	2	0.4023	115.27	<.0001
Same	0.0768	22	0.0035		
Monaural-	0.9531	2	0.4765	87.92	<.0001
Different	0.1292	22	0.0054		
Monaural-	0.0913	2	0.0457	11.77	.0003
Same	0.0854	22	0.0039		

Appendix H2. Summary of one-way repeated measure analyses of variance, in the arcsine data, for the main effect of listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same) at each level of recall task (selective attention, partial report, divided attention #1, divided attention #2, divided attention average).

Recall Task	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
Selective Attention	2.2202 0.1313	3 33	0.7401 0.0040	186.02	<.0001
Partial Report	1.0429 0.2871	3 33	0.3476 0.0087	39.96	<.0001
Divided Attention #1	0.3932 0.1696	3 33	0.1311 0.0051	25.51	<.0001
Divided Attention #2	1.5650 0.3532	3 33	0.5217 0.0107	48.74	<.0001
Divided Attention Average	0.8123 0.1298	3 33	0.2708 0.0039	68.85	<.0001

Appendix H3. Post-hoc results, using the Tukey procedure for pair-wise comparisons, for determining the significance of differences among arcsined means among the different recall tasks for each listening condition. There are two matrices for each listening condition. Those matrices proceeded by (i) represent the analyses where the means for divided attention #1 and #2 were included, while those matrices proceeded by (ii) represent the analyses where the means for divided attention average were included.

Key:
Selective Attention (SA) Partial Report (PR)
Divided Attention #1 (DIV1) Divided Attention #2 (DIV2)
Divided Attention Average (DIVA)

i. **DICHOTIC-DIFFERENT TALKERS**

	SA	DIV1	PR	DIV2
SA		.200**	.250**	.451**
DIV1			.050ns	.251**
PR				.201**

$CVT_{.05} = 0.096$
$CVT_{.01} = 0.119$

ii. **DICHOTIC-DIFFERENT TALKERS**

	DIVA
SA	.342**
PR	.092**

$CVT_{.05} = 0.071$
$CVT_{.01} = 0.092$

i. **DICHOTIC-SAME TALKER**

	SA	DIV1	PR	DIV2
SA		.192**	.292**	.449**
DIV1			.100*	.253**
PR				.153**

$CVT_{.05} = 0.082$
$CVT_{.01} = 0.102$

ii. **DICHOTIC-SAME TALKER**

	DIVA
SA	.337**
PR	.045ns

$CVT_{.05} = 0.061$
$CVT_{.01} = 0.079$

Appendix H3. Continued

i. **MONAURAL-DIFFERENT TALKERS**

	SA	DIV1	PR	DIV2
SA		.157**	.325**	.538**
DIV1			.168**	.381**
PR				.213**

$CVT_{.05}$ = 0.100
$CVT_{.01}$ = 0.124

ii. **MONAURAL-DIFFERENT TALKERS**

	DIVA
SA	.363**
PR	.038ns

$CVT_{.05}$ = 0.076
$CVT_{.01}$ = 0.098

i. **MONAURAL-SAME TALKER**

	SA	DIV1	PR	DIV2
SA		-.116**	.088ns	.348**
DIV1			.204**	.464**
PR				.260**

$CVT_{.05}$ = 0.096
$CVT_{.01}$ = 0.119

ii. **MONAURAL-SAME TALKER**

	DIVA
SA	.119**
PR	.031ns

$CVT_{.05}$ = 0.064
$CVT_{.01}$ = 0.083

Appendix H4. Post-hoc results, using the Tukey procedure for pair-wise comparisons, for determining the significance of differences among arcsined means in the different listening conditions at each level of recall task.

Key:

Dichotic-different talkers (D-D)
Dichotic-same talker (D-S)
Monaural-different talkers (M-D)
Monaural-same talker (M-S)

SELECTIVE ATTENTION

	D-D	M-D	M-S
D-S	.011ns	.169**	.532**
D-D		.157**	.521**
M-D			.364**

$CVT_{.05} = 0.068$
$CVT_{.01} = 0.087$

PARTIAL REPORT

	D-D	M-D	M-S
D-S	-.026ns	.198**	.328**
D-D		.229**	.359**
M-D			.130*

$CVT_{.05} = 0.102$
$CVT_{.01} = 0.129$

DIVIDED ATTENTION #1

	D-D	M-D	M-S
D-S	.019ns	.123**	.224**
D-D		.114**	.205**
M-D			.091*

$CVT_{.05} = 0.079$
$CVT_{.01} = 0.099$

DIVIDED ATTENTION #2

	D-D	M-D	M-S
D-S	.017ns	.261**	.435**
D-D		.244**	.418**
M-D			.174**

$CVT_{.05} = 0.115$
$CVT_{.01} = 0.143$

DIVIDED ATTENTION AVERAGE

	D-D	M-D	M-S
D-S	.016ns	.194**	.314**
D-D		.178**	.298**
M-D			.120**

$CVT_{.05} = 0.069$
$CVT_{.01} = 0.086$

Appendix I1. Summary of one-way repeated measure analyses of variance, in the arcsine data, for the main effect of listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same) at each level of sentence length (short, medium, long).

Sentence Length	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
Short	1.4082	3	0.4694	59.24	<.0001
	0.2615	33	0.0079		
Medium	1.3603	3	0.4534	76.66	<.0001
	0.1952	33	0.0059		
Long	0.7660	3	0.2554	69.02	<.0001
	0.1221	33	0.0037		

Appendix I2. Summary of one-way repeated measure analyses of variance, in the arcsine data, for the main effect of sentence length (short, medium, long) at each level of listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same).

Listening Condition	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
Dichotic-Different	0.2841	2	0.1421	55.20	<.0001
	0.0566	22	0.0026		
Dichotic-Same	0.4048	2	0.2024	48.37	<.0001
	0.0921	22	0.0042		
Monaural-Different	0.0982	2	0.0491	17.69	<.0001
	0.0611	22	0.0028		
Monaural-Same	0.1541	2	0.0770	23.76	<.0001
	0.0713	22	0.0032		

Appendix 13. Post-hoc results, using the Tukey procedure for pair-wise comparisons, for determining the significance of differences among arcsined means among the different listening conditions for each sentence length.

Key:

Dichotic-different talkers (D-D)
Dichotic-same talker (D-S)
Monaural-different talkers (M-D)
Monaural-same talker (M-S)

SHORT

	D-S	M-D	M-S
D-D	-.044ns	.248**	.369**
D-S		.292**	.413**
M-D			.120**
M-S			

$CVT_{.05} = .098$
$_{.01} = .123$

MEDIUM

	D-S	M-D	M-S
D-D	.005ns	.199**	.410**
D-S		.194**	.405**
M-D			.211**
M-S			

$CVT_{.05} = .085$
$_{.01} = .016$

LONG

	D-S	M-D	M-S
D-D	.001ns	.157**	.305**
D-S		.156**	.304**
M-D			.148**
M-S			

$CVT_{.05} = .067$
$_{.01} = .084$

Appendix I4. Post-hoc results, using the Tukey procedure for pair-wise comparisons, for determining the significance of differences among arcsined means among the different sentence lengths for each listening condition.

Key:

Short (SH)
Medium (MD)
Long (LG)

DICHOTIC-DIFFERENT

	SH	MD	LG
SH		.080**	.215**
MD			.135**
LG			

CVT.05 = .052
CVT.01 = .067

DICHOTIC-SAME

	SH	MD	LG
SH		.129**	.260**
MD			.130**
LG			

CVT.05 = .066
CVT.01 = .086

MONAURAL-DIFFERENT

	SH	MD	LG
SH		.031ns	.123**
MD			.092**
LG			

CVT.05 = .054
CVT.01 = .070

MONAURAL-SAME

	SH	MD	LG
SH		.122**	.143**
MD			.029ns
LG			

CVT.05 = .058
CVT.01 = .075

Appendix J1a. Summary of one-way repeated measure analyses of variance, in the arcsine data, for the main effect of recall task (selective attention, partial report, divided attention #1 and #2 scores included) at each level of sentence length (short, medium, long).

Sentence Length	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
Short	0.5636	3	0.1879	31.58	<.0001
	0.1963	33	0.0060		
Medium	0.8503	3	0.2834	52.56	<.0001
	0.1779	33	0.0054		
Long	1.4253	3	0.4751	69.02	<.0001
	0.1353	33	0.0041		

Appendix J1b. Summary of one-way repeated measure analyses of variance, in the arcsine data, for the main effect of recall task (selective attention, partial report, divided attention average scores included) at each level of sentence length (short, medium, long).

Sentence Length	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
Short	0.0513	2	0.0257	7.13	.0041
	0.7917	22	0.0036		
Medium	0.2874	2	0.1437	27.73	<.0001
	0.1140	22	0.0052		
Long	0.5460	2	0.2730	170.36	<.0001
	0.0353	22	0.0016		

Appendix J2. Summary of one-way repeated measure analyses of variance, in the arcsine data, for the main effect of sentence length (short, medium, long) at each level of recall task (selective attention, partial report, divided attention #1, divided attention #2, and divided attention average).

Recall Task	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
Selective Attention	0.0039 0.0700	2 22	0.0020 0.0032	0.62	.5496
Partial Report	0.0859 0.0921	2 22	0.2024 0.0042	38.02	<.0001
Divided Attention #1	0.1421 0.0455	2 22	0.0710 0.0021	34.38	<.0001
Divided Attention #2	0.2386 0.0437	2 22	0.1193 0.0020	60.06	<.0001
Divided Attention Average	0.2901 0.0440	2 22	0.1451 0.0020	72.62	<.0001

Appendix J3. Post-hoc results, using the Tukey procedure for pair-wise comparisons, for determining the significance of differences among arcsined means among the recall tasks for each sentence length. Two matrices are shown for each recall task. Those matrices proceeded by (i) represent the analyses where the means for divided attention #1 and #2 were included, while those matrices proceeded by (ii) represent the analyses where the means for divided attention average were included.

Key:
- Selective Attention (SA)
- Partial Report (PR)
- Divided Attention #1 (DIV1)
- Divided Attention #2 (DIV2)
- Divided Attention Average (DIVA)

i. **SHORT**

	DIV1	PR	DIV2
SA	-.092*	.079ns	.204**
DIV1		.170**	.295**
PR			.125**

$CVT_{.05}$ = 0.086
$CVT_{.01}$ = 0.107

ii. **SHORT**

	DIVA
SA	.081**
PR	.003ns

$CVT_{.05}$ = 0.062
$CVT_{.01}$ = 0.078

i. **MEDIUM**

	DIV1	PR	DIV2
SA	.037ns	.172**	.339**
DIV1		.136**	.302**
PR			.167**

$CVT_{.05}$ = 0.081
$CVT_{.01}$ = 0.101

ii. **MEDIUM**

	DIVA
SA	.203**
PR	.031ns

$CVT_{.05}$ = 0.074
$CVT_{.01}$ = 0.096

Appendix J3. Continued

i.

	LONG		
	DIV1	PR	DIV2
SA	.094**	.220**	.460**
DIV1		.126**	.365**
PR			.240**

$CVT_{.05} = 0.071$
$CVT_{.01} = 0.086$

ii.

	LONG
	DIVA
SA	.289**
PR	.069**

$CVT_{.05} = 0.041$
$CVT_{.01} = 0.055$

Appendix J4. Post-hoc results, using the Tukey procedure for pair-wise comparisons, for determining the significance of differences among arcsined means among the different sentence lengths (short, medium, long) for each recall task (selective attention, partial report, divided attention #1, divided attention #2, and divided attention average).

Key: Short (SH)
Medium (MD)
Long (LG)

SELECTIVE ATTENTION

	SH	MD	LG
SH		-.013ns	.012ns
MD			.026ns
LG			

$CVT^{.05} = .057$
$CVT^{.01} = .073$

PARTIAL REPORT

	SH	MD	LG
SH		.129**	.260**
MD			.130**
LG			

$CVT^{.05} = .047$
$CVT^{.01} = .060$

DIVIDED ATTENTION #1

	SH	MD	LG
SH		.115**	.199**
MD			.083**
LG			

$CVT^{.05} = .047$
$CVT^{.01} = .060$

DIVIDED ATTENTION #2

	SH	MD	LG
SH		.122**	.269**
MD			.146**
LG			

$CVT^{.05} = .074$
$CVT^{.01} = .094$

DIVIDED ATTENTION AVERAGE

	SH	MD	LG
SH		.109**	.220**
MD			.111**
LG			

$CVT^{.05} = .046$
$CVT^{.01} = .059$

Appendix K. Results from separate two-way analyses of variance, in the arcsine data, at each level of the third variable.

Table K1a. Two-way repeated measures analysis of variance, in the arcsine data, for the dichotic-different talkers listening condition. The main effects were recall task (selective attention, partial report, divided attention #1, divided attention #2) and sentence length (short, medium, long).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
RECALL (R)	2.1916	3	0.7305	44.12	<.0001
ERROR	0.5465	33	0.0166		
SENTLEN (S)	0.7773	2	0.3886	89.67	<.0001
ERROR	0.0953	22	0.0043		
R x S	0.4379	6	0.0730	13.13	<.0001
ERROR	0.3669	66	0.0056		

Table K1b. Two-way repeated measures analysis of variance, in the arcsine data, for the dichotic-different talkers listening condition. The main effects were recall task (selective attention, partial report, divided attention average) and sentence length (short, medium, long).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
RECALL (R)	1.1152	2	0.5576	55.67	<.0001
ERROR	0.2204	22	0.0100		
SENTLEN (S)	0.4028	2	0.2014	75.80	<.0001
ERROR	0.0585	22	0.0027		
R x S	0.2911	4	0.0728	20.57	<.0001
ERROR	0.1557	44	0.0035		

Table K2a. Two-way repeated measures analysis of variance, in the arcsine data, for the dichotic-same talkers listening condition. The main effects were recall task (selective attention, partial report, divided attention #1, divided attention #2) and sentence length (short, medium, long).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
RECALL (R)	1.0990	3	0.5495	63.64	<.0001
ERROR	0.1990	33	0.0086		
SENTLEN (S)	0.5207	2	0.2603	30.75	<.0001
ERROR	0.1863	22	0.0085		
R x S	0.5271	6	0.1318	21.54	<.0001
ERROR	0.2692	66	0.0061		

Table K2b. Two-way repeated measures analysis of variance, in the arcsine data, for the dichotic-same talkers listening condition. The main effects were recall task (selective attention, partial report, divided attention average) and sentence length (short, medium, long).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq	F-Ratio	Tail Prob.
RECALL (R)	1.8269	2	0.6090	55.07	<.0001
ERROR	0.3650	22	0.0111		
SENTLEN (S)	0.9634	2	0.4817	49.50	<.0001
ERROR	0.2141	22	0.0097		
R x S	0.8469	4	0.1412	18.15	<.0001
ERROR	0.5133	44	0.0078		

Table K3a. Two-way repeated measures analysis of variance, in the arcsine data, for the monaural-different talkers listening condition. The main effects were recall task (selective attention, partial report, divided attention #1, divided attention #2) and sentence length (short, medium, long).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
RECALL (R)	5.4332	3	1.8111	70.77	<.0001
ERROR	0.8445	33	0.0256		
SENTLEN (S)	0.3798	2	0.1899	20.23	<.0001
ERROR	0.2065	22	0.0094		
R x S	0.5341	6	0.0890	7.03	<.0001
ERROR	0.8358	66	0.0127		

Table K3b. Two-way repeated measures analysis of variance, in the arcsine data, for the monaural-different talkers listening condition. The main effects were recall task (selective attention, partial report, divided attention average) and sentence length (short, medium, long).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
RECALL (R)	2.2804	2	1.1002	62.52	<.0001
ERROR	0.3872	22	0.0176		
SENTLEN (S)	0.1356	2	0.0678	9.43	.0011
ERROR	0.1581	22	0.0072		
R x S	0.3535	4	0.0884	8.59	<.0001
ERROR	0.4526	44	0.0103		

Table K4a. Two-way repeated measures analysis of variance, in the arcsine data, for the monaural-same talkers listening condition. The main effects were recall task (selective attention, partial report, divided attention #1, divided attention #2) and sentence length (short, medium, long).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
RECALL (R)	4.3102	3	1.4367	65.97	<.0001
ERROR	0.7187	33	0.0218		
SENTLEN (S)	0.7373	2	0.3686	25.36	<.0001
ERROR	0.3198	22	0.0145		
R x S	0.0436	6	0.0073	0.66	.6836
ERROR	0.7292	66	0.0111		

Table K4b. Two-way repeated measures analysis of variance, in the arcsine data, for the monaural-same talkers listening condition. The main effects were recall task (selective attention, partial report, divided attention average) and sentence length (short, medium, long).

Source of Variance	**Sum of Squares**	**DF**	**Estimated Mean Sq.**	**F-Ratio**	**Tail Prob.**
RECALL (R)	0.2418	2	0.1209	8.42	.0019
ERROR	0.3159	22	0.0144		
SENTLEN (S)	0.4425	2	0.2213	23.05	<.0001
ERROR	0.2112	22	0.0096		
R x S	0.0216	4	0.0054	0.57	.6848
ERROR	0.4149	44	0.0094		

Table K5. Two-way repeated measures analysis of variance, in the arcsine data, for the selective attention task. The main effects were listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same) and sentence length (short, medium, long).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
LISTCOND (L)	5.0370	3	1.6790	131.40	<.0001
ERROR	0.4217	33	0.0128		
SENTLEN (S)	0.0244	2	0.0122	1.71	.2034
ERROR	0.1565	22	0.0071		
L x S	0.2046	6	0.0341	3.87	.0023
ERROR	0.5809	66	0.0088		

Table K6. Two-way repeated measures analysis of variance, in the arcsine data, for the partial report task. The main effects were listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same) and sentence length (short, medium, long).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
LISTCOND (L)	3.3362	3	1.1121	44.46	<.0001
ERROR	0.8254	33	0.0251		
SENTLEN (S)	0.7382	2	0.3691	37.94	<.0001
ERROR	0.2140	22	0.0097		
L x S	0.1019	6	0.0170	2.09	.0657
ERROR	0.5357	66	0.0081		

Table K7. Two-way repeated measures analysis of variance, in the arcsine data, for divided attention #1. The main effects were listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same) and sentence length (short, medium, long).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
LISTCOND (L)	1.2085	3	0.4028	38.05	<.0001
ERROR	0.3494	33	0.0106		
SENTLEN (S)	0.9745	2	0.4875	64.52	<.0001
ERROR	0.1662	22	0.0076		
L x S	0.1335	6	0.0223	2.65	.0230
ERROR	0.5541	66	0.0084		

Table K8. Two-way repeated measures analysis of variance, in the arcsine data, for divided attention #2. The main effects were listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same) and sentence length (short, medium, long).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
LISTCOND (L)	6.2826	3	2.0942	61.60	<.0001
ERROR	1.1219	33	0.0340		
SENTLEN (S)	2.1030	2	1.0515	46.09	<.0001
ERROR	0.5019	22	0.0228		
L x S	0.4292	6	0.0715	7.62	<.0001
ERROR	0.6198	66	0.0094		

Table K9. Two-way repeated measures analysis of variance, in the arcsine data, for the selective attention task. The main effects were listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same) and sentence length (short, medium, long).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
LISTCOND (L)	3.1774	3	1.0591	84.97	<.0001
ERROR	0.4113	33	0.0125		
SENTLEN (S)	1.4259	2	0.7130	78.46	<.0001
ERROR	0.1999	22	0.0091		
L x S	0.1911	6	0.0319	8.01	<.0001
ERROR	0.2626	66	0.0040		

Table K10a. Two-way repeated measures analysis of variance, in the arcsine data, for short sentence length. The main effects were listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same) and recall task (selective attention, partial report, divided attention #1, divided attention #2).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
LISTCOND (L)	4.4816	3	1.4939	63.71	<.0001
ERROR	0.7738	33	0.0235		
RECALL (R)	1.8713	3	0.6238	32.47	<.0001
ERROR	0.6340	33	0.0192		
L x R	0.8044	9	0.0894	6.86	<.0001
ERROR	1.2905	99	0.0130		

Table K10b. Two-way repeated measures analysis of variance, in the arcsine data, for short sentence length. The main effects were listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same) and recall task (selective attention, partial report, divided attention average).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
LISTCOND (L)	3.4639	3	1.1546	63.64	<.0001
ERROR	0.5987	33	0.0181		
RECALL (R)	0.2009	2	0.1004	9.16	.0013
ERROR	0.2411	22	0.0110		
L x R	0.0633	6	0.0106	1.35	.2488
ERROR	0.5166	66	0.0078		

Table K11a. Two-way repeated measures analysis of variance, in the arcsine data, for medium sentence length. The main effects were listening condition (dichotic- different, dichotic-same, monaural-different, monaural-same) and recall task (selective attention, partial report, divided attention #1, divided attention #2).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
LISTCOND (L)	6.0789	3	2.0263	94.28	<.0001
ERROR	0.7092	33	0.0215		
RECALL (R)	4.1178	3	1.3726	62.61	<.0001
ERROR	0.7235	33	0.0219		
L x R	0.4550	9	0.0506	4.37	.0001
ERROR	1.1440	99	0.0116		

Table K11b. Two-way repeated measures analysis of variance, in the arcsine data, for medium sentence length. The main effects were listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same) and recall task (selective attention, partial report, divided attention average).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
LISTCOND (L)	4.4825	3	1.4942	93.15	<.0001
ERROR	0.5294	33	0.0160		
RECALL (R)	1.5916	2	0.7958	41.70	<.0001
ERROR	0.4199	22	0.0191		
L x R	0.2113	6	0.0352	3.93	.0020
ERROR	0.5917	66	0.0090		

Table K12a. Two-way repeated measures analysis of variance, in the arcsine data, for long sentence length. The main effects were listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same) and recall task (selective attention, partial report, divided attention #1, divided attention #2).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
LISTCOND (L)	3.9002	3	1.3001	84.38	<.0001
ERROR	0.5085	33	0.0154		
RECALL (R)	7.2134	3	2.4045	126.13	<.0001
ERROR	0.6291	33	0.0191		
L x R	0.7288	9	0.0810	8.12	<.0001
ERROR	0.9876	99	0.0010		

Table K12b. Two-way repeated measures analysis of variance, in the arcsine data, for long sentence length. The main effects were listening condition (dichotic-different, dichotic-same, monaural-different, monaural-same) and recall task (selective attention, partial report, divided attention average).

Source of Variance	Sum of Squares	DF	Estimated Mean Sq.	F-Ratio	Tail Prob.
LISTCOND (L)	3.2443	3	1.0814	94.60	<.0001
ERROR	0.3772	33	0.0114		
RECALL (R)	3.2277	2	1.6138	199.92	<.0001
ERROR	0.1776	22	0.0081		
L x R	0.5299	6	0.0883	11.62	<.0001
ERROR	0.5015	66	0.0076		

Appendix L. Comparison of Divided Attention #1 and #2 means (in percentage) for short, medium, and long sentence lengths in the Medwetsky (1987) pilot study versus those obtained in the present study.

Sentence Length	Divided Attention #1		Divided Attention #2	
	Pilot	Present	Pilot	Present
Short	91.0	88.2	80.3	50.5
Medium	84.7	76.5	56.7	34.2
Long	84.2	76.1	50.4	29.5
Grand Mean	85.5	78.4	57.8	35.2

Appendix M. Total number of items incorrectly recalled from the competing sentence, collapsed across subjects, in all test conditions (listening condition x recall task x sentence length). The corresponding percentages are shown in parentheses.

Key:

Dichotic-different talkers (D-D)
Dichotic-same talker (D-S)
Monaural-different talkers (M-D)
Monaural-same talker (M-S)

SELECTIVE ATTENTION

Listening Condition	Sentence Length Short	Medium	Long	Total
D-D	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
D-S	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
M-D	1 (0.23)	0 (0.00)	7 (0.58)	8 (0.33)
M-S	15 (3.47)	18 (2.20)	44 (3.67)	77 (3.15)
Total	16 (0.93)	18 (0.55)	51 (1.06)	85 (0.87)

PARTIAL REPORT

Listening Condition	Sentence Length Short	Medium	Long	Total
D-D	5 (1.16)	0 (0.00)	7 (0.58)	12 (0.49)
D-S	3 (0.69)	34 (4.17)	32 (2.67)	69 (2.82)
M-D	4 (0.92)	17 (2.08)	16 (1.33)	37 (1.51)
M-S	10 (2.31	21 (2.57)	42 (3.50)	73 (2.98)
Total	22 (1.27)	72 (2.21)	97 (2.02)	191 (1.95)

Appendix M. Continued

DIVIDED ATTENTION #1

Listening Condition	Sentence Length Short	Medium	Long	Total
D-D	0 (0.00)	0 (0.00)	1 (0.23)	1 (0.04)
D-S	0 (0.00)	1 (0.23)	0 (0.00)	1 (0.04)
M-D	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
M-S	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Total	0 (0.00)	1 (0.06)	1 (0.06)	2 (0.02)

DIVIDED ATTENTION #2

Listening Condition	Sentence Length Short	Medium	Long	Total
D-D	0 (0.00)	5 (0.61)	8 (0.67)	13 (0.53)
D-S	2 (0.46)	7 (0.86)	14 (1.17)	23 (0.94)
M-D	0 (0.00)	6 (0.74)	2 (0.17)	8 (0.33)
M-S	11 (2.54)	29 (3.55)	27 (2.25)	67 (2.74)
Total	13 (0.75)	47 (1.44)	51 (1.06)	112 (1.14)

Appendix N. Correlation of subject performance on the various recall tasks in the monaural-same talker listening condition.

Key:
Selective Attention (SA) Partial Report (PR)
Divided Attention #1 (DIV1) Divided Attention #2 (DIV2)
Divided Attention Average (DIVA)

	PR	DIV #1	DIV #2	DIVAVG
SA	.65*	.51*	.71**	.72**
PR		.48ns	.88**	.85**
DIV #1			.54*	.73**
DIV #2				.97**
DIVAVG				

The level of significance for a one-tailed test for 10 degrees of freedom:

* $p_{.05}$ = .497

** $p_{.01}$ = .708

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