The Limited Capacity Model of Mediated Message Processing

By Annie Lang

This paper presents an information-processing model that is directly applicable to the investigation of how mediated messages are processed. It applies the model to the case of television viewing to demonstrate its applicability. It provides a measure for each part of the model. It presents evidence that supports the model in the television-viewing situation. Finally, it demonstrates how the model may be used to further research and understanding in well-known theoretical traditions. This model is not meant to stand in opposition to any of these theories but, rather, should work well with them by providing hypothesized mechanisms that may underlie well-known effects. This model should prove useful both to researchers and, eventually, to message producers. To the extent that we can better understand how the content and structure of messages interact with a viewer's information-processing system to determine which parts and how much of a communication message is remembered, we will make great strides in understanding how people communicate.

The goal of this paper is to present a limited capacity information-processing model of mediated message processing and to offer at least one measure of each part of this information-processing model. Using this approach and these measures, researchers should be able to track the content of mediated messages into, through, and back out of the message recipient's information-processing system (the "black box"). The ability to do this will allow us to craft messages that convey their information better and to understand better how our messages may cause very real effects, both intended and unintended.

The model presented here is a data-driven model. Its roots lie in the information-processing tradition of cognitive psychology (Lachman, Lachman, & Butterfield, 1979) and in the social scientific effects research in mass communication (Berger & Chaffee, 1989). The model, as it stands now, is the product of a series of empirical studies that arose from the application of the information-processing model to questions of interest to effects researchers. It provides both a conceptual-theoretical framework for asking questions about the cognitive processing underlying media effects and an operational conceptualization that provides a methodological tool to measure each theorized process and mechanism.

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This paper first will describe briefly a general information-processing model. Second, it will specifically apply that information-processing model to the case of television viewing. Third, it will present how each stage in this model might be measured. Fourth, it will present evidence supporting the model. Finally, it will demonstrate the usefulness of the model to (a) explain the mechanisms underlying well-known areas of communication effects research, and (b) demonstrate how the model can predict and explain some of the contradictory findings in the mass communication literature.

Limited Capacity Information-Processing Approach to Mediated Communication

The particular information-processing model presented here (Lang, 1992; 1995; Lang & Basil, 1998) was specifically developed to investigate how people process television messages. It is an amalgam of many information-processing models developed over the past 30 years (Eysenck, 1993; Lachman, Lachman, & Butterfield, 1979). The model has two major assumptions. First, people are information processors. A major task that people engage in is the processing of information. The basic parts of information processing are to perceive stimuli, turn them into mental representations, do mental work on those representations, and reproduce them in the same or in an altered form. Second, a person's ability to process information is limited. Processing messages requires mental resources, and people have only a limited (and perhaps fixed) pool of mental resources. You can think about one thing, or two, or maybe seven, at the same time, but eventually all your resources are being used, and the system cannot think yet another thing without letting a previous thought go.

Information processing, in this model, is conceived of as a group of simultaneously occurring component processes (or subprocesses) that people perform on stimuli and on the mental representation of stimuli that they construct. Some of these subprocesses are automatic and some are controlled (Shiffrin & Schneider, 1977). Automatic processes happen without conscious volition on the part of the message recipient. Controlled processes are those that people intend. This model proposes three major subprocesses of information processing: (a) encoding; (b) storage; and (c) retrieval. Though the discussion of this model will proceed in a linear fashion, the processes discussed are continuous and iterative. It is assumed that the human brain can, and usually does, engage in all of these processes simultaneously.

Encoding

The subprocess of encoding involves getting the message out of the environment (i.e., off the page or off the screen) and into a person's brain. Historically, in the mass communication field, we have operationally equated this step with measures of exposure, such as the number of hours spent with the medium, or through measures of attention. Many communication models and theories treat this step in the information-processing sequence as simple and dichotomous—as a necessary, but not sufficient, condition on the road to communication effects. Not so, in the model presented here. Rather, this initial passage from environmental stimulus to mental representation is conceived of as being complex, idiosyncratic, and inexact.

This model theorizes that there are three processes involved in converting a message into a mental representation in the brain. First, the message must engage the sensory receptors, that is, eyes, ears, nose, mouth, skin (Eysenck, 1993). This can be thought of as exposure or perception. Information gathered by the sensory receptors enters some kind of sensory store (Zechmeister & Nyberg, 1982). Research on these sensory stores suggests that there is a specific sensory store for each sense, and that these stores may be virtually unlimited. However, the storage here is very short-lived. Information resides in these stores for periods ranging from about 300 msec for the visual (called iconic) store (Coltheart, 1975; Holding, 1975) to 4 or 5 seconds for the auditory (called echoic) store (Crowder, 1976). If a bit of information is not selected for further processing, it is written over by new information and lost.

If a person is exposed to a mediated message, the message should automatically make it into the sensory store. The sensory stores, however, hold more information than a person can be aware of or attend to. Only a fraction of the information held in the sensory stores moves on into active (or short-term or working) memory. The encoding subprocess is a two-step process through which specific bits of information[1] contained in the original message are selected from the myriad information bits available in the sensory store and transformed into activated mental representations in working or short-term memory. The mental representation of the message that is activated in working memory is not a veridical or precise representation of the message, but rather a representation that reflects both which specific bits of information any given person has selected for representation and the act of constructing a mental representation, which is affected in turn by the goals, knowledge, and environment of the person receiving the message.

The initial step in the encoding process is the determination of which bits of information will be transformed into mental representations. This selection process is driven by both automatic (unintentional) and controlled (intentional) processes.

Controlled selection processes reflect the viewer's goals. You might, for example, decide to notice what color shirts people were wearing in a movie; as a result, shirt color would always be selected into short-term memory while you were watching.

Automatic selection processes are unintentional and unconscious and are activated by the stimulus. Two major types of stimuli activate automatic selection

[1] "Information" or "bit of information" is used here to indicate all the individual units of structure and content that make up a message. These bits of information range from purely structural information like luminance levels, color spectrum, audio frequency, and size and location in the visual field, to larger, more content-related units like words, pictures, and actions, and to even larger metaconstructions, such as expressions, tone, intentions, etc. Any given message contains countless bits of information that may or may not be selected and encoded into working memory.

processes: (a) information that is relevant to the goals and needs of the individual, and (b) information that represents change or an unexpected occurrence in the environment (Graham, 1997; Ohman, 1997). Automatic selection processes that are related to individual goals and relevance will vary across situations, cultures, and individuals. On the other hand, automatic selection processes related to stimulus characteristics, such as novelty, change, and intensity, are likely to be the same across individuals within a culture, though the standards of what is novel may vary from culture to culture.

The process of encoding a message, thus, does not produce a precise one-to-one correspondence between the message and the mental representation of the message. The encoded message is neither an exact nor a complete replica of the original message. Rather it is an idiosyncratic representation of the message that is constructed by the viewer. It contains only a small fraction of the total information contained in the original message.

In this model there is nothing simple about exposure and attention. Rather, all the bits of information in a mediated message must engage the sensory receptors and enter the sensory store, where a fraction of them are selected (as a result of automatic and controlled selection processes) and transformed into mental representations in a person's working memory. This is the process of encoding. What a person does with this mental representation of the message is the basis upon which many theories of communication are built. One of the obvious things that people must do is to transfer some of that information from short-term memory to some longer term store.

Storage

Memory theory is a complex and fast-changing area of research. How many types of stores there are, whether they are limited or not, the mechanisms through which memories are stored, are all disputed questions. Recent methodological innovations (e.g., PET, FMRI, single-cell recording techniques, and neurochemical investigations) are rapidly altering our knowledge about where and how memory works. This model uses a general associative network model of memory, but does not take a stance on the specifics of memory architecture and operation.

Associative network models conceptualize individual memories as being connected to other related memories by associations (or links). When a memory is in use, it is activated. Activation can travel through associations, a process that renders related memories more active, or available, than unrelated memories (Eysenck, 1993; Eysenck & Keane, 1990; Klimesch, 1994). This model does not draw a sharp distinction between short- and long-term memory. Short-term or working memory is conceptualized as activated memories within the larger inactive (or long-term) memory. It is conceivable that working memory is just the subset of all memories that are active at any given time. The state of being concurrently activated may be the process that builds associations among new and old mental representations.

During the encoding subprocess, a mental representation of the message is constructed in working or activated memory. Initially, this newly encoded "message information" is activated but has associations only with the other information concurrently active in short-term memory. As a person thinks about the message, more and more associations between the "new" information and old information are formed.

The more a person links a new bit of information into this associative memory network, the better that information is stored. This process of linking newly encoded information to previously encoded information (or memories) is called storage. The more associations are formed between new and old information, the more completely the new information is stored. The result of the storage process is a continuum from poorly stored (few associations and links) to thoroughly stored (many associations and links). Some bits of information in the encoded mental representations of messages may be more thoroughly stored than others. In other words, all of the bits of information encoded from a message do not receive equivalent amounts of processing during storage. Some parts will be more thoroughly stored while other parts receive only cursory storage.

Retrieval

The final subprocess in this model is retrieval. This is the process of reactivating a stored mental representation of some aspect of the message. Put another way, retrieval is the process of searching the associative memory network for a specific piece of information and reactivating it in working memory. By and large, the more associative links there are to a piece of information, that is, the more thoroughly it has been stored, the more readily retrievable it is.

In addition to conceptualizing retrieval as an outcome associated with learning the content of a message, this model also conceptualizes retrieval as an ongoing process during message reception. We activate or retrieve relevant previously stored knowledge from long-term memory as we receive messages in order to comprehend and store them. A message about an election, for example, will result in concurrent retrieval of what you know about elections in general, and about this election in particular, in order for you to understand the message and store this new election information into your associative network. This concurrent retrieval process also plays a role in the storage process because concurrent retrieval causes the simultaneous activation of old and new information.

Any one of these subprocesses—encoding, storage, or retrieval—can be performed in a cursory or a thorough manner. How thoroughly a subprocess is performed and how many resources are allocated to the subprocess affect the likelihood that subsequent or concurrent subprocesses will be performed thoroughly. Memory for a message is, therefore, a composite of the outcome of all three subprocesses.

Information Processing and Limited Capacity

Many things affect how thoroughly a message is processed, that is, how much of the information in the message is encoded, stored, and ultimately retrievable. A major contributing factor is whether or not the recipient of the message has sufficient processing resources available to process the message. There are two main reasons why messages may not be thoroughly processed. First, the message recipient may choose to allocate fewer resources to the task than it requires. Second, the message may require more resources than the message recipient has available to allocate to the task. In either case, fewer resources are allocated to the task of processing a message than it requires, and the message, therefore, will not be thoroughly processed.

This model suggests that processing resources are independently allocated to the three major subprocesses of encoding, storage, and retrieval.[2] As a result, one subprocess (encoding, for example) may be allocated sufficient resources for thorough processing while the other, simultaneously occurring subprocesses (i.e., storage and retrieval) may receive insufficient resources to be performed optimally.

A Limited Capacity Information-Processing Approach to Television Viewing

What follows is a more concrete application of the model to a specific mediated-message context, that of watching television. What happens when limited capacity information processors (i.e., people) allocate their limited resources to television viewing?

Television as a Psychological Stimulus

First things first. We begin with the question, what is television? From an information-processing perspective, a television message is made up of two streams of variably redundant information, one audio and one video. These streams of information are continuous, and their pace is not generally under the control of the viewer. Much communication research has focused on the content of television (sports, violence, sex, news). Both the audio and the video channels carry story or content information. They also, however, contain a great deal of video and audio structural information (e.g., luminance levels, cuts, slow motion, animation, zooms, pans, video graphics, frequency levels, sound effects, music, rate of presentation, narrative structure). The television message is made up of both content and structural information.

To understand how television messages are processed, we must examine how both the structure and the content of the medium interact with each of the models' subprocesses. The following three sections of this paper consider the effects of both content and structure on encoding, storage, and retrieval.

Television Messages and Encoding

The first subprocess in the information-processing model described here is the encoding of the message into working memory. Encoding is an ongoing process. People are continuously selecting (unconsciously and consciously) information

[2] This model is a single-pool model. It assumes that all resources can be allocated to any of these three processes. The possibility exists, of course, that each of these processes might have its own pool of resources. The debate among theorists about multiple-pool vs. single-pool models is hotly contested and continuous. A good review of this literature can be found in Basil (1994a). To date, the data generated by the model presented here have supported the continued use of a single-pool model.

from their environment and encoding it into short-term memory. The discussion here attempts to determine which bits of information in a mediated message are most likely to be encoded into working memory. As discussed above, two types of information are most likely to be selected for encoding into working memory: (a) information relevant to the goals of the individual, and (b) information that is novel, unexpected, or representative of change in the environment. How do these types of information get selected?

This model suggests that one of the automatic selection mechanisms steering the selection of information to be encoded is the orienting response, or OR (Ohman, 1979; 1997). The orienting response, first proposed by Pavlov (1927), is an automatic (some say reflexive) physiological and behavioral response that occurs in response to novel or signal stimuli. A signal stimulus has some meaning for a person—the person's name, for instance. Signal stimuli change from person to person, culture to culture, and even from one situation to another. Once a stimulus has acquired signal status, however, the orienting response will be elicited by it. A novel stimulus is one that represents a change in the environment or an unexpected occurrence. In the context of viewing a television message, novelty or change is interpreted within the context of that television message. When an orienting response occurs, the viewer orients his or her sensory receptors toward the stimulus that caused the response, and an organized set of physiological responses accompanies this behavioral response (Lynn, 1966). The response set includes vasodilation of the blood vessels to the head, decrease in the alpha frequency of the EEG, slowing of the heart, increases in skin conductance and skin temperature, and general vasoconstriction of the blood vessels to the major muscle groups. Research suggests that this physiological response set is associated with attention (quieting of the body and increase in blood flow to the brain) and stimulus intake (Campbell, Wood, & McBride, 1997; Graham, 1997; Hoffman, 1997; Kimmel, Van Olst, & Orlebeke, 1979).

It has been suggested that the orienting response is one of the selection mechanisms that determines what information in the sensory store gets selected to be encoded into working memory (Ohman, 1979, 1997). The model being presented here suggests that many aspects of the structure and content of television messages elicit orienting responses in television viewers. The orienting response causes an automatic allocation of processing resources to the task of encoding the stimulus that elicited the orienting response. This increase in resources allocated to encoding increases the amount of information that can be selected from sensory store and encoded into working memory at that point in time, so long as the television viewer has sufficient available resources to respond to the call for additional resources made by the orienting response.

Consider the case mentioned earlier in which a person has made a controlled decision to notice the color of the actors' shirts. In that case, shirt color becomes a signal stimulus. As a result, whenever a shirt appears, the viewer will orient to the color of the shirt, additional resources will be allocated to encoding the shirt color, and this viewer will encode more information about shirt colors than a viewer who has not made this strategic choice. Thus, the orienting response, as a selection mechanism, can account for both individual choices, about what in the message is relevant and also for universal responses to novelty, structure, and unexpected content.[3]

Television Messages and Storage

What determines how much and which parts of a message are stored? As discussed above, both automatic and controlled processes are likely to be operating here, so storage is affected by both individual differences and by the resource limitations of the human information-processing system. In addition, in the television-viewing situation (because the message is continuous), encoding and storage likely limit one another. To the extent that a message elicits frequent orienting responses, there will be frequent calls for processing resources to encode the message, which may cause a disproportionate amount of processing resources to be automatically allocated to the encoding subprocess. This will decrease the amount of resources that are unallocated and therefore available to be allocated to storage. How many of the remaining resources are allocated to storage will be primarily dependent on the goals and needs of the individual. A person who is watching primarily for entertainment, for example, may not be purposely allocating his or her limited processing resources to storage. This person is "running on automatic." As a result, only sufficient information to follow the story may be stored. The stored information may form associative links primarily with other information from the story, and not be much integrated into already existing memory structures. Because long-term memory is not a goal of this individual, only a small portion of previously stored knowledge may be activated during viewing.

On the other hand, a person watching a television message on which he or she expects to be tested (e.g., watching a science video in school) may make a serious attempt to allocate resources to storage so as to be able to pass the test. In this case, the calls for attention made by structural features may actually interfere with the process of storage because they may "steal" resources from storage in order to allocate them to encoding. In addition, this viewer is likely to allocate a fair number of resources to retrieving what he or she already knows about this topic from long-term memory in order to integrate new knowledge with old knowledge. This viewer is much more likely to run into a resource-limited situation than the person watching to be entertained, since this viewer is purposely allocating resources to storage and retrieval in order to learn and retain the content of the message. On the other hand, because this person is allocating resources to storage and concurrent retrieval, he or she is likely to process the message more fully than someone who is allocating fewer resources, despite the fact that overload will limit the availability of required resources and, therefore, how thoroughly he or she is able to process the message.

In the same way that the orienting response allocates resources to encoding, there appear to be other automatic processes that operate to automatically allo-

[3] Of course, encoding does not occur only in response to orienting. People encode information continuously as they make sense of their environment. However, the orienting response does account for variation in the amount of processing resources allocated to encoding. To some extent this moment-to-moment variation in processing resource allocation can be predicted across subject as a function of the novelty and signal status of the elements of the stimulus message.

cate resources to storage. A specific mechanism, akin to the orienting response, has not yet been proposed for this task. Research suggests, however, that certain types of stimuli are stored much better than other types of stimuli, a phenomenon that may indicate some sort of automatic allocation process. In particular, stimuli that elicit emotion appear to be stored much better than stimuli that do not elicit emotion (Bradley, Greenwald, Petry, & P. J. Lang, 1992; Christianson, 1992; Lang, Dhillon, & Dong, 1995; Reeves, Newhagen, Maibach, Basil, & Kurz, 1991; Thorson & Friestad, 1989). This model suggests that emotion-eliciting stimuli may cause the automatic allocation of additional processing resources to storage.

Television Messages and Retrieval

Two aspects of the retrieval process need to be considered: later retrieval of message content and concurrent retrieval of already known information during viewing. First, consider later retrieval, or memory, for the message content. If the content of a television message has been selected from sensory store, encoded into working memory, and thoroughly stored, then it should be retrievable for use at a later date (that test on the science program). Later retrieval of the information contained in a message differs significantly from the storage and encoding subprocesses in that it is not performed during viewing. In the television-viewing situation, the viewer must keep up with the message. If you don't encode some aspect of a scene and the scene changes, that's it, you didn't encode it. Similarly, if you don't store something that you encoded, that information will remain unlinked or poorly linked. On the other hand, later retrieval of a message's content is not necessarily constrained by time and resources.

Concurrent retrieval, on the other hand, the process of continuously retrieving previously known information during viewing to aid understanding and storage, is constrained by time and resource availability. The demand placed on resources by the need to retrieve information from long-term memory will increase the resources required to process a message and thereby decrease the resources available to be allocated to encoding and storage.

A message that requires viewers to recall facts they already know in order to follow the message will require more resources than one that does not require much background. Further, how available this past knowledge is, that is, how hard it is to retrieve the previously known facts, will also affect how many resources the subprocess requires. If the viewer is an expert in the message area, then retrieval of background information will require few resources, as the associative memory network will be complex and available. If the person knows little about the topic, the retrieval of what information the viewer does know may require many resources, and this will greatly limit his or her ability to learn the new information. In this regard, the model is quite consistent with research in communication, starting with the "knowledge gap," that suggests that the more you know about something the easier it is to learn more about it.

Summary

Briefly, then, this model describes television watching as a combination of controlled and automatic resource allocation mechanisms that combine to allocate processing resources to the encoding, storage, and retrieval of the bits of information that make up a television message. When a viewer has insufficient resources available to perform all of these subprocesses thoroughly, some aspects of processing will suffer. Both the structure and the content of television elicit orienting responses. These orienting responses call processing resources to the encoding process. Certain message characteristics, such as emotion, as well as the goals of the viewer, may increase the resources allocated to storage, which in turn may increase how much and how well content information is stored. Finally, the need to retrieve previous knowledge in order to understand the message also demands resources during viewing and influences how easily information can be stored.

The next section of this paper discusses how each of these subprocesses involved in processing a message can be measured.

Measuring the Information-Processing Subprocesses

The model presents three subprocesses: (a) encoding, (b) storage, and (c) retrieval; and two mechanisms: (a) orienting behavior and (b) resource allocation. In order to test this model, all of these subprocesses and mechanisms need to be measurable. We turn to cognitive psychology for most of these measures. None of the measures presented here is new or even particularly controversial. All of them have rich research traditions associated with them.

Orienting Behavior

As discussed above, the orienting response is made up of an organized set of behavioral and physiological responses. Physiological measures can be used to measure the occurrence of an orienting response during television viewing. One of the most reliable signs of an orienting response is a decrease in heart rate beginning immediately after the orienting-eliciting stimulus and continuing for about 4–6 seconds (Campbell, Wood, & McBride, 1997; Graham & Clifton, 1966; Lang, 1990). Other physiological indicators of orienting include a brief (1–2 second) increase in skin conductance (Kimmel et al., 1979) and alpha blocking in the EEG (Reeves et al., 1985). Research on orienting to television has used all of these.

Resource Allocation

Central to this model is the notion that processing requires resources, that resources are limited, and that resources can be variably allocated among the subprocesses involved in processing a message. Excellent reviews of limited-capacity theories within a communication context can be found by Basil (1994a, 1994b) and Grimes (1991), but the very notion of processing resources is a theoretical construct—it cannot be pointed to in the human brain. Even though the resources cannot be directly observed, at least one method for measuring the allocation of resources exists. This measure is the secondary task reaction time (Basil, 1994b; Lang & Basil, 1998). Secondary task reaction times are measured by having subjects perform a task, called the primary task. (In the literature mentioned below, the primary task is always watching the television and trying to remember the message). In addition to the primary task, the subject is also asked to perform a secondary task. The secondary task is to push a button as fast as the subject can whenever he or she hears or sees a specific signal. In the television-watching studies, the signal might be tones or color bars embedded in the message. Theoretically, the more resources a viewer is using to process the television message, the fewer resources that viewer has available to respond to the secondary task. Variations in the speed of response are interpreted as variations in the viewer's available processing resources.

Traditionally, the secondary task reaction time literature has treated this measure as an indicator of total resources in use. A recent review of this literature (Lang & Basil, 1998) suggests, however, that the secondary task reaction time measure might be better interpreted as an indicator of the resources available to encode a message. Research testing this hypothesis provides some support for this suggestion (Kawahara, Bolls, Hansell, Lang, Potter, & Dent, 1996; Lang et al., 1999). These issues aside, a large body of evidence does suggest that variations in resource allocation can be successfully measured using the secondary task reaction time.

Encoding, Storage, and Retrieval

As discussed above, what a viewer remembers from a television message is the result of how much of the message was encoded, how well the encoded material was stored, and how much of the stored material is retrievable. Following this approach, memory is conceptualized as having varying degrees. Some information from a message may receive such complete processing that it is encoded, stored, and can be retrieved easily by the viewer. Other bits of information from the message may be encoded but less well stored. As a result, a viewer may have a mental representation of the bit of information in his or her memory, but be unable to retrieve it without some cues. If this is the case, then different measures of memory can be used to index different degrees of memory, which, in this model, is interpreted as the thoroughness of various subprocesses (Columbo & D'Amato, 1986; Craik & Lockhart, 1972; Hasher & Zacks, 1979; Metcalfe, 1991; Spear & Riccio, 1994; Tulving & Thompson, 1973; Zechmeister & Nyberg, 1982).

Specifically, recognition (the most sensitive measure of memory) can be interpreted as indexing whether a specific bit of information was encoded. Recognition is the most sensitive measure because the item to be recognized is presented to the subject and contains myriad cues to help the subject retrieve the information (Tulving, 1972; Tulving & Thompson, 1973). Cued recall (the next most sensitive measure of memory) can be interpreted as an index of how thoroughly a specific bit of information was stored. In cued recall, only a single cue is presented to the subject to help the subject retrieve an item from memory (Tulving & Osler, 1968). Finally, free recall (the least sensitive measure of memory) indexes the retrieval process, that is, how well a subject can retrieve a piece of information without any cues at all.

These techniques together—heart rate, skin conductance, secondary task reaction time, recognition, cued recall, and free recall—can be combined to measure, or at least indicate, the thoroughness of each subprocess or mechanism along the information-processing pathway. Communication researchers can combine these techniques to track the progress of mediated information through the black box. This will allow us to assess how myriad mediation and communication independent variables affect specific aspects of information processing.

The next section of this paper presents evidence, gathered by many researchers, that supports the model presented here.

Evidence Supporting the Model

Television and the Orienting Response

Several mass communication researchers have suggested that orienting responses may be elicited by many of the structural features of television (Singer, 1980; Anderson & Levin, 1976; Alwitt, Anderson, Lorch, & Levin, 1980). Subsequently, several researchers have tested various aspects of television to determine if, in fact, people have orienting responses to the structural and formal features of television, and this research shows that people do in fact orient to television's structure. Using EEG as a measure of orienting, Reeves, Thorson, Rothchild, McDonald, Hirsch, & Goldstein (1985) demonstrated measurable alpha blocking in response to cuts, edits, and movement in television commercials. Lang (1990) demonstrated heart rate decelerations in response to the same structural features. Lang, Geiger, Strickwerda, & Sumner (1993) demonstrated heart rate decelerations to both cuts and edits. Thorson & Lang (1992) showed heart rate decelerations to video graphics. More recent research has shown measurable orienting responses to voice changes and special effects in radio messages (Potter, Lang, & Bolls, 1997). Some types of content may also elicit orienting. For example, Lang, Newhagen, and Reeves (1996) demonstrated heart rate decelerations to negative video images, Potter, Lang, and Bolls (1998) measured cardiac orienting in response to sexual words in radio messages, and Reeves et al. (1985) and Lang et al. (1993) both demonstrated orienting to changes in content (for example, breaks between program and commercials).

The first step, then, is fairly certain. Viewers do orient to television's structure and content. Does this orienting response increase the amount of resources a viewer allocates to processing the message?

From Orienting Response to Resource Allocation

If an orienting response results in a call for additional resources to the encoding process, then measurable increases in resources should occur at points in television messages that elicit orienting responses. One study in the communication literature measures both the orienting response and secondary task reaction times in response to orienting eliciting stimuli. Lang et al. (1993) measured heart rate and secondary task reaction times in response to related and unrelated cuts (changes from one camera to another) in television messages. Results showed significant heart rate decelerations in response to both types of cuts. This study demonstrated that both the related and unrelated cuts elicited orienting responses. No significant difference in the size or speed of the orienting response was found for the two types of cuts. The study also measured secondary task reaction times at the point where the cuts occurred. The results showed slower secondary task reaction times to unrelated cuts than to related cuts, as was predicted. (However, reaction times were not compared to points in time where there were no cuts.)

Another study (Geiger & Reeves, 1993) also measured secondary task reaction times to content changes that were semantically related or semantically unrelated. They found that both types of content changes elicited slower secondary task reaction times compared with points in time before the content change, and that the increases were greater for semantically unrelated cuts compared with related cuts.

These studies support the idea that some structural features (cuts, edits, and content changes, at a minimum) result in increased resources being allocated to processing a message. The model further suggests that these increases in resources should increase the resources being allocated to encoding, which should result in more information being encoded, unless the system has insufficient resources available to respond completely to the call for new resources, in which event this resource limitation might prevent an increase in encoding.

From Orienting and Resource Allocation to Encoding

Several studies have looked at the effect of an orienting-eliciting structural feature on the encoding of the information that precedes and follows it. Most of these studies varied cognitive load (how many resources were required to fully process the message), and many of them made distinctions between visual and verbal memory. By and large, these studies show that when cognitive load is low, encoding of information immediately following a structural feature is increased, but when cognitive load is high, encoding for information immediately following a structural feature is decreased.

Lang (1991) examined memory for information immediately following structural features in political advertisements. Recognition memory was measured for audio and video information occurring in the 3 seconds immediately following a structural feature (called immediate recognition memory) and then for information occurring in the 4–9 seconds following the structural feature (called delayed recognition memory). Her results showed that delayed recognition was higher than immediate recognition, and that this effect was consistent for both audio and video recognition. She suggested that immediately following the formal feature, during the orienting response, there is a brief period of overload, but that as the new resources called by the orienting response come on-line, encoding improves. This suggestion could not be confirmed in the study because she did not compare recognition before the structural feature with recognition immediately after the structural feature.

Other studies, however, have since rectified that oversight. Lang et al. (1993) compared recognition memory for information occurring immediately before and immediately following related and unrelated cuts. The results showed that recognition memory for the information presented before related and unrelated cuts did not differ. Marked differences occurred, however, in memory for information following the cuts. For related cuts, recognition memory was significantly greater following the cut than it was before the cut. For unrelated cuts, recognition memory was significantly lower for information following the cut than it was for information preceding the cut. This analysis suggested that the related cut resulted in an orienting response, which called additional resources to processing the message. Because the cut was related (that is, the information on either side of the cut was part of the same story, and often in the same scene), there was very little new information to be encoded, so the additional resources resulted in having more resources to do an easy job, leading to more encoding. For unrelated cuts, however, the cut represented a change in content and scene. In this case, orienting and the resultant increase in resource allocation occurred, but the additional resources were not sufficient to encode all the new information introduced by the unrelated cut. Hence, briefly, the system was overloaded, and encoding decreased.

Two other studies (Bolls, Hibbs, & Lang, 1995; Hibbs, Bolls, & Lang, 1995) tested this hypothesis by having viewers watch randomly selected television messages. They computed the average recognition score (across subjects) for each of 76 randomly selected messages and then, using regression techniques, attempted to predict this average recognition score based on the number of cuts (changes from one scene to a new visual scene) and the number of edits (changes from one camera to another in the same visual scene) in the messages. They found that number of edits had a positive linear relationship with recognition for the messages. As a message had more and more edits, recognition increased. On the other hand, increasing the number of cuts resulted in a different pattern. An initial increase in recognition was followed by a sharp drop-off in recognition if the number of cuts exceeded 10 in 2 minutes. This suggests, as did the two previous studies, that edits (i.e., related cuts) do not increase cognitive load (much), but do increase the allocation of resources to encoding, so that recognition memory increases. On the other hand, cuts (i.e., unrelated cuts) increase cognitive load in addition to increasing the resources allocated to encoding. The increase in resources allocated to encoding doesn't generally keep up with the increase in processing load, and recognition memory decreases.

A recent series of studies (Bolls et al., 1996; Kawahara et al., 1996; Lang, Bolls, & Kawahara, 1996; Lang, Bolls, Potter, & Kawahara, 1999; Yoon, Bolls, & Lang, 1998; Zhou et al., 1997) manipulated the number of cuts in 30-second messages and found a curvilinear relationship between recognition for information contained in the messages and the number of cuts in the message. These studies also support the notion that increasing the number of cuts increases the processing load, which overloads the system, which in turn results in a decrease in overall recognition memory, despite the increase in resources allocated to the task.

Other studies also support the conclusion that multiple structural features in television messages tend to result in decreased recognition for the content of the message. For example, Reeves, Thorson, and their colleagues did a series of studies looking at the effects of audio and video complexity on recognition memory (Reeves, Thorson, & Schleuder, 1986; Thorson, Reeves, & Schleuder, 1985; Thorson, Reeves, & Schleuder, 1986). They found, by and large, that increasing structural complexity decreased recognition memory for messages globally. However, they also reported that points in complex messages that were not themselves complex were recognized better than complex parts of the messages (Thorson, Reeves, & Schleuder, 1986).

Thorson & Lang (1992) measured orienting to video graphics inserted in televised lectures and recognition memory for information presented immediately before the video graphic, during the 12 seconds the video graphic was on the screen, and during the 12 seconds immediately following offset of the video graphic. They manipulated cognitive load by showing viewers lectures that were either on familiar topics (judged to be easy) or on unfamiliar topics (judged to be more difficult). They found that viewers did indeed orient to the video graphics, but that the effect of the video graphic on recognition was modulated by cognitive load. If the lectures were familiar or easy, memory for information following the orienting response increased, compared with recognition before the video graphic. If the lecture topics were unfamiliar or difficult, recognition for memory following the orienting response decreased.

Taken together these studies suggest the following. The increase in resources associated with orienting responses does improve encoding of the information following the orienting response, if cognitive load is low. On the other hand, if cognitive load is high, the orienting response will elicit a brief period of overload, and recognition memory decreases.

These studies support and demonstrate two aspects of the model. First, they support the proposal that orienting, resource allocation, and recognition memory are causally related to one another in a predictable fashion. Second, they underscore the importance of the limited capacity framework of the model. Whereas the effect of the orienting response may be to increase the resources allocated to encoding, the effect of this increase in resources on encoding is dependent on the overall level of resources required to perform the viewing task.

In all of these studies, viewers were instructed to pay close attention to the message as they would be tested on them at a later time. Hence, the viewers were likely allocating a fair amount of their limited resources to storage, which would reduce the resources available to be allocated to encoding. Hence, deficits at encoding show up with fairly mild increases in cognitive load. It would be interesting to see if viewers instructed to watch and be entertained would show these same deficits. It seems likely that in that case, encoding of information following structural features might be much better than it is in the previous experiments, because viewers would not be using controlled processes to reserve some portion of their resources for storage. A recent study (Potter et al., 1997) using radio messages offers some support for this idea.

The model next predicts that following encoding, information must be stored. The model suggests that the resources are allocated to storage as a result of controlled and automatic processes. If this is the case, then cued recall (our measure of storage) should increase when viewers are attempting to remember the message, or when messages are arousing or emotional. In addition, cued recall should also increase if the storage process requires fewer resources (i.e., if the content is very simple or the viewer is very expert).

From Encoding to Storage

Evidence for the first of these propositions comes from many areas of communication research. Research in the uses-and-gratifications model, for example, has clearly demonstrated that a television viewer's goals affect what he or she remembers from a message. Viewers who watch the news to be entertained, for example, remember less of the news than those who watch to be informed (Gantz, 1978). This model predicts that viewers watching to be informed will allocate more resources to storage than those who watch to be entertained.

Another example, from the broadcast news literature, is a study by Katz, Adoni, & Parness (1977). This study showed that pictures aided recall for news stories only if the material was not relevant to the viewer. In other words, if the story is not relevant, then the viewer will not purposively allocate sufficient resources to store the message. In that case, the addition of the picture engages the automatic encoding processes (because the cut to video will elicit orienting) and increases the likelihood of recall of nonrelevant material. If the story is relevant, however, then viewers will purposively increase the resources allocated to storage and will be able to recall the story.

Potter et al. (1997) had subjects listen to radio messages in between a television-viewing task and a computer-based task. Half the subjects were told to attend to the radio message as they would be tested on its contents. Half were told that the experimenter had to adjust some equipment, and they should just sit back and relax. About 30 minutes later, subjects were given a cued-recall test. Cued recall was much higher for the groups instructed to attend than it was for those encouraged to sit back and relax. This study is notable in that it also measured cardiac-orienting responses to structural features of the radio messages and recognition for information presented before and after those structural features. Neither the orienting responses nor the recognition memory, both of which are based on automatic mechanisms in this model, was altered by the instruction condition. Only the controlled resources allocated to storage varied as a function of instruction.

Another area of research that bears on the question of allocating resources to storage focuses on the effects of emotion-eliciting content on memory for television messages. Research studies investigating emotion-eliciting commercials (Lang & Friestad, 1993; Thorson & Friestad, 1989), emotion-eliciting programming (Davidson, Schwartz, Saron, Bennet, & Goleman, 1979; Lang, Dhillon, & Dong, 1995; Reeves, Lang, Thorson, & Rothschid, 1988), emotion-eliciting movies (Dimmond, Farrington, & Johnson, 1976), political commercials (Lang, 1991), emotion-eliciting slides (Bradley et al., 1992), and emotion-eliciting news (Lang, Newhagen, & Reeves, 1996; Newhagen & Reeves, 1995) show that emotion-eliciting messages are remembered better than messages that do not elicit emotion. Much of this research also suggests that this effect is greater for recall measures than for recognition measures (Bradley et al., 1992).

The presence of emotion-eliciting content in a message certainly alters processing (Christianson, 1992). For one thing, emotion-eliciting messages are difficult to ignore (Campbell, Wood, & McBride, 1997; Hoffman, 1997; Lang, P. J., Bradley, & Cuthbert, 1997; Newhagen & Reeves, 1992). The presence of emotion-eliciting content appears to engage the automatic attention system. Lang et al. (1997) demonstrated that negative video in news stories elicited heart rate deceleration (indicative of orienting) in television viewers. Similarly, Lang et al. (1999) showed slower heart rates in response to emotion-eliciting messages than to messages that did not elicit emotional responses. In addition to this automatic increase in resources allocated to emotional messages, controlled processes tend to be activated. People pay closer attention to emotion-eliciting messages, they like them more (generally), and often find them difficult to ignore. It is almost impossible not to look when driving by the scene of an accident or when witnessing a couple fighting or kissing on the sidewalk. Since many emotion-eliciting images (sex and violence, for example) have survival value (that is, they are primally related to procreation or protection), it makes sense that these messages would, in a sense, compel attention (Newhagen & Reeves, 1995: Reeves & Nass, 1996).

The theoretical model presented here suggests that when messages elicit emotion, the experience of emotion compels the allocation of resources to the subprocesses of encoding and storage (McGaugh, 1992; Revelle & Loftus, 1992). Several well-known and robust results related to memory for arousing and emotional material provide evidence for this proposition. For example, it is often found that the occurrence or the topic of the message that elicits emotional arousal is recalled better, but that specific information contained in a message is remembered less well (Christianson, Goodman, & Loftus, 1992; Heuer & Reisberg, 1992; Yuille & Tollestrup, 1992). If the emotion-eliciting content results in additional resources being allocated to storage, this would result in fewer resources being available to be allocated to encoding. Hence, the overall amount of information encoded might be reduced, but most of the information encoded would be well stored. Hence, one would expect to see a decrease in recognition memory, but an increase in cued recall. Similarly, since the resources available to encode the message would be diminished, secondary task reaction times (the measure of resources available at encoding) would be expected to increase when messages are arousing.

There is evidence to support both aspects of this theoretical model. Bradley et al. (1992), Lang et al. (1999), and Lang & Potter (1996) have all presented evidence that secondary task reaction times are slower for messages rated to be high on emotional arousal than they are for messages rated as low on emotional arousal, supporting the contention that there are fewer resources available at encoding. Similarly, two of these studies (Bradley et al., 1992; Lang et al., 1999) also measured recall for the stimuli. Both studies showed that cued and free recall were better for the emotionally arousing stimuli than for the nonemotionally arousing stimuli.

From Storage to Retrieval

Finally, the model presented here considers the question of retrieval. It holds that two kinds of retrieval occur in the television-viewing situation: later retrieval of information presented during a television presentation and concurrent retrieval of information required to comprehend the ongoing television message. It predicts that later retrieval will be dependent on factors determined by the viewing situation. Later retrieval will depend on cognitive load, the level of engagement of the automatic and controlled resource allocation systems, resources allocated by those mechanisms to encoding, and resources allocated by those mechanisms to storage. Concurrent retrieval, on the other hand, functions in many ways like the cognitive load variables discussed previously. If a viewer needs to retrieve a great deal of information "on-line" in order to follow the television message, then that viewer will need to allocate resources to retrieval while viewing. That viewer will have fewer resources available to encode and store the information in the message, and memory (recognition, cued recall, and recall) for the content of the message will be reduced. On the other hand, if a message is constructed in such a way that the viewer does not need to retrieve previously known information, resources will not be allocated to retrieval, and memory for the content of the message is likely to increase.

Evidence for this portion of the model exists in the broader communication literature also. Thorson (1990; Thorson & Friestad, 1989) suggests that television commercials that can be understood well episodically are remembered better because they are processed episodically, in a narrative fashion. One does not access one's knowledge base on, say deodorants, when viewing a deodorant commercial, but rather one processes it as an event, or small happening, primarily because this requires less cognitive effort, and one does not generally engage in high effort when viewing television commercials.

Lang (1989) found similar results investigating news stories. In an experiment, she showed viewers two different versions of a television newscast. In one version, two of the stories were written in broadcast news style (what's new, followed by the causes, followed by the consequences). In the other version, the sentences in the stories were reordered to be in chronological order (causes, events, consequences). Nothing about the stories was changed except the order of the sentences. She predicted and found that memory was better for the chronological stories. She argued that this was because viewers did not need to access their long-term memories in order to understand the chronological stories.

Limited Capacity Theory and Communication Effects Research

The limited capacity information-processing model presented here is a general model of how people interact with mediated messages. Although most of the evidence presented in support of the model is specific to the television medium, the model might be equally applied to other media and even to nonmediated situations. To apply the model to a nontelevision situation, the researcher must consider the following four specific questions: (a) What aspects of the *structure* of the communication situation or medium will engage the automatic resource allocation system? (b) What aspects of the *content* of the communication situation or medium will engage the automatic resource allocation system? (c) What demands does the medium or content place on cognitive load? (d) What aspects of the situation or medium will engage the controlled allocation processes? The answers to these questions should allow researchers to predict variations in orienting behavior, resource allocation, recognition, cued recall, and free recall for messages being presented.

When these four questions are answered, the model will make specific predictions. For example, consider the situation where (a) the structure does engage the automatic resource allocation system; (b) the content does not engage the automatic resource allocation system; (c) cognitive load is low, and (d) controlled allocation is low. The model predicts the following results: (a) Orienting should occur, and secondary task reaction times should be slower at points where orienting is occurring; (b) recognition should be good since cognitive load is low and additional resources are being allocated to encoding by the orienting behavior; (c) cued and free recall should be fairly low because neither the content nor controlled processes are increasing the allocation of resources to storage.

The model accounts well for many of the seemingly counterintuitive results that we see in our literature. It predicts instances where encoding is low and storage is high—the case of good memory for the event, but poor memory for detail, as often occurs in eyewitness memories (Christianson, Goodman, & Loftus, 1992; Heuer & Reisberg, 1992; Yuille & Tollestrup, 1992). It predicts instances where encoding is high and storage is low—the case of good recognition memory but very poor cued or free recall (broadcast news is an excellent example of this). It allows for high attention and poor memory of all types, which can result, for example, when multiple structural features engage the automatic allocation systems at a very high level, but the system is overloaded. Despite all the resources in a system being allocated to the task of viewing, only a small amount of the information in the message can be thoroughly processed.

The model can also be used productively in applied research. Many of the production techniques used in television programming are designed to maximize attention. The use of production features and video content that elicit orienting and engage attention is rampant. Use of techniques that encourage storage of encoded information is rare. To the extent that common features of television messages do allocate resources to storage, it tends to be through the use of violent or sexual (i.e., emotional) images. People tend to use the medium to be entertained, which means controlled processing resource allocation tends to be quite low, or while engaged in some other task, in which case cognitive load is going to be fairly high.

These are conditions under which this model predicts fairly high automatic allocation of resources to encoding, fairly good encoding if cognitive load is low, but poor encoding if cognitive load is high, and generally poor storage and recall unless the content is emotional or personally relevant. This description is a fairly apt description of research on learning from television. The medium has the reputation of being a poor teacher. "You see it, but you don't remember it!" Our field is littered with findings that people who watch a lot of television know less than people who don't, a fact brought home by the title of Barrie Gunter's book reviewing broadcast news research, *Poor Reception: Misunderstanding and Forgetting Broadcast News* (Gunter, 1987). Further, many studies show that, although recall for televised information can be quite poor, recognition levels are much higher (Gunter, 1987).

For people working within specific effects models or traditions, the model presented here may also prove useful. The knowledge gap (Chew, 1994; Olien, Donohue, & Tichenor, 1982) and the uses-and-gratifications model (Gantz, 1976; Rubin, 1994) have already been used as examples earlier in the paper.

Knowledge gap research highlights the finding that the more you know, the more you learn from the mass media. The model presented here would predict this finding because most people encounter mass media information campaigns in the context of entertainment programming. Thus, a low level of resources is likely to be allocated to these messages, and the messages are probably not perceived to be very relevant. As a result, those who already have memory networks associated with the topic require few processing resources to activate that network and add new information to it, whereas those with little knowledge may need a significant allocation of resources in order to build new knowledge structures and store the information. However, because these latter viewers are probably not allocating this level of resources, and their automatic allocation systems aren't responding to the information as relevant or important, little information is gained.

A recent study (Grabe, Lang, Zhou, & Bolls, 1999) tested this model and found that television viewers with less than a high school education and television viewers with more than a college education paid equal amounts of attention (indexed by heart rate) to television news stories. However, the high education group remembered significantly more specific information from the stories.

Research in the uses-and-gratifications tradition emphasizes what viewers bring to or do with the medium. The approach presented here models these behaviors as controlled resource allocation mechanisms, which have a great effect on how viewers process messages. Viewers whose intent is to learn can and do allocate more resources to storage and remember more of the message. Viewers whose intent is to relax allocate fewer resources to storage and recall less of the message.

An example of how the limited capacity model of television viewing can be used to explain seemingly contradictory findings in the literature can be found in Lang (1995). In this paper, Lang uses the limited capacity model of television viewing to explain the many contradictory findings in the literature on audio-video redundancy. To do so, Lang used the limited capacity model to identify the theoretically important differences between studies related to measurement of memory and manipulation of audio-video redundancy. She then rederived the hypotheses for each study, and successfully predicted the actual outcomes of over 80% of the studies in the literature.

The model may also prove useful for investigating larger, more macro aspects of message processing. For example, this model could be used to theorize about the processing mechanisms underlying message attributes such as narrative structure, genre, appeal, and emotion. Lang and her colleagues, for instance, used the theory to investigate the effects of narrative structure on memory for broadcast news stories (1989) and prime-time television messages (Lang, Sias, Chantrill, & Burek, 1995). The first study (Lang, 1989), hypothesized that a chronological narrative structure would require fewer processing resources than the standard broadcast news story. As a result, she predicted and found that encoding of the story, and therefore recognition for story material, would be better when stories were produced in a chronological fashion. Similarly, Lang et al. (1995) predicted that strong audio narratives would be easier to process than weak audio narratives. Interestingly, they found that viewers allocated more resources to strong narratives compared to weaker ones and remembered them better.

Whereas the bulk of the research reported here has focused on short-term attention changes, short-term memory, and microelements of messages, other researchers could apply this framework to studying many other aspects of messages and audiences. To do so requires only that the researcher conceptualize his or her variables in terms of (a) the resources required for encoding, storage, and retrieval of the messages, (b) the impact of the content and structure on automatic and controlled processing resource allocation mechanisms, and (c) the effects of the environment and goals of the user on message processing.

The model as it stands now is a work in progress. Other researchers, working within its framework, may apply the model to other areas of interest to communication scholars and extend the model both theoretically and methodologically. Future research using the model might, for example, explore the use of implicit memory measures as an indicator of concurrent retrieval or investigate how individual and message factors influence the accuracy of the construction of the mental representation during encoding.

This model should prove useful both to researchers and, eventually, to producers by increasing our understanding of how the content and structure of a medium interact with a user's information-processing system and to determine which parts and how much of communication messages are remembered. This model should allow us to better understand how micro- and macroelements of individuals, societies, and cultures shape the communication process.

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