

The Effects of Production Pacing and Arousing Content on the Information Processing of Television Messages

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The limited capacity model of television viewing is used to investigate the impact of arousing content and fast paced production of viewers' information processing of TV messages. Results show that both fast pace and arousing content elicit self-reported arousal, but they elicit different patterns of physiological arousal. Both fast pace and arousing content increase the allocation of processing resources to messages. The combination of fast pace and arousing content overloads the processing system resulting in less recognition and cued recall for the specific content of the message. Results generally support the limited capacity theory of television viewing.

Recent research on how television viewers process television messages has used the limited capacity model of television viewing to investigate the effects of emotion (Lang, Dhillon, & Dong, 1995), narrative structure (Lang, Sias, Chantrell, & Burek, 1995), negative video images (Lang, Newhagen, & Reeves, 1997), and audio video redundancy (Lang, 1995). The study reported here employs this theory to investigate how pacing and arousing content affect viewers' attention, allocation of cognitive resources, encoding, and storage of television messages. Pacing is defined as the number of cuts in a message; arousing content is manipulated through the emotional arousal level of the message content.

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The Limited Capacity Model

The Limited Capacity model of television viewing defines the viewer as an information processor, the television medium as a variably redundant ongoing stream of audio and video information, and the message content as the topic, genre, and information contained in a message. Television viewing is the continuous allocation of a limited pool of processing resources to the cognitive processes required for viewers to make sense of a message. Processing a message includes (but is not limited to) the parallel cognitive subprocesses (or tasks) of encoding, storage, and retrieval.

Comprehension of a television message involves the continuous and simultaneous operation of these subprocesses. New information from the message is continuously attended to, encoded into short term or working memory, processed, and stored. Previously held information (required to understand the message) is concurrently retrieved, associated with the new information, and stored again. Information encoded earlier in the message is being stored as later information is being encoded.

Since it is not possible for the viewer to encode and store all the information in the message, the viewer continuously selects which information in the message to encode, process, and store. The amount of information that can be attended to, encoded, and stored has an upper bound created by the availability of the viewer's processing resources, which are limited. Viewed in this way, television viewing, although it "feels" simple, is, in fact, a complex and difficult cognitive task. How large a portion of a television message is successfully encoded, stored, and eventually retrieved is determined by the level of resources required by and allocated to the various subprocesses involved in viewing. The viewer, the medium, and the content all affect how resources are allocated to processing the message.

The viewer controls some aspects of the allocation of processing resources by making decisions about whether to watch, how carefully to watch, and how hard to try, based on how interesting the subject is, how relevant the information is, or simply whether the viewer wants to remember it (Gantz, 1978). This voluntary or controlled allocation of processing resources is a relatively long term process occurring over minutes or hours. Similarly, characteristics of the viewer (like familiarity with the topic, emotional response to a topic, etc.) partly determine the level of resources required to make sense of and store the message.

The medium itself controls the automatic allocation of processing resources through the elicitation of orienting responses (ORs) in viewers. These ORs are automatic, reflexive attentional responses to changes in the environment or to stimuli that people have learned signal important information. In television, ORs are elicited by structural features like cuts, edits, movement, flashes of light, and sound (Lang, 1990; Lang, Geiger, Strickwerda, & Sumner, 1993; Reeves et al., 1985; Thorson & Lang, 1992). This automatic allocation of resources is a relatively short-term response, occurring over seconds.

The content of the message can also invoke both automatic and controlled allocation of processing resources. Aspects of content like relevance and difficulty

can elicit controlled allocation of processing resources (Basil, 1994; Thorson & Lang, 1992). Other aspects of content, like emotion, elicit automatic allocation of resources (Lang, Dhillon, & Dong, 1995; Lang, Newhagen, & Reeves, 1997; Newhagen & Reeves, 1992). Of particular relevance to this study is the hypothesis that arousal results in the automatic allocation of resources to encoding and to storage.

In summary, the limited capacity model makes the following general predictions: (1) the viewer allocates an overall level of processing resources to the complete viewing task based on goals, interests, etc.; (2) the viewer's goals influence the proportion of resources allocated to the various subprocesses (such as storage and retrieval); (3) structural and content features of the message elicit orienting behavior and the automatic allocation of resources to encoding; (4) content and structural attributes can elicit arousal which results in the automatic allocation of resources to encoding *and* to storage; (5) when there are insufficient resources available to carry out all the sub-processes, some aspect(s) of processing will be performed less well.

The current study manipulates the speed of pacing and the amount of arousing content in television messages, attempting to predict effects on viewers' arousal, attention, and memory using the limited capacity model.

Pacing

Previous research suggests that the production pacing of a message strongly affects how viewers feel about and learn from television messages. Such research has generally confounded the pace of production of a message with the complexity of the message. For example, Reeves, Thorson, and Schleuder (1986) defined a variable they called complexity in terms of the pace of structural features, i.e. as the number of structural features occurring in a message. Watt and Krull (1977) used information theory to develop static and dynamic measures of complexity also based on image complexity and the variation in production and rate of formal features. Hill and Lang (1993) used a combination of image complexity and the number of structural or formal features in a message to manipulate this variable. The current study will attempt to alleviate this confound by examining only the production feature of pacing, defining it as the number times a particular structural feature known to elicit orienting in attentive television viewers appears in a message.

The limited capacity model suggests that as the pacing in a message increases, the number of orienting responses elicited by the message, and the amount of information available to be encoded, should increase. As a result, viewers should automatically allocate more resources to encoding fast paced messages.

It has also been suggested that increased pacing increases viewers' sense of arousal (Gunter, 1987; Hitchon, Thorson, & Duckler, 1994; Reeves, Thorson, & Schleuder, 1986; Watt & Krull, 1977). The limited capacity theory suggests that stimuli which elicit arousal result in the automatic allocation of resources to encoding and to storage. Thus, an increase in pacing should increase viewers' arousal levels and result in the allocation of additional resources to encoding and to storage.

To test these predictions, pacing will be operationalized by manipulating the number of cuts in a 30-second television message. A cut is defined as a shift from one visual scene to a completely different scene. Three levels of pacing will be used in this study: slow, medium, and fast. Arousal will be measured in two ways: (a) viewers will use the SAM (Self-Assessment Mannequin; Bradley, Greenwald, Petry, & Lang, 1992) scale to report how aroused they feel after each message, and (b) skin conductance (SC) will be measured during viewing (Hopkins & Fletcher, 1994). Resource allocation will be measured using secondary task reaction times (STRTs, Lang & Basil, 1998).

Arousing Content and Viewer Arousal

Like pacing, the ability of the content of a message to elicit arousal in viewers also plays a major role in the enjoyment and processing of television messages (Gunter, 1987; Lang, Dhillon, & Dong, 1996; Lang, Newhagen, & Reeves, 1997; Lang & Potter, 1996).

The limited capacity model described above makes two predictions associated with the presence of emotionally arousing content in a television message: (a) arousing content is likely to elicit feelings of arousal and measurable sympathetic nervous system activation in viewers, and (b) arousal (in viewers) results in the *automatic* allocation of processing resources to encoding and storage. Thus, arousing content should increase viewers' self-reported and sympathetic nervous system arousal levels and, as a result, increase the number of resources allocated to encoding and storing the message.

To test this aspect of the model, the arousingness of the content of the messages was manipulated. Messages were chosen that included contents which were pre-judged to be arousing or calm. Content arousingness was then completely crossed with pacing to yield six types of messages: calm-slow, calm-medium, calm-fast, arousing-slow, arousing-medium, and arousing-fast.

Hypotheses

The impact of pacing and arousing content on physiology and self-reported arousal. First, fast paced messages should elicit arousal in television viewers (Reeves, Thorson, & Schleuder, 1986).

H₁: As pacing increases, viewers' self-reported arousal will increase.

H₂: As pacing increases, skin conductance will increase.

Second, arousing content should also increase viewers' arousal levels. Thus:

H₃: Messages with arousing content will elicit higher levels of self-reported arousal than messages with calm content.

H₄: Messages with arousing content will elicit higher skin conductance than messages with calm content.

The Impact of Pacing and Arousing Content on Resource Allocation

The theory predicts that pacing will increase the resources allocated to encoding the message through the elicitation of multiple orienting responses. In addition, both pacing and arousing content are predicted to elicit arousal in viewers. Arousal, in turn, is predicted to cause the automatic allocation of resources to both encoding and storage. Therefore, the theory predicts that both pacing and arousing content should increase the level of resources automatically allocated to processing the message. What is less clear is how this increase in allocation will be reflected in secondary task reaction time data. Here the difficulty in prediction results from two different models of overall cognitive capacity that appear in the literature. The first is the variable-capacity model which suggests that one's overall pool (or amount) of cognitive resources increases as arousal levels increase (Kahneman, 1973). The other is the fixed-capacity model, which views the total amount of cognitive resources as fixed regardless of how aroused or calm one is (Basil, 1994).

The variable capacity model predicts that arousal elicited by a message will increase the size of the viewer's overall pool of processing resources. Since both pacing and arousing content are predicted to increase viewer arousal level, both variables must be examined when making hypotheses. If we control for the effect of pacing, arousing content should always elicit more arousal than calm content. Therefore, the viewer's overall pool of resources at each level of pacing should be greater for arousing messages than calm messages. As a result, under the variable capacity model arousing messages should always have faster secondary task reaction times than calm messages, controlling for pacing.

This model also predicts, however, that pacing increases arousal. Thus, even though pacing *requires* processing capacity due to the orienting responses, it may also *produce* processing capacity. What is unclear, however, is first, whether arousal elicited by pacing will increase pool size sufficiently to cover the increased processing demands caused by the increased pacing, and second, if there exists an upper bound on the increase in pool size which is reached at some combination of arousing content and pacing. In either case, it seems likely that any increase in pool size associated with pacing is likely to be relatively larger during calm messages than during arousing messages. This is because, for arousing messages, increased pacing may not be able to increase pool size much or at all, if an upper limit on pool size exists. As a result, secondary task reaction times might slow as pacing increases for messages with arousing content since the upper limit would prevent the pool from increasing sufficiently to meet the additional processing demands of the fast paced message. On the other hand, secondary task reaction times might speed up as pacing increases for messages with calm content, since the increase in pacing should result

in an increase in pool size, and therefore the impact of pacing on secondary task reaction times should be lessened. Thus,

H_{5a} Variable Capacity: There will be a main effect of Arousing Content such that arousing messages will always result in faster reaction times than calm messages. In addition, there will be an interaction of Arousing Content and pacing such that, increasing pacing will slow secondary task reaction times more during arousing messages than it will during calm messages.

Different predictions result from the fixed capacity model. While it still predicts higher resource demands for arousing messages than calm due to automatic allocation of resources to encoding and storage, the size of the pool of available resources remains constant. Thus, arousing messages, controlling for pacing, should have slower reaction times than calm messages. Also, as pacing increases more and more, resources should be automatically allocated to the encoding subprocess as a result of orienting. However, since these resources are required to encode the new visual scenes, there should be fewer resources available at encoding. The scarcity of encoding resources is likely to be greatest for arousing messages due to the additional automatic allocation of resources to storage. Hence this model predicts:

H_{5b} Fixed Capacity: There will be a main effect of Arousing Content such that arousing messages always have slower reaction times than calm messages. In addition, there will be an interaction between Arousing Content and Pacing such that, as pacing increases reaction times will get slower for both calm and arousing messages, but will get slower faster for arousing messages.

The Impact of Pacing and Arousing Content on Effort

In addition to affecting the moment to moment allocation of resources, arousing content and production pacing are also likely to impact the ongoing level of attention being paid by the viewer to the stimulus. This study measures attention using heart rate. Research demonstrates fairly clearly that high attention to an external stimulus (like a television message) results in significant short term slowing of the heart rate (Lacey & Lacey, 1974; Lacey, Kagan, Lacey, & Moss, 1963; Lang, 1990; Lang, Newhagen, & Reeves, 1997). If viewers pay more attention to messages as pacing increases, then they should have slower heart rates (indicative of greater attention) during fast paced messages than they do during slow paced messages:

H₆: As pacing increases, heart rate will decrease.

Similarly, research shows that arousing contents like horror films (Carruthers & Taggart, 1973), compelling negative images (Lang, Newhagen, Reeves, 1997), and negative slides (Bradley, 1994) all elicit the decreases in heart rate associated with increased attention to the stimulus. Hence:

H₇: Arousing messages should elicit slower heart rates than calm messages.

The Impact of Pacing and Arousing Content on Encoding

This model assesses how thoroughly viewers encode a message using verbal and visual recognition tests. The model predicts that as pacing increases, the allocation of resources to encoding will increase. Eventually, however, there will be insufficient resources to respond to additional calls for them at encoding (ORs), and performance on the encoding task will be impaired. Therefore, as pacing increases, viewers should encode more and therefore recognize more of the specific content of a message up to the point where capacity is overloaded, at which point they should encode less (and, therefore, recognize less) of the specific content of a message. Thus:

H₈: As pacing increases, recognition for message content will increase up to a point after which it will level off or actually decrease.

The model goes on to suggest that arousing content also increases the resources allocated to encoding, in which case:

H₉: It is predicted that arousing messages will be recognized better than calm messages.

Finally, the model suggests that the point at which a viewer's capacity is exceeded (in other words the point at which there are insufficient resources to answer the demands for resources) will occur sooner for arousing messages than for calm messages for two reasons: first, because of the additional allocation of resources to storage caused by the arousing content, and; second, because arousing content is more difficult to encode (Bradley, Greenwald, Petry, & Lang, 1992; Lang & Potter, 1996). Therefore:

H₁₀: Recognition for the information in calm messages should increase from slow to medium pace with a possible leveling off at high levels of pacing. For arousing messages, however, overload should occur sooner. Thus, recognition may increase from slow to medium paced and then decrease significantly for fast paced messages, or it may decrease continuously across the levels of pacing.

The Impact of Pacing and Arousing Content on Storage

The model predicts that arousal increases the resources allocated to storage. Both pacing and arousing content are predicted to elicit arousal. Thus, both variables should increase storage. Storage is assessed by measuring viewers' cued recall for the content of the messages (Zechmeister & Nyeberg, 1987). It is predicted that:

H₁₁: As pacing increases, cued recall will increase (though that increase may level off if viewers are overloaded at high levels of pacing).

H₁₂: Cued recall will be higher for arousing messages than it is for calm messages.

H₁₃: There will be an interaction between Pacing and Arousing Content such that, for calm messages, as pacing increases, cued recall will increase. On the other

hand, for arousing messages, as pacing increases, cued recall will increase to a point, and then decline.

Method

Materials

This experiment is a mixed 3 (Order of Presentation) X 3 (Pacing) X 2 (Arousing content) X 5 (Message) design. To construct the stimulus tapes 30 messages were chosen from a pool of 312 coherent 30 second television messages (none of which were commercials) which had been taped from a local cable system (not including premium channels). Two levels of Arousing content (calm and arousing) and three levels of Pacing (slow, medium, and fast) were completely crossed. Five messages were chosen in each arousing content/pacing category, resulting in a total of thirty messages. Three semi-random presentation orders were constructed and Order of Presentation was the only between subjects variable. Orders were constructed in blocks of six messages. The six messages in each block contained one message from each arousing content/pacing category. The messages making up each block were randomly chosen for each order with the constraint that, across the three orders, each individual message had to appear in the first or last block of six once.

Pacing was operationalized as the number of cuts in a 30 second message. Slow paced messages had 0 or 1 cut, medium paced messages had 4-6 cuts, and fast paced messages had 11 or more cuts in thirty seconds. Trained coders working together in pairs coded the messages for number of cuts.

Arousing content was operationalized as follows. First, three undergraduate coders rated each message in the pool of 312 messages using SAM (the Self-Assessment Mannequin) developed by P.J. Lang (Bradley, Greenwald, Petry, & Lang, 1992). SAM is a pictorial arousal scale which translates into a 9 point scale ranging from 1=very aroused or excited to 9=calm, sleepy, not aroused. Messages were selected from the pool for further consideration only if they were rated 1-3 or 7-9 by all the original coders.

Dependent Variables

Arousal. Arousal was measured in two different ways. First, all subjects in the experiment used SAM to rate how aroused they felt immediately following each message. Second, one group of subjects ($n = 30$) in the experiment was assigned to the physiological condition. In this condition subjects' heart rate (HR) and skin conductance (SC) were measured during viewing. Skin conductance—an indicator of activation in the sympathetic nervous system—was used as a measure of arousal (Hopkins & Fletcher, 1994).

Resource allocation. Resource allocation was measured using secondary task reaction times. This method requires participants to watch television (called the

primary task) as hard as they can. Periodically, they hear a tone. Participants are instructed to push a button as fast as they can (the secondary task) whenever they hear the tone. The faster they push the button, the more resources are thought to be available to perform this secondary task, and the fewer resources are thought to be required by the primary task of viewing the television message.

One auditory reaction time probe was placed randomly within each ten second period of each message with the constraint that no probe was placed within one second of a cut, since research has shown that the local increase in secondary task reaction time associated with a cut occurs primarily within 500 ms of the cut (Geiger & Reeves, 1993). The long term component of resource allocation to the message was assessed using heart rate to index level of attention to an external stimulus (Lang, 1994).

Encoding. Recognition was used to assess encoding and was measured using forced choice four alternative multiple choice tests with four questions per message. To control for fatigue effects, the multiple choice tests were arranged in four systematically different orders that were not related to the orders of the stimulus tape. Results are reported as percent correct (25% being the level achievable by chance).

Storage. Cued recall was used as an indicator of storage. Cued recall was measured by having subjects fill out a 30 page booklet. Each page had the sentence, "Write down everything you can remember about" followed by a unique cue for each message. Fatigue effects were controlled by having the booklets arranged in four random orders. Cues were constructed by naming the major subject of each message. Occasionally a cue contained a second descriptor to clearly differentiate it from a similar message. Subject responses were coded into the following three categories:

- (1) Number of words: Coders simply counted the number of words written by the subjects.
- (2) Narrative description: Coders identified and counted statements describing things that happened in the messages, what the messages were about, or objects, actions, or persons the subject had seen on screen.
- (3) Auditory description: Coders identified and counted statements describing things subjects heard in the message including music, sound effects, descriptions of sounds or voices, or attempts at direct quotes. (Accuracy was not a factor.)

Two of the researchers on the project coded independently. Responses from 30 of the 51 subjects were coded twice, with intercoder reliability obtaining Cronbach's alphas above .90. The remaining responses (n=21) were coded once.

Apparatus

The experiment was controlled by a Zenith 286 computer with a Labmaster A/D D/A board. Reaction time probes were placed on the second audio track of the video

tape and came out of the television speakers. The tones were clearly audible but not significantly louder than the message audio. The tones and the subject responses were both recorded as digital events by the computer and the milliseconds between them were recorded as the reaction time.

SC was measured by placing two Beckman standard AG/AGCL electrodes on the subject's non-dominant hand after washing the skin with distilled water to control hydration. The signal was passed to a Coulbourn SC module which provides a constant measurement voltage of .5v. SC level was sampled and recorded 20 times per second throughout message viewing. For analysis, the data were averaged over 5-second periods. This yielded a baseline 5-second average and six 5-second averages per message. Change from baseline was then calculated and used in the analysis.

HR was measured by placing two Beckman mini AG/AGCL electrodes on subjects' forearms. A ground electrode was placed on subjects' non-dominant forearm. HR was recorded using a Coulbourn bio-amplifier with filters. Heart activity was recorded as milliseconds between beats and later converted to beats per second. These values were then averaged over 5-second periods resulting, again, in a 5-second baseline average and six 5-second averages per message.

Participants

One hundred and twenty six undergraduates at a large Western University participated in this experiment for extra credit in a Communications course. Participants were assigned to one of three conditions: (1) Physiology ($n = 30$); (2) Reaction Time ($n = 51$), or; (3) Memory Only ($n = 47$).

Procedure

Procedures vary slightly by condition due to the different requirements of the dependent measures. In all conditions, however, participants performed the following tasks: (a) first they viewed a short "practice" tape to acclimate them to the laboratory environment; (b) next they took a multiple choice test on the contents of the practice tape; (c) then they viewed the stimulus tape, and (d) they completed the appropriate post-stimulus instruments.

Participants in the Reaction Time and Memory Only conditions viewed the stimulus tape in groups of 2-6 on a 19-inch color television and were instructed to watch the television closely, since they would be tested on what they could remember. Participants in the Reaction Time condition held a button in their dominant hand which they were told to press as fast as they could whenever they heard the signal tone. In this condition, the practice tape contained five practice reaction time tones.

Participants in the Physiology condition took part in the experiment individually. The reaction time tones were not audible in the physiology condition. These subjects

also were instructed to pay close attention, as they would be tested. They viewed the practice tape in order to become accustomed to the electrodes and the environment and took the practice test before viewing the stimulus tape.

In all conditions there was a 30-second pause between messages. Participants were given 15 seconds to rate their emotional responses to the message (using the SAM scale described above) followed by either a 10-second recovery period and a five second base-line data collection period in the Physiology condition, or a 15-second preparatory period in the Reaction Time and Memory Only conditions.

All three groups of subjects filled out questionnaires following viewing. Subjects in the Reaction Time condition completed the cued recall questionnaire. Subjects in the Memory Only condition completed a free recall questionnaire (not reported here) followed by the recognition questionnaire. Subjects in the Physiology condition completed the recognition tests.

Thus, subjects in all three conditions completed the SAM arousal ratings. Subjects in two of the three conditions completed the recognition measures. The cued recall measures were completed by subjects in only one condition. Whenever possible, to allow for an internal replication of the results, hypotheses are tested separately for each condition.

Results

Hypothesis 1

This hypothesis predicts that pacing will increase viewers' self-reported arousal. Hypotheses involving the SAM ratings were analyzed using an Order (3) X Arousing Content (2) X Pacing (3) X Message (5) mixed design ANOVA. The main effect for pacing on the self-reported arousal scores was significant in all three conditions (see Table 1). Thus, in all conditions, participants report increased arousal in response to increased pacing.

Table 1
Mean Self-Reported Arousal Ratings as a Function of Pacing

Condition	Slow	Medium	Fast	<i>df</i>	<i>F</i>	<i>p</i>	Epsilon-Squared
Memory Only	3.21a (.79)	3.97b (.97)	4.39c (1.11)	2,92	47.00	.00	.495
Physiology	3.08a (1.19)	3.57b (1.20)	3.88c (1.41)	2,54	10.86	.00	.261
RT	3.03a (1.78)	3.71b (1.83)	4.03c (1.99)	2,98	26.71	.00	.340

Note. Standard deviations appear in parentheses under rating.

Means in the same row with differing subscripts differ significantly using Tukey contrasts.

Hypothesis 2

This hypothesis predicted that skin conductance would increase as pacing increased. The skin conductance data was aggregated over 1-second periods, converted into change scores (using a 5-second baseline average), and then averaged over 5-second blocks. These data were submitted to an Order (3) X Pacing (3) X Arousing Content (2) X Message (5) X Time (6) mixed ANOVA. The Time factor represents the six 5-second periods.

The main effect for Pacing on the skin conductance data was significant ($F_{2,54} = 5.63$, $p < .006$, epsilon squared = .142). As predicted, skin conductance was highest, compared to baseline levels, for fast paced messages ($M = .05$, $SD = .20$), followed by medium ($M = -.07$, $SD = .20$) and slow ($M = -.08$, $SD = .19$) messages. Thus, in addition to feeling more aroused as pacing increases, participants exhibit higher SCL, an indicator of sympathetic nervous system activation.

Hypothesis 3

This hypothesis predicted that messages pre-judged to contain arousing content would elicit higher levels of self-reported arousal in viewers than messages with contents pre-judged to be calm. This hypothesis was also supported as shown in Table 2. In all three conditions viewers reported feeling significantly more aroused during arousing messages than they did during calm messages.

In addition to the main effect of pacing and arousing content reported here, there was also a significant pacing by arousing content interaction for all three conditions. The means for these interactions are reported in Table 3. This interaction shows that the effect of pacing on self-reported arousal is much larger for calm messages than it is for arousing messages.

Table 2
Self-Reported Arousal Ratings as a Function of Arousing Content

Condition	Calm	Arousing	df	<i>F</i>	<i>p</i>	Epsilon-Squared
Memory Only	3.38 (.71)	5.03 (1.12)	1,46	150.00	.00	.760
Reaction Time	2.78 (2.13)	4.34 (2.43)	1,49	196.66	.00	.797
Physiology	2.81 (1.08)	4.21 (1.43)	1,27	52.29	.00	.798

Table 3
Mean Self-Reported Arousal Ratings by Pacing and Arousing Content

Condition	Content	Slow	Med	Fast	<i>df</i>	<i>F</i>	<i>p</i>	Epsilon-Squared
Memory Only	Calm	2.06 (.71)	3.23 (1.04)	3.81 (1.02)	2,92	17.01	.00	.256
	Arousing	4.36 (1.29)	4.65 (1.25)	4.98 (1.44)				
Reaction Time	Calm	1.80 (.92)	2.95 (1.28)	3.58 (1.31)	2,98	23.96	.00	.315
	Arousing	4.26 (1.41)	4.47 (1.31)	4.48 (1.50)				
Physiology	Calm	2.21 (1.25)	2.83 (1.34)	3.39 (1.25)	2,54	4.28	.00	.458
	Arousing	3.95 (1.52)	4.32 (1.36)	4.37 (1.75)				

Hypothesis 4

This hypothesis predicts that messages with arousing content will elicit higher skin conductance than messages with calm content. Neither the main effect for arousing content ($F_{1,27} = 1.59, p < .219$) nor the interaction between arousing content and time ($F_{2,54} = 1.98, p < .086$) were significant. However, there was a significant Arousing content X Pacing X Time interaction ($F_{10,270} = 2.45, p < .008$, epsilon squared = .053), shown in Figure 1.

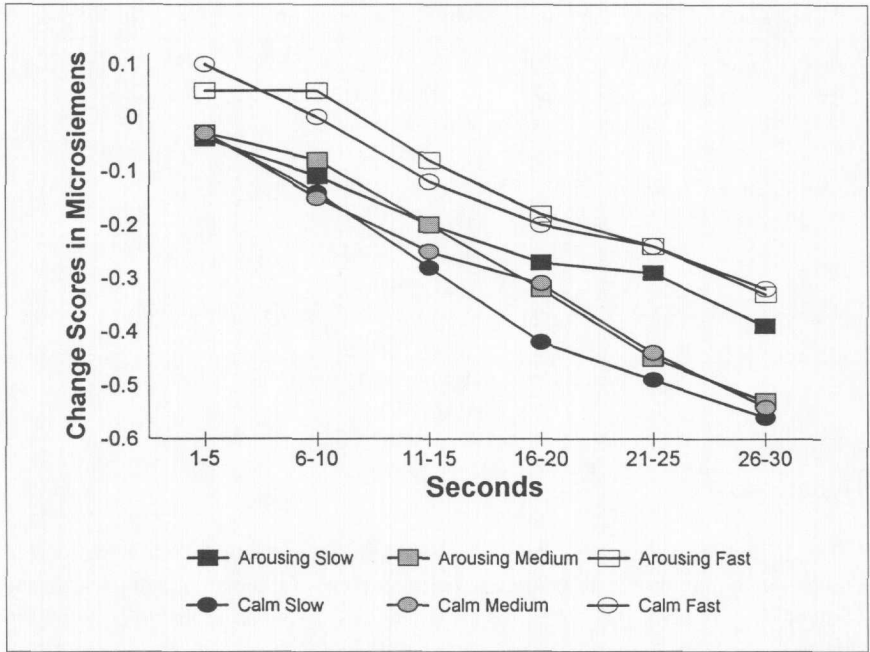
This interaction shows that arousing content appears to have no effect on skin conductance levels except when pacing is slow. In the slow pacing condition there is an apparent effect of arousing content in the predicted direction such that arousing messages have greater skin conductance levels (as would be predicted) than calm messages. Post hoc analysis shows that the effect of arousing content on skin conductance in the slow paced condition is significant ($F_{5,135} = 6.14, p < .0001$, epsilon squared = .159).

Taken together, the results of hypotheses 1-4 suggest that while both content and pacing elicit something viewers label as a feeling of arousal, the physiological states associated with that feeling are different for the two variables. Pacing elicits increases in SC regardless of content, but content has measurable effects on SC only when pacing is absent.

Hypothesis 5

Both the fixed and variable capacity alternatives predict a main effect for arousing content on the secondary task reaction time data. The main effect of arousing content

Figure 1
Skin Conductance Change from Baseline as a Function of Arousing Content, Pacing, and Time



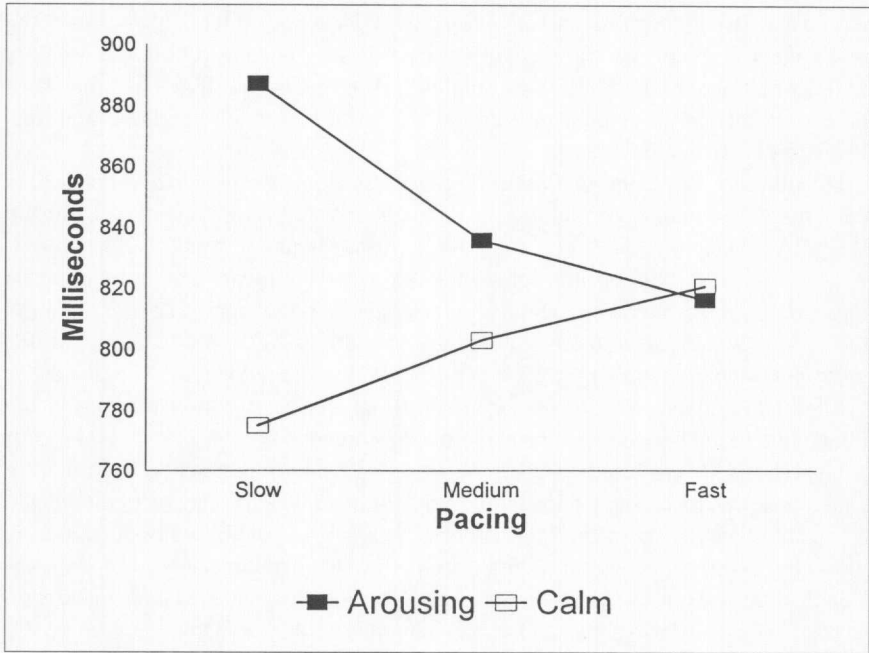
on the secondary task reaction time data was significant ($F_{1,48} = 15.36, p < .0001$, epsilon-squared = .227). Results showed that arousing messages had slower secondary task reaction times ($M = 845.71, SD = 250.66$) than calm messages ($M = 799.37, SD = 299.63$). This result supports the fixed capacity prediction.

Both models also predicted the significant Pacing by Arousing Content interaction ($F_{2,96} = 3.42, p < .037$, Epsilon squared = .047) which is shown in Figure 2. The interaction depicted in this figure, however, does not clearly support either of the hypotheses put forth. The overall slower reaction times for arousing messages and the increasing reaction times across levels of pacing for calm messages support the fixed capacity view. However, the decreasing reaction times across levels of pacing for arousing messages is in the direction predicted by the variable capacity view.

Hypothesis 6

This hypothesis predicted that heart rate would decrease as pacing speeds up. The heart rate data were collected as milliseconds between beats and converted into heart rate (expressed as beats per minute) per second and averaged over five second

Figure 2
Secondary Task Reaction Times as a Function of Arousing Content and Pacing



periods. These data were then submitted to an Order (3) X Pacing (3) X Arousing Content (2) X Message (5) X Time (6) mixed ANOVA. The main effect for pacing on the heart rate data was not significant ($F < 1$) nor were there any significant interactions of pacing with the other factors.

Hypothesis 7

This hypothesis predicted that arousing messages would elicit slower heart rates than calm messages. The main effect for Arousing Content on the heart rate data was significant ($F_{1,27} = 21.33$, $p < .000$, epsilon squared = .421). Average heart rate in arousing messages was 75.21 ($SD = 10.04$) compared to an average heart rate of 76.10 ($SD = 10.14$) for calm messages.

The Recognition Hypotheses: 8, 9, and 10

Recognition data were collected in both the Memory Only and Physiology conditions. They were analyzed separately to provide an internal replication of the data. In each case, scores on the recognition questions were summed across

messages and submitted to an Order (3) X Arousing Content (2) X Pacing (3) X Message (5) mixed ANOVA.

Hypothesis 8 predicted that as pacing increased, recognition for message content would increase up to a point, after which it would level off or actually decrease. The main effect of Pacing on the recognition data was significant in both the Memory Only condition and the Physiology condition. The means are shown in Table 4. As predicted, recognition increases from the slow to the medium condition and then decreases from medium to fast.

Hypothesis 9 predicted that arousing messages would be recognized better than calm messages. In both conditions, the main effect of Arousing Content is significant (Memory Only, $F_{1,46} = 6.21$, $p < .016$, Epsilon squared = .099; Physiology, $F_{1,27} = 9.66$, $p < .004$, epsilon squared = .237), but the means are in the opposite direction from that predicted, with calm messages being recognized better (Memory Only $M = 55.88$, $SD = 8.89$; Physiology $M = 59.39$ $SD = 8.14$) than arousing messages (Memory Only $M = 52.73$, $SD = 9.41$; Physiology $M = 54.06$, $SD = 8.72$). While at first glance this seems quite surprising, the explanation may lie in the interaction found between pacing and arousing content.

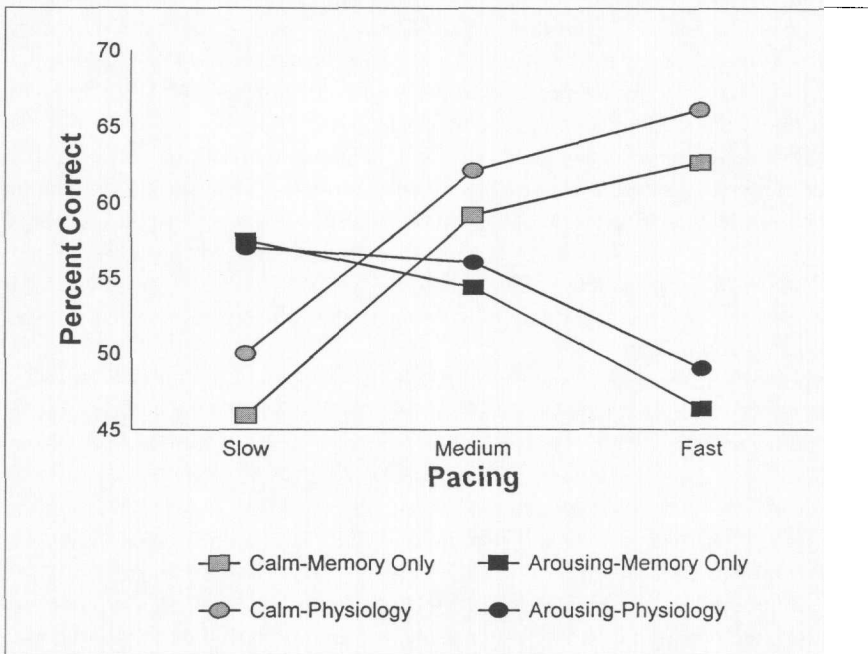
Hypothesis 10 predicted a Pacing by Arousing Content interaction such that for calm messages, increased pacing would result in steadily increasing recognition with a possible leveling off of the increase at high levels of pacing, while for arousing messages, recognition would increase from slow to medium paced, but decrease significantly for fast paced messages. The Arousing Content X Pacing Interaction (shown in Figure 3) was significant in both conditions (Memory Only— $F_{2,92} = 56.21$, $p < .001$, Epsilon-squared = .536); Physiology— $F_{2,54} = 24.55$, $p < .000$, epsilon-squared = .458). As predicted, recognition increases across levels of pacing for calm messages, while for arousing messages, recognition decreases steadily across levels of pacing. The means are shown in Table 5.

Table 4
Mean Recognition Scores as a Function of Pacing

Pacing	Condition	
	Memory Only	Physiology
Slow (0-1 cut)	51.72a (8.83)	53.67a (10.38)
Medium (5-6 cuts)	56.73b (8.65)	59.00b (6.62)
Fast (>10 cuts)	54.46b (12.17)	57.40b (10.32)
<i>F</i>	$F_{2,92} = 5.54$, $p < .01$	$F_{2,54} = 3.06$, $p < .055$
Epsilon-squared	.0885	.0673

Note. Means in the same column with differing subscripts differ significantly using Tukey post-hoc contrasts.

Figure 3
Recognition as a Function of Pacing and Arousing Content



The Cued-Recall Hypotheses: 11, 12, and 13

Separate Order of Presentation (3) X Arousing Content (2) X Pacing (3) X Message (5) mixed ANOVAs were run on each of the three types of cued recall scores (Number of Words, Narrative Description, and Auditory Description).

Table 5
Mean Recognition Scores as a Function of Pacing and Arousing Content

Pacing	Condition			
	Memory Only		Physiology	
	Calm	Arousing	Calm	Arousing
Slow	45.95a (12.50)	57.49b (10.04)	50.00a (14.20)	57.33d (10.96)
Medium	59.14b (5.91)	54.32d (9.94)	62.33b (10.06)	55.67d (8.88)
Fast	62.55b (6.26)	46.37a (16.85)	65.83c (9.66)	49.17a (15.09)

Note. Means in the same condition with differing subscripts differ significantly using Tukey post-hoc contrasts.

Hypothesis 11 predicts that as pacing increases, cued recall for the message will increase. Results show a significant main effect for Pacing on cued recall for Number of Words ($F_{2,96} = 14.01, p < .0001$, Epsilon squared = .210), Narrative Description ($F_{2,96} = 7.72, p < .001$, epsilon squared = .121), and Auditory Description ($F_{2,96} = 4.92, p < .009$, epsilon squared = .0719). The means (see Table 6) show that cued recall increases for all measures from slow to medium pace, and then levels off or declines from medium to fast paced messages.

Hypothesis 12 predicts that cued recall will be higher for arousing messages than for calm messages. Results show a significant main effect for Arousing Content on Number of Words ($F_{1,48} = 15.14, p < .0001$, Epsilon squared = .224), Narrative Description ($F_{1,48} = 10.71, p < .002$, epsilon squared = .166), and Auditory Description ($F_{1,48} = 22.51, p < .000$, epsilon squared = .304). As predicted, cued recall was greater for arousing messages than for calm messages. The means for each memory measure are reported in Table 7.

Hypothesis 13 predicts a significant Pacing by Arousing Content interaction on cued recall such that calm messages will be recalled better as pacing increases, while for arousing messages, cued recall will increase as pacing increases from slow to medium, but then either level off or decrease from medium to fast. As predicted, there was a significant interaction for Number of Words ($F_{2,96} = 14.01, p < .0001$, Epsilon squared = .220), Narrative Description ($F_{2,96} = 12.85, p < .000$, epsilon squared = .195), and Auditory Description ($F_{2,96} = 6.84, p < .002$, epsilon squared = .104). The Means are shown in Table 8. Narrative Descriptions and Number of Words show the predicted pattern with linearly increasing memory for the calm messages and an inverted U-shaped function for the arousing messages. Auditory Description shows the inverted U-shaped function for both calm and arousing messages.

Discussion

These results speak to the ability of the limited capacity theoretical model to predict and explain the impact of video message variables on information processing and,

Table 6
Cued Recall as a Function of Pacing

Pacing	Words	Narrative	Auditory
Slow	10.11a (4.81)	3.61a (1.98)	.13a (.16)
Medium	12.73b (6.86)	4.44b (2.77)	.18b (.20)
Fast	12.51b (6.15)	3.86a (2.50)	.11c (.14)

Note. Means in each column with differing subscripts differ significantly using Tukey post-hoc contrasts.

Table 7
Cued Recall as a Function of Arousing Content

Content	Words	Narrative	Auditory
Calm	10.95 (5.35)	3.69 (2.15)	.09 (.12)
Arousing	12.62 (6.16)	4.24 (2.55)	.18 (.18)

further, have implications relevant to understanding how the design and production of video messages can affect viewers' feelings and memories.

Implications for the Limited Capacity Model

The model put forth here attempts to explain how specific variations in a television message (in this case, arousing content and number of cuts) will affect automatic allocation of processing resources, orienting, physiological arousal, subjective arousal, and the processes of encoding and storage. Generally, the model did well in predicting how pacing and arousing content would affect information processing. A summary of the results is presented in Table 9.

As expected, both arousing content and fast pace increased self-reported arousal in television viewers. However, while both variables elicited significant increases in

Table 8
Cued Recall as a Function of Pacing and Arousing Content

Condition	Words	Narrative	Auditory
Calm slow	9.25a (4.65)	3.33a (1.90)	.04a (.10)
Calm medium	10.38b (5.90)	3.60ab (2.15)	.13b (.20)
Calm fast	13.21c (7.34)	4.14b (3.04)	.11c (.15)
Arousing slow	10.96c (6.22)	3.88ab (2.42)	.21d (.27)
Arousing medium	15.08d (8.82)	5.27c (3.82)	.23e (.26)
Arousing fast	11.81c (5.93)	3.58ab (2.18)	.11c (.20)

Note. Means in each column with differing subscripts differ significantly using Tukey post-hoc contrasts.

Table 9
Summary of Results

Theoretical Idea	H#	DV	Finding	Effect Size	Supported
Arousing content elicits arousal	H3	SAM	Self-reported arousal was higher for arousing messages than it was for calm messages in all conditions.	Memory .76 STRT .80 Physio. .65	Yes
	H4	SC	SC was higher for arousing contents compared to calm contents only for slow paced messages.	.16	Partially
Pacing elicits arousal	H1	SAM	Self-reported arousal increased as pacing increased in all conditions.	Memory .50 STRT .34 Physio. .26	Yes
	H2	SC	SC increases as pacing increases	.14	Yes
Arousing content increases resource allocation/attention	H5	RT	STRTs are slower for arousing messages than for calm messages.	.23 .42	Yes Yes
	H7	HR	Arousing messages elicit slower HR	—	No
As pacing increases viewers will allocate more resources to encoding. Encoding will improve up to overload than decline.	H6	HR	Pacing has no effect on HR		
	H8	Recog	Recognition increased from slow to medium paced messages and then decreased for fast in all cond.	Memory .09 Physio. .07	Yes No
	H9	Recog	Recognition was lower for arousing messages than for calm messages.	Memory .10 Physio. .24	Yes
	H10	Recog	For calm messages recog. increases with pacing, for arousing messages it decreases as pacing increases.	Memory .54 Physio. .49	
Pacing and arousing content should increase storage up to a point of overload.	H12	Cued recall	Cued recall is higher for arousing messages than for calm messages.	Words .22 Narrative .17	Yes Yes
	H13	Cued recall	Cued recall increases from slow to medium messages and then decreases from medium to fast messages.	Auditory .32 Words .21	Yes Yes
Overload should occur sooner for arousing messages.	H14	Cued recall	For calm messages, cued recall increased with pacing for words, & narrative, decreased at fast for auditory.	Narrative .12 Auditory .31	Yes Yes
			For arousing messages, cued recall increased then decreased as pacing increased for all measures.	Words .22 Narrative .20 Auditory .10	Yes Yes Yes

self-reported (subjective) arousal, the actual physiological responses elicited are different.

Only pacing elicited the predicted increase in skin conductance (a measure of sympathetic nervous system activation). Fast paced messages had higher skin conductance than medium or slow paced messages. Arousing content, however, did not appear to affect skin conductance except in slow paced messages. In slow paced messages arousing content evoked higher skin conductance than did calm content.

The reverse occurred with the heart rate data. Only arousing content elicited the expected decrease in heart rate. Arousing messages resulted in slower heart rates than calm messages. Pacing, by itself, had no effect on heart rate.

One possible explanation for these findings might be found by considering the architecture of the nervous system. The central nervous system is composed of the sympathetic nervous system (SNS) and the parasympathetic nervous systems (PNS) (Lang, 1994; Cacioppo & Tassinari, 1990). Skin conductance (the measure of "autonomic" arousal used in this study) is innervated only by the SNS. Heart rate, on the other hand, (used in this study primarily as a measure of attention) is dually innervated by both the SNS and the PNS. Increasing activation in the SNS speeds up the heart rate. Greater activation in the PNS slows down the heart rate. Previous research involving physiological responses to emotional and arousing media stimuli demonstrates consistently that the PNS activation of the heart during viewing of emotional media dominates the SNS activation resulting in net decreases in heart rate (Carruthers & Taggart, 1973; Lang, 1990; Lang, Dhillon, & Dong, 1995; Lang, Newhagen, & Reeves, 1997).

With this in mind, these data might be interpreted to suggest that Pacing primarily results in increases in SNS activation while Arousing Content is more tied to PNS activation. Further, the significant effects of both independent variables on viewers' *self-reported arousal* suggest that both types of activation (sympathetic and parasympathetic) are interpreted by the viewers themselves as increases in "arousal".

These results also offer some support for the notion that both types of increases in arousal (sympathetic system activation elicited by pacing and parasympathetic system activation elicited by content) increase the resource demands of the message. Secondary task reaction times are significantly slower during arousing messages than during calm messages, and, for calm messages, secondary task reaction times get slower yet as pacing gets faster. In arousing messages, on the other hand, secondary task reaction times get faster as pacing gets faster.

The slower secondary task reaction times for arousing content compared to calm content appear to support a fixed (rather than a variable) capacity model of information processing. Interestingly, however, most variable capacity models, when they conceive of arousal, probably contemplate only sympathetic nervous system activation. These results may suggest that arousing television content elicits primarily parasympathetic arousal (not sympathetic arousal). If this is the case, it could follow that arousing content elicits the "wrong kind" of arousal to increase the pool of resources while pacing elicits the "right kind."

Fast pace does appear, on the other hand, to elicit sympathetic arousal, but has no main effect on the secondary task reaction time data. Instead an interaction between Pacing and Arousing Content appears. For calm messages (those with low parasympathetic activation), increasing pacing slows secondary task reaction times. For arousing messages (those with high parasympathetic activation), increased pacing speeds reaction times. One possible explanation is that capacity is fixed except in cases of both high sympathetic and high parasympathetic activation.

This is an area that deserves further study. In any case (leaving behind the question of fixed or variable capacity pools) the results of the reaction time data support the basic underlying premise that both pacing and arousing content increase the resources required by and allocated to processing the message.

The last six hypotheses deal with specific hypotheses about the effect of Pacing and Arousing Content on the processes of encoding and storage. These results support the limited capacity theory.

The results of the recognition analysis, which are the same in both conditions where recognition was measured, demonstrate the predicted overloading of the encoding process between the medium and high levels of pacing for arousing messages. For calm messages, where the additional resource demands made by arousing content are not present, there was no evidence of overload at fast levels of pacing.

A similar pattern can be seen for cued recall results. Again, storage appears to be overloaded in the arousing condition, but not in the calm condition. There is, in addition, some evidence (provided by the auditory description category of the cued recall data) that storage of auditory elements of the message may be overloaded before storage of the narrative elements of the message.

Finally, the hypothesis that arousing contents would automatically call resources to the task of storage, finds some support. The impact of arousing content was greater on the cued recall data than it was on the recognition data. This was demonstrated by the fact that for the cued recall data, the arousing content main effect was significant (and fairly large with estimated effect sizes ranging from 17-29% across the three cued recall measures) in spite of the Arousing Content by Pacing interaction which showed the expected overload of the storage process for fast paced arousing messages.

This prediction should continue to be tested in future work. In particular, future investigations might include a delayed cued recall measure, collected days or weeks after stimulus presentation, to provide a better test of this hypothesis.

Implications for Message Production

The results of this study may have broad application in any area of video production where both attention and memory matter (such as educational or children's video). The results lend support to the contention that the relationship between attention and memory is not linear. While attention is a necessary condition for memory, it is not sufficient. Evidence continues to mount that television messages

designed to maximize attention through the use of production features (like pacing) do so at the expense of memory for the content of the message.

This does not mean, however, that pacing and arousing content cannot both be used when memory is a goal, since clearly they can also result in improved memory as well as improved attention when a judicious balance is maintained between the processing resources required at encoding and the processing resources required at storage.

This study suggests that engagement of autonomic systems (either parasympathetic or sympathetic) will improve processing of messages. Further, engaging both systems may be optimal, so long as neither is overloaded. Thus, producers who want their messages to be remembered should create arousing messages that are slow or medium paced, or calm messages that are medium or fast paced. Producers should not create messages that are calm and slow paced or arousing and fast paced.

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Notes

¹. This is a fixed capacity model. The psychology literature contains both fixed and variable capacity models (Kahneman, 1976). However, research using the limited capacity model of television viewing has consistently supported predictions made by a fixed model. Since a fixed capacity model is more parsimonious than a variable capacity model, we have continued to use a fixed capacity model.

². The amount of information introduced by a cut is a continuous variable. The distinction being made here is an attempt to define a range of values at either end of that continuum. Some "edits" will introduce a good deal more information than others. For example, an establishing shot of a crowd, followed by a cut to a close-up of an individual in the crowd, we would define as an edit in this study, but it clearly introduces a great deal of new information. Other "edits" introduce very little new information, such as the change from a camera on the left side of a set to a camera on the right side. In this study, a cut to anything that existed in a previous establishing shot was called an edit. If the cut was to something which did not appear in a previous establishing shot, it was called a cut. All of the cuts and edits occurred in coherent 30 second messages.

³ In addition, increased arousal has been theorized to increase cognitive capacity (Kahneman, 1976). This hypothesis has been tested twice in the context of television viewing using the limited capacity model. In neither case did the data support the hypothesis that increased arousal increased capacity (Lang, Dillon, & Dong, 1995; Lang et al., in press).

⁴ Other research, and our experience gathering the stimuli, suggest that these rates are within (and possibly cover comprehensively) the normal range of rate of edits in naturally occurring television. For example, Hibbs, Boll, & Lang (1995) selected a random sample of 70 two-minute television messages. They found that the number of edits in these messages ranged from 0-57 with an average of 14.1. The average would be in our medium range, with our fast and very fast rates being well above average. The same study found the rate of scene changes or cuts to range from 0-54 within average of 8.9. Thus, holding our rate of cuts to less than 3 in two minutes does correspond to a slow rate of cuts. Another example can be found in a content analysis of the structural features of standard and tabloid news magazines shows. Grabe, Zhou, & Barnett (1998) found that the average shot length for standard TV news magazines was 5.28 seconds, and for tabloid news magazine shows it was 3.72. These numbers correspond to an average rate of combined cuts and edits of ten per minute for standard news magazine shows and sixteen per minute for the tabloid shows. This would make the standard shows medium and the tabloid shows fast in this study.

⁵ Epsilon squared is a standard effect size estimate which can be used with repeated measures analysis. Epsilon-squared is a more conservative estimate of effect size than the better known eta-squared (Keppel, 1982).