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AUTHOR	Basil, Michael D.
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ABSTRACT

A study investigated whether selective attention to a particular television modality resulted in different levels of attention to and memory for each modality. Two independent variables manipulated selective attention. These were the semantic channel (audio or video) and viewers' instructed focus (audio or video). These variables were fully crossed in a within-subjects experimental design. Attention levels were investigated by measuring reaction times to cues in each modality (audio tones and color flashes). Memory questions asked about channel-specific contents. Both selective attention manipulations affected intensive measures of attention similarly. Because of this similarity, the modalities appear to tap a common pool of resources. Memory measures showed a modality-specific effect. Visual information was remembered whether or not that information was important semantically, and whether or not subjects were instructed to focus on that channel. Auditory information, however, was better remembered when viewers were focused on the audio channel. Auditory information and auditory-based messages appear to demand greater resources than visual information and visual-based messages. Further research in this field can lead to a better understanding of the processing of not only television material, but also real-world multi-channel sources of information. (Seven figures are included; three appendixes--description of stimuli, order of tapes, and a sample questionnaire-- and 181 references are attached.) (Author/SR)

ATTENTION TO AND MEMORY FOR AUDIO AND VIDEO INFORMATION IN TELEVISION SCENES

Michael D. Basil

Department of Speech
George Hall 326
University of Hawaii
Honolulu, HI 96822
(808) 956-3320

BITNET: MBASIL@UHCCVX

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Abstract

This study investigates whether selective attention to a particular television modality results in different levels of attention to and memory for each modality. Two independent variables manipulated selective attention. These were the semantic channel (audio or video) and viewers' instructed focus (audio or video). These variables are fully crossed in a within-subjects experimental design. Attention levels are investigated by measuring reaction times to cues in each modality (audio tones and color flashes). Memory questions ask about channel-specific contents.

Both selective attention manipulations affect intensive measures of attention similarly. Because of this similarity, the modalities appear to tap a common pool of resources. Memory measures show a modality-specific effect. Visual information is remembered whether or not that information is important semantically, and whether or not subjects are instructed to focus on that channel. Auditory information, however, is better remembered when viewers were focused on the audio channel. Auditory information and auditory-based messages appear to demand greater resources than visual information and visual-based messages.

ATTENTION TO AND MEMORY FOR AUDIO AND VIDEO INFORMATION IN TELEVISION SCENES

Television contains two channels of information -- audio and video. Some theorists suggest that the visual information on television helps people to understand the verbal information presented (Graber, 1990; Katz, Adoni & Parness, 1977; Lewis, 1984). Other theorists, however, propose that visual information interferes with people's ability to understand verbal information (Grimes, 1990a, 1991; Gunter, 1987; Robinson & Davis, 1990). Some theorists who believe in interference think that people miss information in the other channel. Other interference theorists think that people's information processing capacities are taxed by additional information. Believers in interference think that when people watch they cannot listen. Less frequently, they think that when people listen they cannot watch.

An unanswered question is whether people process both channels of television information at once or whether they examine one at a time. Several studies of simultaneous multiple-channel processing have been attempted in psychology. Some of this research has investigated the processing of meaningful stimuli. In the 1950s, the locus of much of the research was how many channels of audio information people could handle at a time. Cherry (1953), for example, investigated the "cocktail party" problem -- how many conversations could be overheard simultaneously. The answer was, in most cases, only one (Broadbent, 1958; Cherry, 1953). This research suggests that only one source of meaningful or semantic information presented in a single modality can be understood at one time.

Later psychological research has investigated simpler stimuli. Research has examined whether the detection of light flashes is helped or hindered by the presence of audio tones (Dornbush, 1968, 1970; Halpern & Lantz, 1974; Ingersoll & DiVesta, 1974; Lindsay, Taylor & Forbes, 1968; Triesman & Davies, 1973). The results of this research suggest that detection of non-meaningful or non-semantic signals can occur in two modalities at the same time.

The results of this psychological research appear to indicate that people can inspect more than one channel, but may not be able to understand more than one. This assertion, however, is derived from distinct types of studies. Comparing them in this way confounds the complexity of the stimulus with the dependent measure that was used to assess "limitations." Specifically, detection studies use light flashes and tones. The effects are measured as differences in reaction times or accuracy. People can detect signals in multiple modalities as quickly and as accurately as in a single modality. The comprehension studies, however, use sentences and stories. The effects are measured as differences in learning or memory. People are generally able to detect simultaneous tones and flashes, but are not able to comprehend or remember messages from more than a single channel. It is not clear whether the limitation is due to the increased complexity of the stimuli themselves, or in the different form of processing that is performed. This research will address the question of whether people can attend to and remember both modalities at once.

Because television material is complex, these limitations may be imposed by a single channel system. The limitations may also be imposed by resource restrictions. The next section will examine psychological concepts and theories about people's restrictions in processing information. Next, we will examine how these restrictions can be applied to television and discuss previous communication research in this area. Specific hypotheses will be formulated. The experiment that was used to investigate this question and the results of this experiment will be then be discussed. In the final section, the conclusions that can be drawn from this experiment will be discussed.

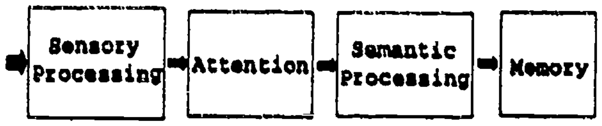
Theories about people

The process by which people process information can be envisioned as a series of stages (Basil, 1991; Craik & Lockhart, 1972; Hsia, 1971; Wickens, 1984; Woodall, Davis & Sahin, 1983). This individual stage approach to processing may help organize the literature, findings, and current thinking to develop definitions of audience and media appropriate to psychological theories.

A general overview of these stages was discussed by Craik and Lockhart (1972) as the "depth of processing." Specifically, people analyze stimuli at several levels. The first level involves sensory analysis of the material. Preliminary analysis is concerned with lines, angles, brightness, pitch, or loudness. If only the first stage occurs, this is described as "shallow processing." The second level involves analysis for meaning. Information is compared to abstractions from past learning. Information is enriched or elaborated upon.When the second stage of analysis occurs, Craik and Lockhart describe this as "deeper processing." They propose that deeper processing leads to better memory. The third level involves memory itself.

Memory is the storage and retrieval of information. Information is stored as a "memory trace" (Craik & Lockhart, 1972). These processes are illustrated in Figure 1.

FIGURE 1:
Stages of information processing



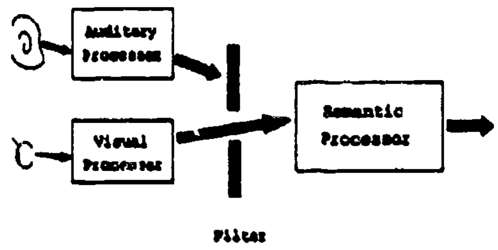
This experiment will concentrate on attentional limitations. Conceptualizations of this process and how it could bear on audiences' comprehension of television messages is discussed in the next section.

<u>Attention</u>

The notion of attention is based on the observation that people are only able to handle a limited amount of information at a time (Broadbent, 1958; Cherry, 1953). Various mechanisms have been proposed to account for how people manage incoming information. The history of attention research may provide insights into the nature of this process.

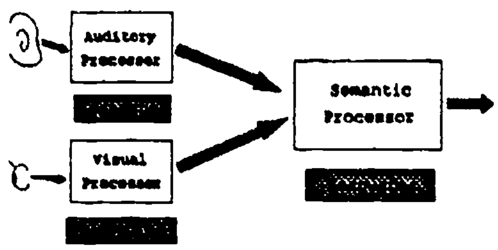
Early research conceptualized attention to be a <u>structural</u> filter (Broadbent, 1958; Cherry, 1953). According to structural models, the process of attention is a precursor to a sequence of information processing events (Craik & Lockhart, 1972; Harris, 1983; Norman & Bobrow, 1975). A filter selects information for further processing. Information that is not attended to cannot be processed further. For example, messages that are not attended will not be remembered (Broadbent, 1958). A filter model is shown in Figure 2.

FIGURE 2:
Structural Model of Attention



Researchers, however, noticed that subjects can detect their own name even when it is presented in a "non-attended" channel (Moray, 1959). Unattended information is sometimes remembered. Unattended information, then, appears to be admitted into the processing system (Triesman & Riley, 1969). Because unattended information appears to receive some awareness, later theorists have come to believe that there is not necessarily a particular filter (Allport, 1989; Wickens, 1984). Instead, they propose that attention is a process of resource allocation (Kahneman, 1973). Resources are allocated to particular channels of incoming information. Those channels that receive the most resources are processed to a greater extent (Navon & Gopher, 1979, 1980). An illustration of a resource model is shown in Figure 3.

FIGURE 3:
Resource Model of Attention



Attentional resources, however, are limited (Kahneman, 1973). Because of the importance of these resource limitations, these models are referred to as <u>resource</u> or capacity models of attention. Resource models propose that the allocation of resources to sensory channels can also depend on the nature of the task, the stimulus, or its relevance (Kahneman, 1973).

People's limitation in processing simultaneous stimuli, then, has been explained in two ways. Structural theorists feel that limitations are determined by the processing system architecture of the brain. They believe, for example, that a filtering mechanism limits processors to one channel of arriving information at a time. Resource theorists, however, do not believe that limitations are imposed by the architecture of the brain. Instead, they believe that limitations are determined by limited resources (Kahneman, 1973; Navon & Gopher, 1979, 1980).

This study conceptualizes attention according to both models of attention. First, the selection of information is described as "focusing." Selective attention or focusing can be controlled by the viewer (Anderson & Lorch, 1983). It depends on the desires of the viewer and on aspects of the message (Drew & Grimes, 1987). Two operationalizations of selective attention are presented in the method section. The second conceptualization of attention is the level of resources. The allocation of resources can also be described as the "level of attention." Resources are allocated by the viewer. Whether this allocation can be changed by conscious effort on the part of the viewer is not known. Kahneman (1973) believes it can. Using Kahneman's conceptualization, attention level may also be specific to particular modalities (Wickens, 1980). The attention level, then, is the activation level of a particular sensory modality -- auditory or visual. Attention levels vary over time. Attention levels can range from none to some maximum attentional

Implications

The presence of multiple stages of processing suggests competition for processors' focus and resources (Burris, 1987; Swets, 1984; Wickens, 1984). It is not clear whether the resources for a particular modality of television information are reduced by a second modality (Grimes, 1991). It is possible that sufficient resources are available for processing both modalities. It is also possible, however, that limitations in the information processing system restrict viewers' ability to glean information from two modalities simultaneously. For example, viewers may focus on one modality and ignore information in the other modality.

If there are limitations on processing, they could be as a result of two potential causes. First, limitations may be structural. People simply may not be able to examine two channels simultaneously.

Second, limitations may be a result of resource or capacity limitations. People may be able to examine both channels simultaneously, but only if that information is simple.

Previous research

Previous research using memory measures

Several studies of the extent to which video information affects the understanding of audio information also have been done in the field of communication. Most of these studies rest on the structural filter models of selection to infer attention. If memory is good, then attention must have been high (Broadbent, 1958; Triesman, 1960). These theories suggest that television viewers can receive one channel or the other. As a result, researchers usually only measure comprehension or memory for information in one of the two channels. Most of these studies investigated memory for information in the audio channel (Burriss, 1987; Dornbush, 1968,1970; Drew & Grimes, 1987; Edwardson, Grooms & Pringle, 1976; Edwardson, Grooms & Proudlove. 1981; Edwardson, Kent & McConnell, 1985; Edwardson, Kent, Engrstrom & Hofmann, 1991; Hoffner, Cantor & Thorson, 1989; Hsia, 1968a, 1968b; Ingersoll & DiVesta, 1974; Katz *et al.*, 1977; Kisielius & Sternthal, 1984; McDaniel, 1973; Warshaw, 1978; Young & Bellezza, 1982).

The results of this line of research demonstrate that in about half of these studies the presence of visuals interferes with understanding of the audio content (Burris, 1987; Drew & Grimes, 1987; Edwardson *et al.*, 1985, 1991; Hoffner *et al.*, 1989; Son, Reese & Davie, 1987; Warshaw, 1978).

The other half of the studies, however, have found that visuals do not interfere with memory for audio information (Dornbush, 1968, 1970; Edwardson *et al.*, 1981; Gunter, 1980; Ingersoll & DiVesta, 1974; Katz *et al.*, 1977; Kisielisu & Sternthal, 1984). When the visual information complements the audio information, comprehension can even be enhanced (Drew & Reese, 1984; Findahl, 1981; McDaniel, 1973; Reese, 1984). These findings conflict not only with the previous findings, but with the filter model of attention. Two studies, however, examined memory for both audio and video information. Drew and Grimes (1987) compared memory for redundant or conflicting audiovisual information in news stories. They observed that when exposed to conflicting information, viewers "attend to the video at the expense of the audio" (1987: 459). Unfortunately, these studies have examined only the effects of visuals on auditory comprehension and memory. If interference occurs, what happens to people's memory for the visual information? Five studies have examined memory measures for both audio and video information. Pezdek and Hartman (1983) distracted children with either a visual distractor (a toy) or an auditory distractor (a record playing). They found that such distractions were modality specific. That is, a visual distraction interfered only with memory for visual information and an auditory distraction interfered only with memory for audio information. These results suggest that attention and memory is indeed modality specific.

Pezdek and Stevens (1984) compared memory for auditory and visual information under four conditions: match, mismatch, video-only, and audio-only. The results showed memory for information was the same in the matched condition as in the single-modality condition. In the mismatched condition, however, "processing the audio information suffers more than does processing the video information" (p. 217). Difference between recognition and comprehension scores suggest that the findings do not represent limitations in processing, but in the selection of channels.

Similarly, Drew and Grimes (1987) compared memory for redundant or conflicting audio-visual information in news stories. They observed that when exposed to conflicting information, viewers "attend to the video at the expense of the audio" (1987: 459). When faced with two channels of conflicting information, the viewer's filter selected the auditory channel. This finding shows evidence of a single channel system but is contrary to other research that shows visual dominance (Posner *et al.*, 1976).

Another study conducted by Grimes (1990b) examined the possibility of information from one channel creeping into the other channel. This research is similar to several studies in psychology (e.g., Loftus & Palmer, 1974). Grimes found that viewers occasionally translated auditory information into visual "memories." When faced with complementary channels of television news information, it appears that audio information was more likely to affect visual memory than the reverse. The results are interpreted to suggest that viewers have a single code for memory. If that is the case, however, it is not clear why audio memory wasn't as affected by pictures.

Newhagen (1990) also examined both auditory and visual memory for two types of television news scenes. He manipulated the presence or absence of compelling visuals and measured memory. People were shown to have poorer memory for the audio information when accompanied by compelling visuals. The results appear to demonstrate that people were overwhelmed by these attention-demanding features and were unable to dedicate sufficient processing to understand the message. Some of these effects, however, may have been attributable to changes in the primary modality of processing. The compelling nature of the visual stimuli may have caused subjects to switch from the audio channel, which contained the majority of the semantic information, to processing the video channel. In this case, the nature of the stimulus may have determined the primary processing channel. The results -- that compelling visual material caused poorer comprehension and memory for audio information -- are compatible with either explanation. It is not clear whether what occurred was an overload in capacity, or the selection of visual information to the exclusion of the auditory information. Other potential explanations for the variability in results will be discussed below.

These studies have attempted to use memory-based measures to draw inferences about attentional limitations. Recall and other memory measures, however, are limited in their ability to identify attentional limitations for five reasons. First, most studies use varying levels of redundancy between the two channels (e.g., Drew & Grimes, 1987; Grimes, 1990a, 1990b). In cases of redundancy, viewers could have received the information from either channel (Severin, 1967). These studies, then, are not always comparing instances of two sources of information. Instead, they are comparing instances of receiving one message split over two channels with receiving one message in two independent channels. Instead, they are comparing instances of receiving one message split over two channels with receiving two distinct messages. This approach will not necessarily tell us whether a single channel is selected or whether both channels are examined (Grimes, 1990b). Second, memory measures provide little information about the nature of the limitation. The limitations may be while watching and listening or in later processing. For example, Kahneman's (1973) model suggests that allocating attention reduces other remaining resources. As a result, it is difficult to determine whether receivers are unable to attend to both channels or whether their resources do not allow the processing of both channels (e.g., Hsia, 1968b; Jester, 1968; Swets, 1984; Travers, 1970). Third, the natures of the visuals themselves also affect memory. For example, shocking visuals may interfere with comprehension of the audio channel (Newhagen, 1990). Therefore, finding poorer memory for specific information does not necessarily indicate that memory problems are caused by attention difficulties. Instead, they may be caused by difficulties with the nature of the content. Fourth, interest or motivation levels are allowed to vary. For example, visuals can improve learning when they generate greater interest (Edwardson *et al.*, 1981; Katz *et al.*, 1977). Better knowledge or comprehension may not be attributable to content, but more effort. Fifth, the presence of visuals may operate by distracting viewers from the audio channel. Distraction appears to occur only when the visuals are interesting (Edwardson *et al.*, 1976). Distraction, strictly speaking, is not evidence of cognitive limitations. These five explanations, then, suggest other factors that may determine memory independent of attention, and therefore, suggest that memory is not a reasonable surrogate for attention.

After considerable research, then, it is still not clear whether it is visual features or visual content that interferes with audio comprehension. After considerable research, it appears that there is not an all-or-nothing filter that selects visual information at the expense of auditory information. It is still not clear, however, whether the presence of activity in the other modality changes viewers' selective attention or whether complexity of that information interferes with viewers' comprehension of auditory material.

Another difficulty is the reliance on news stories for this research. Television news stories generally contain the majority of their semantic information in the auditory channel (Barkin, 1989; Grimes, 1991). Additional visual information is usually added to the auditory message. If visual information were the basis of a message, however, it is not clear whether audio features or content would interfere with visual comprehension. Therefore, we have no information applicable to other television genres.

Previous research using attention measures

The other factors that affect memory suggest that the examination of attentional limitations would benefit from measurement of attention to each channel directly. The process of attention allocation to television information has been subject to empirical investigation in communication. These studies have investigated general attention to the audio and video channels (Geiger & Reeves, 1989, 1991; Grimes, 1990; Meadowcroft & Reeves, 1989; Meadowcroft & Watt, 1989; Reeves & Thorson, 1986; Reeves *et al.*, 1985, 1991; Thorson *et al.*, 1985, 1987; Watt & Meadowcroft, 1990; Wartella & Ettema, 1974). Specifically, research has examined the amount of attention people pay to complete messages or the amount of effort that the entire message demands.

Kahneman's (1973) proposal that resources can be shifted between modalities, suggests that attentional resources may be modality-specific. People may be able to process information and recognize cues in a modality only to the extent that attentional resources are available in that modality. This proposal suggests that each modality has its own attentional resource level (Eysenck, 1982; Kahneman, 1973; Wickens, 1980). As a result, one way of studying attentional limitations is to examine modality-specific attention levels. Research to date has not examined whether resources are shared or are specific to each modality (Eysenck, 1982). Because of the dual-channel nature of television, the study of competition and for resources is important (Wickens, 1984).

Prior research has not explicitly examined whether resources are specific to each modality (Eysenck, 1982). If, however, attentional mechanisms share a common resource pool, allocating attention to one channel may reduce the attention available to the other channel. Because of the dual-channel nature of television, the study of competition for attention is important (Wickens, 1984).

There may be two reasons why little research has followed up the question of modality-specific attention. First, psychologists typically investigate processing effort for single-channel tasks such as reading, or memorizing nonsense syllables. In these instances, the secondary tasks are assumed to be slowed as a result of processing effort. Secondary reaction times are a measure of resources left over from processing. Reaction time in either channel should provide similar results.

The second reason modality specific effects may not have been measured is that psychologists usually assess effort in modalities that do not interfere with the presentation of material. For example, audio tones are used to assess reading difficulty (Britton, Glynn, Meyer & Penland, 1972). This research compares reaction times while reading simple and complex passages. It can be observed, however, that single-modality resu' ·· sometimes counter-intuitive. For example, Britton *et al.* (1972) found that people responded faster to tones while reading complex passages, and more slowly to tones with simple passages. The explanation posed was that simple passages used cognitive capacity to a greater extent. It may also be possible, however, that when faced with complex passages, people "borrowed" attentional resources from their auditory channel for semantic processing. The other explanation is that secondary reaction times measure arousal. Determining which of these effects occurs, however, would require measuring attention in both channels.

Although several studies have investigated secondary reaction task times to multiple-channel presentations, at the time this study began, none had explicitly examined modality-specific selective attentional effects (Grimes, 1990a). Inspection of these results, however, can provide insights into whether selective attention effects may be occurring. Further analysis suggests that although there may be a general attention factor, there also appears to be evidence of selective attention. These data can be interpreted as demonstrating that secondary reaction times respond as a measure of modality-specific attentional resources. These studies will be reviewed here briefly.

A series of experiments was conducted by Reeves, Thorson & Schleuder. The first of these reports (Reeves, Thorson & Schleuder, 1985) showed that multi-channel presentations resulted in significantly slower secondary reaction times to cues than single-channel presentations. When viewers were required to split their attentional resources among two modalities, they had less attentional capacity available. Therefore, they took longer to respond to secondary task cues. It appears that dual-channel processing depletes resources more than a single-channel. This finding is consistent with either a selective attention filter or a common pool of shared resources.

The second published study (Thorson, Reeves & Schleuder, 1985) consisted of three experiments. The first experiment looked at how auditory message "complexity" affected secondary reaction times to an audio tone and memory. When they only listened, subjects responded more quickly while listening to simple messages than complex ones. This suggests that the resources available to cope with the audio cue were decreased by complex audio. When they only watched, the effect was in the opposite direction. When subjects were presented with both channels of information, however, there was no difference in responding to simple or complex audio messages. These results appear compatible with modality-specific resources. Specifically, viewers may have been able to shift attentional resources from unused modalities -- for example, while listening, from the visual to the auditory modality.

The third experiment in this report (Thorson *et al.*, 1985) used a visual cue -- a strobe light mounted behind the subject. Visual complexity did not affect attention levels. The strobe light cue, however, may have caused a startle reaction on the part of subjects (Reeves, personal communication, 1991). This may have been due either to the light's intensity, the nature of the cue, or its spatial location. Startling subjects could have washed out possible effects. The comparison of secondary reaction times across cue channels supports this interpretation -- reaction time to the visual flash remained near baseline. The results for video complexity were in the direction that would be predicted. Subjects in the video-only condition tended to respond more slowly to visually complex messages than to visually simple messages. While the researchers noted that "modality of the secondary task interacts with channel condition" (p. 448), they did not suggest how modality differences might have altered the observed secondary reaction times. If the results are interpreted with respect to modality-specific resources, they are compatible with modality-specific attentional effects. It appears that information consumes attentional resources specific to its particular modality. Visual information uses visual resources, and auditory information uses auditory resources.

The data from the Thorson *et al.* (1985) study were reanalyzed according to micro (local) and larger (global) measures of complexity (Thorson, Reeves & Schleuder, 1987). An interesting conclusion suggests that the video modality may not be as limited as the audio modality; that is, video processing may require fewer resources than audio processing. Unfortunately, this research confounded the modality with the nature of the content. Specifically, audio complexity was operationalized as a "count of propositions" (1985: 434) and video complexity as scenes that "contained many edits, scene changes [etc.]" (p. 434). In this case, audio complexity, by the nature of the operationalization, measured semantic complexity while video complexity measured non-semantic complexity. Therefore, we cannot be sure if the observed differences are due to the modality or the nature of the information. Some forms of information require more effortful processing than other forms (Triesman, 1988). Semantic information may require more effort than non-semantic information. We know that audio semantic information taxes resources. We do not know, however, whether it is the semantic nature of the information or its auditory presentation that taxes resources. The differences between the auditory and visual modalities should be investigated further. This would cross the nature of the information (semantic, non-semantic) with the modality in which the information is transmitted.

In the fourth report of the Reeves *et al.* research, Schleuder, Thorson & Reeves (1988) compared the effects of time compression (none, 120%, and 140%) with secondary reaction times to cue in two channels. Time compression yielded slower reaction times to auditory cues for compressed messages, but faster reaction times to tactile cues for compressed messages. Because there was no independence between the manipulation of video and audio complexity, it is not clear which of these two complexity differences may affect attention levels. The results were interpreted as indicating two competing processes -- modality-specific interference combined with an increase in general arousal. They commented that "experiments using secondary reaction time measure[s] as an index of attention should incorporate three modalities -- auditory, visual, and tactile....Each modality competes for visual and auditory processing resources differently" (Schleuder *et al.*, 1988, p. 22). Again, this research suggests that resources may be specific to particular modalities.

Five other studies are relevant to the examination of modality-specific resources. The first two were conducted by Geiger and Reeves (1989; 1991). This research examined the resource demands of television editing. In these studies, two types of edits were compared -- semantically related and semantically unrelated. Semantically unrelated cuts were expected to show evidence of greater resource demands. The results showed significantly slower reaction times to audio cues after semantically unrelated cuts. An alternative explanation for these results, however, is that the visual discrepancy caused viewers to shift more mental energy to their visual modalities. Viewers may have selectively attended to their visual modality instead of their auditory modality. This would have made them slower in responding to audio cues. This explanation cannot be ruled out with the existing data. It could, however, be investigated by crossing semantically related and semantically unrelated cuts with the modality of secondary task cues.

Grimes (1990a) conducted a study of audio-video correspondence (redundancy) on secondary reaction times and memory for news stories. In this study, auditory (10,000 hertz tones) and visual (color bars) cues responded similarly. High and low correspondence between the audio and video channels resulted in slower reaction times than moderate levels of correspondence. This was significant only for the visual probes, however. Grimes proposed that the relationship between secondary reaction times and memory demonstrate competition between these two modalities. That is, he proposed that these results suggest that each modality competes for the same attentional resources.

Basil & Melwani (1991) conducted a secondary analysis of reaction times to secondary cues. These results show that reaction times to the auditory cues were slowed by the presence of people on the screen. Interactions also appeared in that these effects were lessened when music was present. While people's reactions were slowed by the presence of particular visual information, their reactions were quickened by the presence of other audio information. This finding is compatible with the notion of resource shifts -- namely, that viewers shifted resources to channels with more information. Again, this result is compatible with selective attention effects and the possibility of a common pool of resources that is shifted between the auditory and visual modalities.

Subsequent to undertaking this study, Grimes (1991) examined modality-specific attention to television scenes. He examined the effect of varying levels of cross-channel redundancy in television news stories on attentional resources. The results suggest that there may indeed be a common pool of resources that is shifted among modalities. Specifically, while watching audio-based television news stories, subjects appear to have shifted additional attentional resources to their auditory modality. This study only examined attention effects, however; therefore, we have no information on whether processing resources or memory differences are also modality specific.

Implications for research

Research that uses memory measures to assess cognitive resource limitations is inconclusive. A variety of factors affect memory independent of resource limitations. In addition, resource limitations may be different at various stages of processing. When attention is examined through secondary reaction task times, however, the results do not suggest an all-or-nothing filter. Instead, they appear to support theories of a common pool of resources that are shared between modalities. These results suggest that we should measure effects at multiple stages of processing. Studying these outcomes simultaneously would allow us to identify the nature and location of these limitations in processing multiple channels of information.

One approach to the question of resource limitations has been used in psychology, but has not been explored in communication. It involves presenting viewers with both channels of information, but asking them to attend selectively, or focus, on a particular channel (Schneider *et al.*, 1984). This manipulation could be used to examine whether the human information processing system handles single or multiple channels.

If people can attend to only a single modality, they would miss information in the other modality. If, however, people process multiple modalities simultaneously, then they should still glean information in the unfocused channel. This investigation can measure the effects of selective attention at two distinct stages. First, we can examine the possibility of modality-specific attention. Second, we can examine the possibility of modality-specific memory differences.

Manipulating viewers' focus on a particular channel of information could result in three specific outcomes. First, according to structural models, if viewers can only attend to one modality at a time, then they will only be able to detect and remember information in that channel. They will miss information in the unfocused channel. Second, according to a resource model, if television viewing uses modality-specific resources, then focusing on one channel will increase the attentional resources available to that modality at the expense of the other modality. Viewers will not miss the other information, but will be less able to detect flashes or remember information in the unfocused modality. Third, according to the multiple stage model, the location of these resource limitations may not be at the attention stage, but at the semantic processing stage. If this is the case, then allocating more resources to one channel will not enhance attention to that channel but will enhance memory for information in that channel. Viewers will be able to detect information in both channels, but have better memory for the focused channel.

Hypotheses

Because television contains both auditory and visual information and people have limited information processing abilities it is expected that viewers make use of selective attention to focus on a particular channel. First, viewers should shift attentional resources based on the location of the semantic information in a message. Viewers should pay more attention to the semantic channel than to the non-semantic channel. This leads to the following prediction:

> H1: When the semantic information is in the audio channel, subjects will show more attention to the auditory modality; however, when the semantic information is in the video channel, subjects will show more attention to the visual modality.

Second, viewers should shift attentional resources according to instructions. Viewers should show more attention to the channel of instructed focus than to the opposite channel. This results in the following prediction:

H2: When instructed to focus on the audio channel, subjects will show more attention to the auditory modality; however, when instructed to focus on the video channel, subjects will show more attention to the visual modality.

Third, viewers should shift semantic processing resources based on the location of the semantic information in a message. Because of the dedication of additional resources, a semantic channel effect should result in better memory for information in the semantic channel than for information in the non-semantic channel. This leads to the following prediction:

H3: When the semantic information is in the audio channel, subjects will show better memory for auditory information; however, when the semantic information is in the video channel, subjects will show better memory for visual information.

Fourth, viewers should shift semantic processing resources according to instructions. This instructed focus effect should cause better memory for information in the channel of instructed focus than to information in the opposite channel. This leads to the following prediction:

H4: When subjects are instructed to focus on the audio channel, they will show better memory for auditory information; however, when subjects are instructed to focus on the video channel, they will show better memory for visual information.

Methods

Design

This experiment used a two-by-two, fully-crossed, within-subjects design to investigate modality-specific attention and memory. Two independent variables were used to create selective attention to a particular channel. The first independent variable is the channel containing the semantic content (audio or video). The second independent variable is the channel in which viewers were instructed to focus (audio or video). The first dependent variable, attention, was investigated in two modalities (auditory and visual) by measuring viewers' secondary reaction time to modality-specific cues (audio tones and color flashes). The second dependent variable, memory, was investigated by asking paper-and-pencil multiple-choice questions about channel-specific content.

To insure that most of the variance in secondary reaction task times and memory was due to experimental differences, with minimal noise from external factors, this research took place in a controlled laboratory setting. Subjects were instructed to "watch the television with your full attention." The necessity of responding to the secondary task cues also insured a high level of attention. Secondary reaction times for messages were assessed while viewing. Memory was measured after viewing.

Operationalizations

Selective attention

One of the most important aspect of information processing and attention discussed so far is selectivity -- what is "attended to" (Broadbent, 1958). Selective attention to specific channels of television information, however, probably depends on both the contents of the message and the desires of the viewer (Anderson & Lorch, 1983; Collins, 1982; Geiger, 1988; Watt, 1979). Either of these two factors may determine whether viewers focus on a particular channel of television information (Salomon, 1972, 1974). Both of these operationalizations are explained below.

Semantic channel

Channel focus can be an attribute of a message. Viewers may focus on a particular channel based on what is in the message. One message factor that may affect channel focus is the location of the plot information or meaning. If this information is in a particular channel, viewers may be more likely to devote more effort to that channel (Triesman, 1964, 1968). Semantic or plot information can result in a focus on that channel because of its importance to the viewer (Collins, 1982; Salomon, 1979).

In television scenes, semantic information can be carried in either the audio or video channel. This is possible by finding television scenes where the semantic information is in a particular channel. Specifically, there are instances in which either the audio or video channel contains the bulk of the semantic information. Documentaries, for example, often contain the semantic information in a narrative audio track complimented by visual images. Chase scenes, however, use visuals to carry the story, and are [illegible]d by sound effects in the audio channel. This study will operationalize scenes as containing semantic information in one of the two channels.

The semantic channel was identified in the following way. Messages were selected that had a dominant semantic channel. This selection was based on finding scenes that were comprehensible by only hearing them and scenes that were only comprehensible by seeing them. Scenes that were only comprehensible with the audio channel were "audio-semantic." Scenes that only convey the story through video were "video-semantic." In this way, scenes contained semantic information in either the audio or video track. The semantic channel was a categorical variable -- audio or video.

Instructed focus

Channel focus can also be an attribute of a viewer (Collins, 1982; Salomon, 1979, 1983). For example, the desire to focus on a particular channel may depend on viewer interest. This contention is based on evidence that viewers can switch between particular channels of information. One demonstration of this effect can be seen in the "figure-ground" effect (Kahneman, 1973). For example, an ambiguous drawing can be seen as a vase or a face at various points. It cannot, however, be seen as a vase and a face simultaneously. Although selective attention does not completely exclude information in other modalities, information in the secondary modality appears to be processed at a less completely. For this study, it was important to control for and examine the effects of selective attention. This experiment, therefore, manipulated viewers' focus directly. Receiver focus, then, is operationalized as a categorical variable -- audio-focused or video-focused.

Viewers' focus was manipulated by asking viewers to attend to the audio or video channel. This manipulation has been used previously (Dornbush, 1970; Katz, Adoni & Parness, 1977). The experimenter will ask the subject to either "concentrate on the audio material -- the words and sounds" or to "concentrate on the video material -- the pictures."

Attention

Attentional resources are widely believed to be limited (Kahneman, 1973). Through these limitations, a person's performance of a task reduces the amount of resources remaining for other tasks being performed concurrently (Kahneman, 1973). As more effort is devoted to a primary task, less is available for the second task. This study used secondary reaction times to measure attention. While people are engaged in the primary task of watching television, they are timed on an occasional secondary task. Secondary reaction times are the interval that elapses between a cue and the person's response (Geiger & Reeves, 1989, 1991; Reeves & Thorson, 1986; Reeves *et al*, 1991; Thorson *et al.*, 1986). The latency to response is compared across a sampling of different types of television material. Reaction times to visual cues and auditory cue were measured for each scene. These measures were then averaged to represent means for particular conditions. Secondary reaction time, then, is a ratio-level variable that can be seen as modality-specific. Reaction times were a continuous interval measure compared across different television scenes.

Secondary reaction times were assessed in both the auditory and visual modalities. This was done through the use of both auditory and visual cues (Grimes, 1990; Schleuder *et al.*, 1988; Thorson, *et al.*, 1986). The auditory cue was a 1000-Hertz tone lasting for 100 milliseconds. It was fired by computer. Tones were played through the television monitor at comfortable listening levels. The visual cue has consisted of both strobe flashes (Thorson *et al.*, 1986) and color flashes on the screen (Grimes, 1991). The visual cue was an orange flash on the screen. It consisted of four frames of solid color edited onto the videotape (lasting for 133 milliseconds). Response latency to these cues was measured by computer.

Memory

This study used the recognition of information as a measure of memory. The ability to recognize information from memory, of course, rests on the parsing and storage of that information and the ability to retrieve it from memory (Kellermann, 1985). For this research, memory was measured as recognition accuracy for audio and video components of scenes (Grimes, 1990). Although memory is conceptualized as a continuum (from none to complete), the measures are probabilistic samples of this continuum. Memory, then, is a ratio-level accuracy measure compared within subjects but across television scenes. This study examined cued recall in the form of multiple choice question. Questions asked about information specific to a particular channel. Visual questions, for example, asked about what happened, and how people were dressed. Auditory questions asked about what was said and the background music.

Unit of Analysis

There is not intrinsic "container size" for theories about information processing (Reeves, 1989). Previous research, however, suggests that people "chunk" information into meaningful bits (Carter, Ruggels, Jackson & Heffner, 1977). According to these and other results, people can chunk thirty-second segments such as advertisements as psychological "units."

In this study, the unit of analysis was a thirty-second "scene." This unit of analysis was encouraged by the use of discreet segments of programs lasting 28 to 33 seconds. Each was separated by 5 seconds of black. The selective attention manipulations caused the semantic channel and the instructed channel focus to vary between scenes. Attention was averaged over 30-second scenes to represent attention levels for scenes. Memory was also averaged to represent recognition levels for scenes. So thirty-second scenes were meaningful units for theories about message factors such as the contents of a channel, and viewer factors such as channel focus, level of attention, and memory.

Subjects

Twenty-four summer school students at a large Western University's Mass Media Institute were recruited to take part. They had come from various locations around the United States for special summer school courses on the mass media. All participation was voluntary. The entire procedure took less than one-half hour (approximately 25 minutes). Subjects ranged from 16 to 47 years of age. Twelve were women and twelve were men.

Stimuli

A variety of television scenes that used either the audio or video channel to carry the semantic information were sampled. Sampling allowed us to insure a variety and range of naturally-occurring messages and correlated factors (Jackson & Jacobs, 1983; Jackson, O'Keefe & Jacobs, 1988; Morley, 1988a, 1988b; Reeves & Geiger, in press). This variety of messages included a range of genres (Levy, 1989; McLeod & Pan, 1989; Reeves, 1989). To select the stimuli for this study, the following steps were taken. First, six genres were selected.[1] Three of these -- news, interviews, and documentaries -- represented

[1] This sample was based on a survey of 10 Ph.D. students who rated 18 genres on their information, action, and emotion level. The genres which were rated as high on information were news, interviews, and documentaries. The genres rated as high on action were animation, action, and crime. All six genres were

generally audio-based genres. The other three -- animation, action, and crime -- represented video-based genres. Programs were recorded from actual television broadcasts. These programs were then viewed for content. When a scene was incomprehensible without one channel of information, it was selected for pretesting. Two raters verified these ratings. The first rater listened to the scenes and tried to identify what the message was about. A second rater both watched and listened to the messages and tried to identify "whether the audio or visuals are most important to conveying the story." Both raters were used for classification of the experimental scenes. A list of these scenes is presented in Appendix A. Two alternate orders of the stimulus tape was made. These tape orders are shown in Appendix B.

Previous research has shown that audio and video complexity may affect secondary reaction times (Reeves *et al.*, 1985; Thorson, *et al.*, 1985, 1986). Therefore, stimuli were selected which used a range of audio and video complexity. These measures can be seen in Appendix B.

Location of cues. Previous research has discovered that both local and global complexities can affect reaction times to secondary cues (Thorson *et al.*, 1986). Local complexity refers to what is occurring in the scene at that particular moment. Global complexity refers to what is happening more generally. This research concentrated on the global complexity dimension for two reasons. First, scenes were the unit of analysis. Second, it would be preferable to avoid smaller factors that might add noise to this level.

For these reasons, the location of each secondary task cue was carefully placed according to four criteria. First, one cue was placed in the first 15 seconds and the second in the last 15 seconds. Second, to avoid the effects of production factors such as cuts (Geiger & Reeves, 1989, 1991; Kim, Hawkins & Pingree, 1991), cues were not placed within three seconds of a cut. Third, cues were placed at natural breaks or pauses in the audio channel. Fourth, whether the first cue was auditory or visual was based on a random number table. An alternative version of the tape was made which used the opposite order. To insure that subjects could not anticipate the occurrence of secondary task cues, seven experimental scenes contained a third cue of random modality. The sequences of secondary task cues can be seen in Appendix B.

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equivalent on rating of emotion level.

Procedure

Subjects were run individually. Each subject was welcomed to the lab, the experimenter introduced himself, and the subjects were seated in front of the television. They were given the general instructions and shown a short practice tape to acquaint them with the secondary task tones and flashes as well as the procedure. When they had become proficient in responding to both tones and flashes, the practice material was stopped. The subjects were asked if they had any questions or problems.

Next, subjects were given the first manipulation. They were asked to concentrate on the video or audio material, and told what type of questions they would be asked for information in that channel. Subjects were not told that they would be asked about information from the non-focused channel. Subjects then watched eleven scenes. The first two scenes provided practice for the focus manipulation and were not included in later analyses. This segment lasted for approximately 7 minutes. (The orders are shown in Appendix B.) The experimenter left the room. He returned at the end of the sequence and asked how it had gone and whether there were any problems or questions. The other manipulation was then given (to concentrate on the audio or video material, and what type of questions would be asked). Subjects then watched nine more scenes that lasted for approximately 6 minutes. The experimenter then left the room. He returned at the end of the sequence. The subjects were then given the memory questionnaire. This questionnaire contained 96 multiple choice question to test recognition accuracy for all segments. When they finished the questionnaire, subjects were debriefed, asked if they had any questions, thanked, and shown out.

Analysis

The effects of semantic channel and viewers' instructed focus on secondary reaction time were investigated. These effects were investigated in both modalities. For the first step, data were plotted. Non-responses and outliers that were more than 4 standard deviations from the mean were removed. This deleted 31 of 1320, or 3% of the cases.

The effects of semantic channel and viewers' instructed focus on memory were also investigated. Data were subjected to statistical analysis with a within-subjects analysis of variance procedure. The .05 level of significance was used for all comparisons.

Results

Manipulation check

Four self-report measures were used as manipulation checks for the instructed focus. In the first, viewers were asked, "When I told you to focus on the video material -- the pictures -- were you able to?" Twenty-one of the twenty-four subjects (88%) indicated that they were able to "focus" on the video material as instructed. All twenty-four were used in the analyses. For the second manipulation check, subjects were asked "How easy was it to focus on the video material?" They were provided a 1-to-7 scale labelled "very easy" to "very hard." The average response was 2.4, nearer the "easy" end. For the third manipulation check, subjects were asked, "When I told you to focus on the audio material -- the words and sounds, were you able to?" Twenty-three (96%) indicated that they were able to focus on the audio material as instructed. For the fourth manipulation check, subjects were asked "How easy was it to focus on the audio material?" They were provided a 1-to-7 scale labelled "very easy" to "very hard." The average response was 3.0, nearer the middle of the scale than to "easy" end.

All four viewers' self-reports suggested that they were able to focus on particular message channels. Viewers also reported that it was fairly easy for them to focus on a particular message channel. These results suggest that the viewers' focus was successfully manipulated.

The results, however, indicate that it may have been easier for subjects to focus on the video channel than the audio channel. A paired t-test examined subjects' report of the difficulty of focusing. Their report of the difficulty of focusing on the video channel ($M=2.4$) was significantly easier than their report of focusing on the audio channel ($M=3.0$) ($t[23]=2.17, p<.05$).

Secondary reaction time

Secondary reaction times were analyzed with a repeated-measures analysis of variance. No significant disordinal interactions were found. Before examining the hypotheses, three main effects need to be discussed.

Subjects responded more quickly to visual cues ($M=399$ msec.) than to auditory cues ($M=421$ msec) ($F[1,1090]=24.4, p<.001$). This difference in the speed of responding to these two cues does not reflect more attention to the visual modality than to the auditory modality. Instead, it is due to detection levels. It was easier to detect visual cues than auditory ones. As a result, people were faster to these visual cues than to these auditory cues.[2] Further analyses, therefore, compared reaction times to each type of cue separately.

Hypothesis 1 predicted that subjects would be faster to audio cues in audio-based scenes and video cues in video-based scenes than to opposite-modality cues. This was not found ($F<1$). Instead, subjects responded more quickly to both auditory and visual cues in audio-semantic scenes than in video-based scenes ($F[1,1090]=9.49, p<.01$). The average secondary reaction time to auditory cues in audio-based scenes was 415 msec. and in video-based scenes was 428 msec. ($p<.05$ by Tukey procedure). The average secondary reaction time to visual cues was 391 msec. in audio-based scenes and 407 msec. in audio-based scenes ($p<.05$). This result can be seen in Figure 4. As predicted, people are faster at detecting cues in the auditory modality when the semantic information is in the audio channel. However, they are also faster at detecting cues in the visual modality when the semantic information was in the audio channel. The results of the semantic channel conflict with Hypothesis 1.

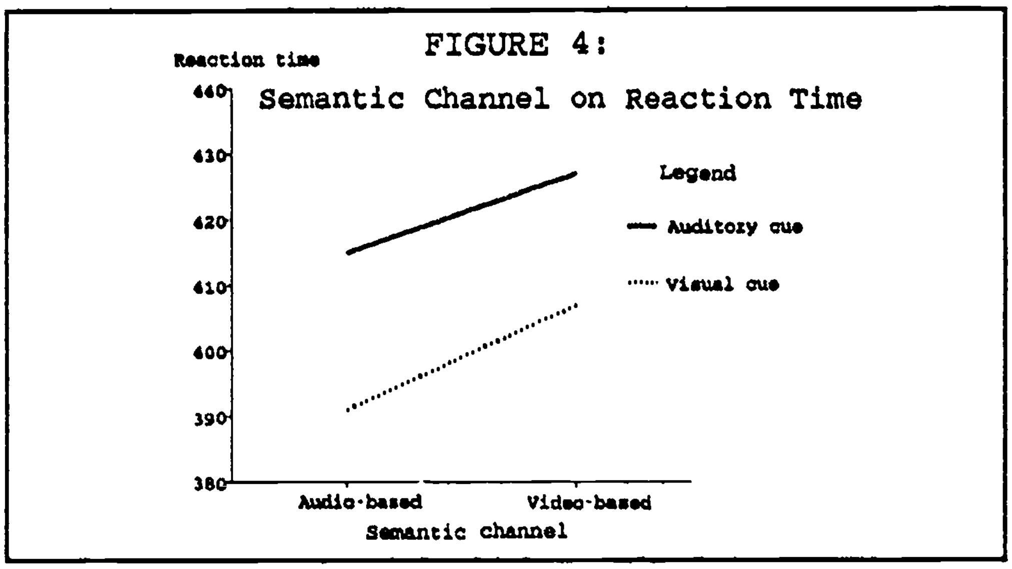

FIGURE 4:
Semantic Channel on Reaction Time

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[2]Evidence for this assertion can by seen in comparing the second pretest of the experiment with the final results. In the pretest, responses to the 3-frame visual cue were slightly faster than responses to the auditory cue. When the cue was lengthened to four frames, subjects became faster in responding to visual cues. In both cases, however, subjects were faster for audio-based scenes than for video-based scenes. Thus, the overall effect remained the same, even though the main effect for baseline reactions seems to depend on the specifics of the visual cue that was used.

Hypothesis 2 predicted that subjects would be faster to detect cues in the auditory modality when focused on the audio channel and in the visual modality when focused on the video channel. This was not found ($F<1$). The result, shown in Figure 5, also conflicts with the predicted effect for instructed focus.

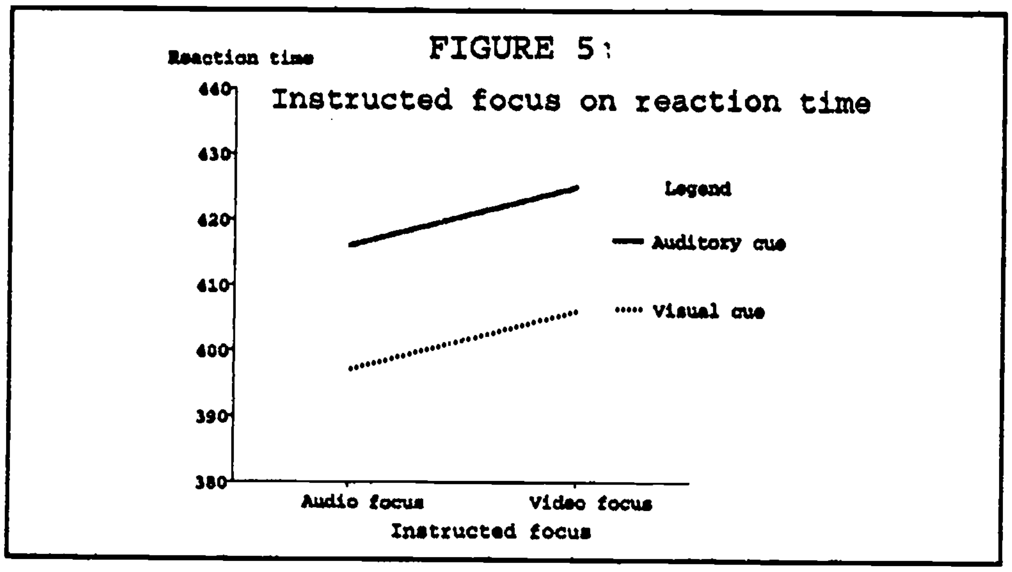


FIGURE 5:
Instructed focus on reaction time

Subjects were faster in detecting cues when focused on the audio channel than when focused on the video channel ($F[1, 1090]=4.41, p<.05$). The average secondary response time to auditory cues when focused on the audio channel was 416 msec. and when focused on the video channel was 425 msec. ($p<.05$). The average secondary response time to visual cues when focused on the audio channel was 396 msec. and when focused on the video channel was 406 msec. ($p<.05$).

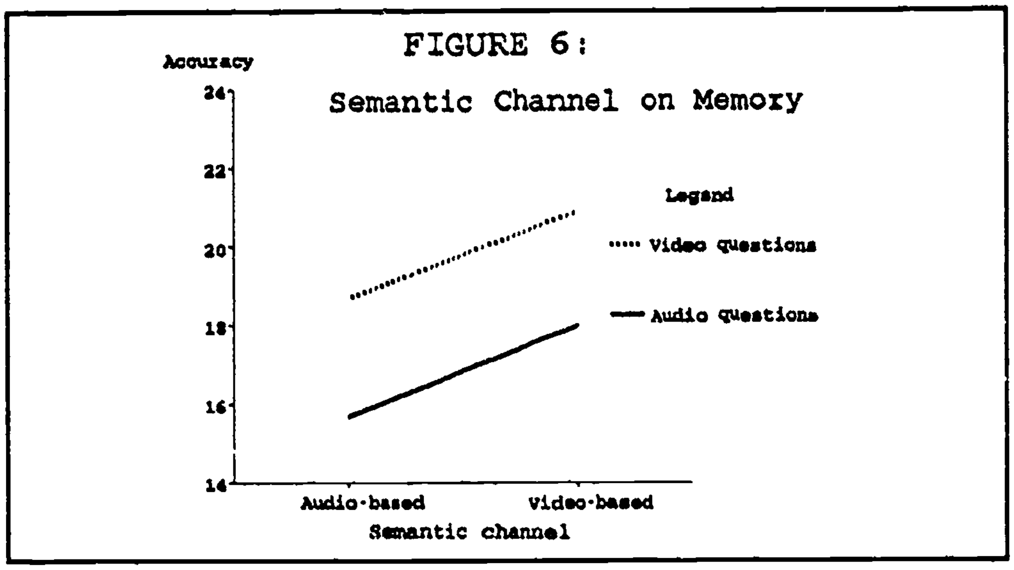
The results across these two variables were surprisingly similar. The variables, however, were completely independent. The semantic channel variable, for example, alternated randomly among the 24 scenes. This can be seen in Appendix B. Meanwhile, instructed focus was manipulated only twice -- one channel for the first 12 scenes, and the opposite focus for the last 12 scenes. The location of these two manipulations is also shown in Appendix B. Therefore, the variables plotted in Figure 4 are completely uncorrelated with each of the manipulations plotted in Figure 5.

These results suggest that regardless of the selective attention variable examined -- semantic channel or instructed focus -- subjects were faster at detecting secondary task cues when these variables attempted to focus them on the audio channel of television material.[3]

Memory

Memory measures were analyzed with two separate repeated-measures analyses of variance. Two specific hypotheses were investigated.

Hypothesis 3 predicted that memory would be better for audio material in audio-based scenes and for video material in video-based scenes. This was not found ($F<1$). Instead, subjects showed better memory for visual questions, as can be seen in Figure 6 ($F[1,23]=34.6, p<.001$).

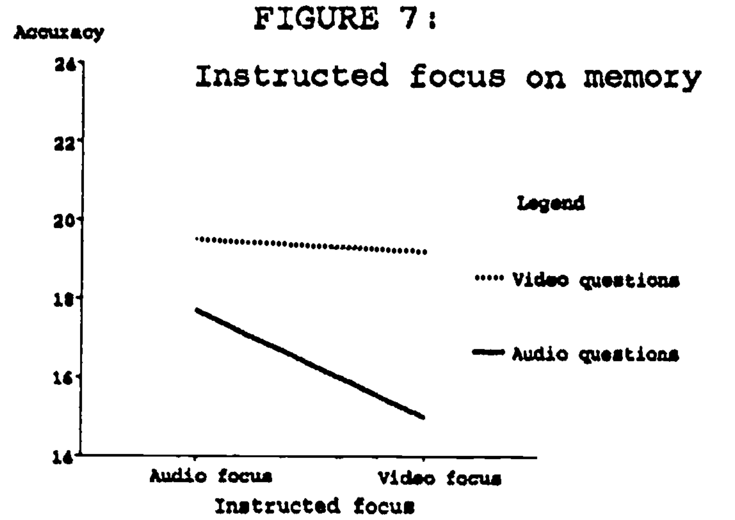


Questions about visual information were easier for subjects. In addition, subjects showed better memory for both types of material when semantic information was in the video channel ($F[1,23]=16.4, p<.001$). Subjects correctly identified an average of 18.7 video questions when the semantic information was in the audio channel versus 20.9 when the semantic information was in the video channel ($p<.05$). Similarly, subjects correctly identified 15.7 audio questions when the semantic information was in the audio channel, but 18.0 when the semantic information was in the video channel ($p<.05$).

[3]Further evidence can be seen in both pretests of this experiment. In the first pretest, responses to auditory secondary-task cues were faster for audio-based messages than for video-based messages. In the second pretest, responses were faster for the audio-based messages for both cue modalities. Both pretest results, then, are consistent with the direction found in the final experiment.

Hypothesis 4 also predicted that subjects would show better memory for the material on which they were instructed to focus. They were expected to show better memory for audio material when focused on the audio channel, and for video material when focused on the video channel. This effect was significant ($F[1,23]=6.6$, $p<.02$). It is illustrated in Figure 7.

FIGURE 7: Instructed focus on memory



Along with this result, there was also an effect for modality of questions -- visual questions being easier than auditory questions ($F[1,23]=35.9$, $p<.001$). In addition, an effect for instructed focus emerged. Subjects showed better memory when they were instructed to focus on the audio channel ($F[1,23]=10.2$, $p<.001$). This effect should be interpreted in view of the significant modality of material-by-instructed focus interaction. Little effect was seen on the video accuracy. Specifically, subjects correctly identified 19.5 video questions when focused on the audio channel and 19.2 when focused on the video channel (n.s.). The effect was seen for the audio questions, however. For the audio questions, subjects correctly identified 17.7 questions when focused on the audio channel, but only 15.0 when focused on the video channel ($p<.05$).

These results suggest that memory was significantly affected by both variables. Viewers' memory appears to depend on where the viewer is focused. For the semantic channel variable, memory was better for audio and video information when the scenes contained most of the semantic information in the video channel. With the instructed focus manipulation, however, memory for audio was better when subjects were instructed to focus on the audio channel.[4]

Discussion

This experiment demonstrates that selectively focusing on a particular channel of television has several significant effects on measures of attention and memory. The results indicate differences in the nature of audio-based and video-based messages and the processing of auditory and visual information. Each of the hypotheses, and the implications of the results, will be discussed in turn.

Reaction time

Hypothesis 1 predicted that, because of selective attention, people would demonstrate more attention to the channel that contained the semantic information. Subjects were expected to respond more quickly to auditory cues when that channel contained the semantic information and to visual cues when that channel contained the semantic information. This was not found. Instead, the results show that under these laboratory conditions, subjects had faster reactions to secondary task cues when the semantic information is in the audio channel.

Hypothesis 2 predicted that people would show more attention to the channel in which they were instructed to focus. That is, when subjects were focused on the audio channel they were expected to respond faster to audio cues, and when they were focused on the video channel they were expected to respond faster to video cues. This was not the case. Instead, viewers were able to detect cues in both channels, regardless the channel on which they were instructed to focus. Again, subjects had faster reactions to both types of secondary task cues when they were instructed to focus on the audio channel.

The attention results have two important implications. First, because viewers were not any faster at detecting cues in the semantic or instructed focus modality, it suggests that attention is not modality-specific.

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[4] Further analyses were conducted. These analyses investigated potential relationships between attention and memory measures. Analyses averaged across subjects to obtain mean reaction times to particular scenes and mean memorability scores. Small correlations were obtained. The correlation between reaction time and visual memory was positive (.14). The correlation between reaction time and auditory memory was negative (-.13). The reciprocal nature was intriguing. Further analyses, however, showed that the relationship was too weak to be statistically significant.

Instead, people appear to monitor both channels of television for salient events and cues. Viewers perceptual system does not appear to be limited to a single channel. All modalities appear to gain some admittance into the processing system.

Second, regardless of whether the cue is auditory or visual, responses are faster to audio-based messages and when subjects are instructed to focus on the audio channel. The auditory and visual systems, therefore, appear to have similar resources available at the same time. This appears to be evidence that at the detection level resources are not shifted to specific channels. Detection of these types of cues, then, does not benefit from a focus on that channel. These responses may be an automatic, and may occur as a pre-attentional sensory-level response (Neisser, 1967).

The results also show that these two modalities of television do not use resources equally. Secondary reaction times were faster for audio-based scenes. Secondary reaction times were also faster when subjects were instructed to focus on the audio channel. Because this effect occurred for both the semantic channel variable and the instructed focus manipulation, the results suggest that this effect is quite robust. It is widely believed that processing of the audio channel of television is more difficult than processing the video channel. Also, viewers reported that it was more difficult to focus on the audio channel than the video channel. Responses to secondary tasks were faster while viewers were engaged in difficult material than when they were engaged in easy material. Faster reaction time to cues in difficult material is consistent with previous findings. For example, Britton *et al.* (1982) found subjects responded faster to audio cues in complex material than in simple material. Thorson *et al.* (1985) also found subjects faster to secondary tones for complex auditory information than for simple auditory information.

The secondary reaction time results warrant interpretation. Some researchers purport that secondary reaction times are as a measure of attentional demands (e.g., Britton *et al.*, 1982; Sperling & Dosher, 1986; Thorson *et al.*, 1985). These researchers assume that capacity is taxed to the point of reaching its limitations (Norman & Bobrow, 1975). Slower reaction times, therefore, are believed to indicate more difficult material (Reeves & Thorson, 1986; Reeves *et al.*, 1985; Schleuder *et al.*, 1988; Thorson *et al.*, 1986). Other researchers, however, use the same secondary tasks as a measure of attentional allocation (e.g., Kahneman, 1973). If (a) attentional limitations are not always taxed to capacity by television material, or (b) responses to secondary cues are automatic, and not bogged down by processing loads, then it seems quite possible that secondary reaction times measure attentional resource allocation by the viewer. As this study proposed, these results appear to indicate that this measure appears to measure resource allocation. This result is consistent with theories of arousal and autonomic activation (Kahneman, 1973; Wickens, 1984). It validates the suggestion that "the secondary task measure may...capture automatic responses associated with arousal" (Reeves *et al.*, 1991: 692).

The conclusion that secondary reaction times respond as a measure of attentional allocation is consistent with quite a few results in both communication and psychology (Basil & Melwani, 1991; Britton *et al.*, 1972; Meadowcroft & Reeves, 1989; Mitchell & Hunt, 1989; Reeves & Thorson, 1986; Reeves *et al.*, 1985, 1991; Schleuder *et al.*, 1988; Thorson *et al.*, 1987; Watt & Meadowcroft, 1990). These results suggest that secondary reaction time measures do not measure attentional or sensory-level processing limitations, but measure processing resources. Secondary reaction times are not slowed for difficult material -- they are faster. Secondary reaction times also do not appear to benefit from resource allocation to specific channels through selective attention. The interpretation appears to be that more resources are available for difficult material. Additional resources appear to allocated when necessary. Attention, then, does not appear to be operating at resource-limited levels (Norman & Bobrow, 1975) for television viewing.

Another potential explanation for this effect warrants mention. This explanation is based on psycho-biological theories of evolution (Posner *et al.*, 1976). Posner *et al.* proposed that the precedence of visual processing makes sense phylogenetically. They proposed that the brain is biased toward the reception of visual stimuli. Although these results may go beyond that theory, they appear to conflict with it. When subjects are focused on audio information, they responded more quickly to both visual and auditory cues. Posner might have predicted the opposite result.

From a survival-of-the-species perspective, however, it may make sense that people respond more quickly to changes in the environment when focused on auditory stimuli. When they are not monitoring the visual environment for signs of danger, the nervous system may compensate by shifting additional resources to the attentional system. Danger detection system may involve both channels of attention. So when people are not looking the autonomic nervous system may be enhanced in a general sense to compensate.

Memory

The memory results show evidence of modality-specific effects. Most importantly, there appears to be evidence of resource limitations in the auditory modality. These conclusions will be discussed in terms of the original hypotheses.

Hypothesis 3 predicted a semantic channel effect such that viewers would have better memory for information in the modality that contained most of the semantic information. This hypothesis was not borne out. Instead, viewers had better memory for both audio and video information when the semantic information was in the video channel.

Hypothesis 4 predicted that viewers would show better memory for material in the channel on which they were instructed to focus. This hypothesis was partially borne out. The effect occurred over a background of better memory for the video questions. Viewers had, however, better memory for audio information after they were instructed to focus on the audio channel.

The results for the two memory measures show limited evidence of modality-based differences. Subjects were more accurate in responding to questions about audio and video content in visual-based scenes. This result probably indicates that video-based television scenes such as chase scenes are easier than audio-based scenes such as news stories. This result is also consistent with research that suggests that video information processing requires fewer resources (or less effort) than auditory information (Colvatio, 1974; Schleuder *et al.*, 1988). This may be due to the different form of the code systems (Salomon, 1979). Video-based codes may be easier than audio-based codes.

When viewers were focused on the audio channel, however, memory occurred for audio information was better. This finding was in accord with Pezdek and Stevens (1984). Four potential theories have been posed so far. First, there was the possibility of structural filters. Focusing on a specific modality may determine what is accepted for central processing. The results, however, are not consistent with this theory. Specifically, viewers were able to remember auditory information when they were focused on the video channel.

The second potential theory was general resource limitations. Processing semantic auditory information may require considerable allocation of either sensory-level or semantic-level resources. In this way, attending to the audio channel may lead to more effort overall -- more overall resource allocation. When these resources are directed to the auditory channel, this may result in better memory for the items. The results did not, however, show improved memory for visual information in these instances. Instead, the visual information was remembered equally well regardless of the channel focus.

A third theory was that more attention may be required to remember information than to attend to it. Perhaps attention is not as limited as are processing resources (Colvatia, 1974; Posner *et al.*, 1976). The results are only somewhat consistent with this theory. Specifically, visual memory was neither helped nor hindered by a visual focus. Auditory memory, however, was enhanced. This result suggests that visual processing is not enhanced by the presence of additional resources. Such a finding is consistent with previous research that compared visual and auditory processing. Visual processing is not the same as auditory processing. As Kahneman (1973, p. 135) commented, "It is tempting to speculate that the modern study of attention would have taken a different course if Broadbent (1958) had been concerned with how one sees dances rather than how one hears messages."

A fourth theory revolves around the possibility that visuals require fewer processing extrapolations than audio (Cohen, 1973). This may be due to the greater immediacy of visual symbols than language-based auditory messages (Salomon, 1979). Visual information may access meaning more directly. If auditory information requires more stages of processing, it may benefit more from additional resources than would visual information. This could show up as better memory.

An alternative reason for the results is that the concentration on the audio channel may have encouraged a different form of processing. When watching both channels of information, viewers may have processed the information only at a sensory level. It may have been stored to memory temporally or episodically. When viewers focused on the audio channel, however, they may have processed this information semantically. This deeper meaning-level processing may have led to better auditory memory as Craik and Lockhart proposed (1972). Therefore, the focus instruction may have inadvertently changed the nature of the processing. Although this seems unlikely, it is not possible to eliminate this explanation for these effects at this time.

Overall

Comparing these two dependent variables yields results that are compatible with one another and with other studies. In general, the results suggest that, at the attentional stage, resources are shared between modalities and are not modality-specific. Memory results, however, show a benefit for audio information when focused on the audio channel.

How is it possible that viewers were not better at detecting audio cues when they were focused on the audio channel, but had better memory for the audio information? The general conclusion that can be drawn is derived from two more specific conclusions.

Specific conclusion #1. First, attention is not modality-specific. Detection of information appears to occur in both channels simultaneously, regardless of the viewers selective attention. The evidence for this assertion can be seen in the first two figures. In Figure 4, secondary reaction times were faster to audio-based scenes. In Figure 5, reaction times were faster when viewers focused on the audio channel. This suggests that responding to information at a basic level uses a common pool of resources. Because instructions to focus on particular channels did not affect the attentional detection of secondary task cues, this detection appears to occur automatically (Neisser, 1967; Shiffrin & Grantham, 1974).

Specific conclusion #2. The processing of visual information in television scenes is not equivalent to processing auditory information. The evidence for this assertion can be seen in the last two figures. In Figure 6, viewers show better memory for both types of information in visual-based scenes. In Figure 7, viewers show better memory for auditory information when they are focused on the audio channel. These two figures show results which indicate that video information does not benefit from being in the channel of instructed focus to the extent that auditory information does.

The results show that processing of auditory television material is enhanced by focusing on that channel. The first potential explanation is that human information processors have a structural filter after sensory processing and before semantic processing (Deutsch & Deutsch, 1963). In this scenario, only one channel of information can "get into" the processing system and be processed semantically. Visual information, however, shows evidence of being detected and processed equally well regardless of viewers' focus. Specifically, visual information is detected and remembered, regardless of the instructed focus. The enhancement of auditory memory was not at the expense of information in the other channel. Specifically, auditory information is not at the expense of visual information. This result, therefore, contradicts the structural theory.

The second potential explanation is resource theory. Some of these theorists predict that auditory processing makes significantly greater resource demands than does sensory processing (Kahneman, 1973). In this experiment memory measures show that viewers were able to process and remember information in either channel. Viewers were able to remember visual information even when focused on the audio channel. However, there was a slight increase in audio performance when viewers focused on the audio channel. If additional resources were dedicated to this channel, and auditory information requires more resources than processing visual information, the results of this experiment support a resource model of processing.

Colavita (1974) found similar results. That is, visual stimuli take precedence over auditory stimuli. Visuals may require fewer extrapolations than audio (Cohen, 1973). Salomon (1979) proposed that this may be due to the greater immediacy of visual symbols than language-based auditory symbols. Visual information may access meaning more directly. If auditory information requires more stages of processing, it seems consistent that it would require additional resources. Because auditory information requires these additional resources, it would show a decrement before visual information does. Even with limited resources, visual information can be processed.

These results suggest that it is not attention that is the limiting factor in comprehension of television information. Instead, comprehension appears to suffer from limitations in comprehension, understanding, or memory at some later stage. Similar to results in the field of psychology, monitoring of channels does not tax resources to the extent that comprehension of audio semantic information does. It is the process of understanding of auditory information on television that requires resources.

Overall, these results show that television viewers process both modalities simultaneously. They automatically detect audio and video cues -- even when these cues occur along with information that is peripheral to the plot and not their main focus. Subjects also remember details of television scenes whether or not the information is semantically relevant and whether or not they are instructed to focus on that channel. That is, viewers are able to remember audio and video information, regardless of the channel on which they are focused.

The results of this experiment may not be directly generalized to natural viewing situations. They suggest, however, that television viewers appear to process two channels of information at once. Viewers glean visual and auditory information from television at the same time whether they intend to or not. This is consistent with results that indicate television viewers often are affected by visual and other non-verbal information while processing auditory information. Viewers use this information to form conclusions about news events and political candidates (e.g., Garramone, 1983; Grimes, 1990b). So while television users may gain less semantic information than users of other media such as newspapers, they are also gaining non-semantic information. Television viewers can take quite a bit of visual information away from the viewing experience. Audio-presented information, however, benefits from a concentration or a focus on that channel. Viewers need to be focused on the audio channel to take the most away from audio-based television news programs. Meanwhile, visual information appears to affect viewers more directly and immediately.

The finding that audio memory is enhanced by focusing on the audio channel is consistent with research on news programs. News programs usually contain most of the semantic information in the audio channel (Grimes, 1990a, 1991). It should not be surprising, therefore, that novel or inconsistent visual interferes with comprehension or memory for audio information (e.g., Edwardson *et al.*, 1985, 1991; Grimes, 1990a; Newhagen, 1990; Son *et al.*, 1987). In these instances the novel or inconsistent visual is interfering with the audio focus. Visuals reduce the resources available to the auditory modality, however briefly.

Finally, these results suggest that this multi-stage model and multi-measurement method can be used to investigate the attentional allocation and memory for television programs. Because of the complexity of television stimuli, "Our noisy, hard-to-control stimuli may actually place in high relief the versatility of the human-information processing system" (Grimes, 1990: 25). This method is likely to be useful in determining the nature of these processes and their limitations. These methods and measures, then, provide insights into not only how people process television information, but about how they process information generally. Further research can work toward determining which aspects of programs lead to arousal. We can also learn which aspects can lead to resource limitations, and which aspects lead to better memory for audio or visual information. In this way, the intricacies of the human information processing system can be related to dimensions of television stimuli. This research, then, can lead to a better understanding of the processing of not only television material, but also real-world multi-channel sources of information. In this way, this research will lead to the study of day-to-day information processing.

Appendix A:

DESCRIPTION OF STIMULI

	Shots	Sentences
VIDEO-BASED:		
Animation		
1. Disney -- Bee conducting	4	0
2. Smurfs -- Going to picnic	12	5
3. Chipmunk girls -- Faking asleep	7	4
4. The Simpsons -- Bart cheats	14	3
Adventure		
1. Lonesome Dove -- Burial	8	1
2. Gabriel's Fire -- Finding a tape	2	9
3. Vietnam movie -- Getting even	7	6
4. Lonesome Dove -- Into sunset	1	3
Crime or Detective		
1. Magnum, P. I. -- Fight scene	7	12
2. Sledge Hammer -- Visions	6	4
3. Crime Story -- Searching	7	0
4. McGuiver -- Being whipped	8	6
AUDIO-BASED		
News		
1. CNN -- Iraqi refinery	6	5
2. NBC -- Swartzkopf returns	3	5
3. CNN -- El Salvador Peace talks	11	6
4. KTVU -- Homeless veterans	1	6
Talk or Interview		
1. Oprah -- Disputed phone bill	2	8
2. Psychologist -- Looking for Dad	4	4
3. Phil Donohue -- Virgins	8	7
4. Johnny Carson -- Jay Leno	4	13
Documentary		
1. Winds of Everest -- Climbing	5	5
2. History of TV-- First broadcast	10	4
3. Sinatra -- The war years	9	6
4. Jaws: The true story	4	6

Appendix B:

TAPE ORDERS

Tape #1

Number Type	Name		Secondary Cues	
Warm-up				
1. A.	Indiana Jones 1	A	V	
2. V.	Indiana Jones 2	V	A	V
Focus manipulation #1				
1. V.	News 1	V	A	
2. A.	Talk 1	A	V	
3. A.	Documentary 1	A	A	V
4. V.	Animation 1	A	V	
5. V.	Crime 1	V	V	A
6. V.	Adventure 1	A	V	
7. A.	News 2	A	V	
8. V.	Adventure 2	V	A	A
9. A.	News 3	A	V	
10. A.	Documentary 2	V	V	A
11. V.	Crime 2	V	A	
12. V.	Crime 3	A	V	
Focus manipulation #2				
13. V.	Crime 4	A	V	V
14. A.	Documentary 3	A	V	
15. V.	Animation 2	V	A	
16. A.	Talk 2	V	A	
17. V.	Animation 3	A	V	
18. A.	Talk 3	V	A	V
19. A.	Documentary 4	A	V	A
20. V.	Adventure 3	V	A	
21. A.	News 4	V	A	
22. V.	Adventure 4	A	V	
23. A.	Talk 4	A	V	
24. V.	Animation 4	A	V	

Appendix B (Cont.):

TAPE ORDERS

Tape #2

Number	Type	Name	Secondary Cues		
Warm-up					
1.	A.	Indiana Jones 1	V	A	
2.	V.	Indiana Jones 2	A	V	A
Focus manipulation #1					
1.	V.	Crime 4	V	A	A
2.	A.	Documentary 3	V	A	
3.	V.	Animation 2	A	V	
4.	A.	Talk 2	A	V	
5.	V.	Animation 3	V	A	
6.	A.	Talk 3	A	V	A
7.	A.	Documentary 4	V	A	V
8.	V.	Adventure 3	A	V	
9.	A.	News 4	A	V	
10.	V.	Adventure 4	V	A	
11.	A.	Talk 4	V	A	
12.	V.	Animation 4	V	A	
Focus manipulation #2					
13.	A.	News 1	A	V	
14.	A.	Talk 1	V	A	
15.	A.	Documentary 1	V	V	A
16.	V.	Animation 1	V	A	
17.	V.	Crime 1	A	A	V
18.	V.	Adventure 1	V	A	
19.	A.	Ne[illegible]	V	A	
20.	V.	[illegible]e 2	A	V	V
21.	A.	[illegible]	V	A	
22.	A.	Doc[illegible]ary 2	A	A	V
23.	V.	Crime 2	A	V	
24.	V.	Crime 3	V	A	

Appendix C:

SAMPLE QUESTIONNAIRE

SUBJECT __________

SAMPLE QUESTIONS

There are two parts to this questionnaire. First, I have a few questions about the experiment in general. Second, there are several questions about what appeared in the television scenes. This will take about 15 minutes.

Please respond by circling or writing in your answer. Thank you

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1. When I told you to focus on the <u>video</u> material -- the pictures -- were you able to?

YES (1)
NO (0)

2. How easy was it to focus on the <u>video</u> material?

VERY EASY					VERY DIFFICULT	
1	2	3	4	5	6	7

3. What made it <u>easy</u> to focus on the <u>video</u> material?

4. What made it <u>difficult</u> to focus on the <u>video</u> material?

5. When I told you to focus on the <u>audio</u> material -- the words and sounds -- were you able to?

YES (1)
NO (0)

6. How easy was it to focus on the <u>audio</u> material?

VERY EASY					VERY DIFFICULT	
1	2	3	4	5	6	7

In the report on the refinery in Baghdad, the damage was a result of:
a. clandestine operations
b. repeated bombing
c. Kurdish sabotage
d. retaliation by Kuwaitis

The refinery has been restored to
a. 25% of capacity
b. 50% of capacity
c. 75% of capacity
d. 100% of capacity

In the story men were:
a. inspecting plans
b. filling trucks with oil
c. welding pipes
d. drilling new wells

What was the man who was interviewed wearing?
a. blue hard hat
b. traditional
c. suit and tie
d. military uniform

In the story on 900 numbers, the man's business phone was billed
a. $500
b. $700
c. $1000
d. $1200

In a letter from a credit collection bureau, he was told,
a. in 24 hours they would turn off his phone
b. in 24 hours they would prosecute him
c. 48 hours, they would turn off his phone
d. 48 hours, they would prosecute him

The man was on the
a. Phil Donohue Show
b. Geraldo
c. Good Morning America
d. Oprah Winfrey Show

He was or had:
a. clean shaven
b. a mustache
c. a beard
d. shoulder-length hair

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