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The Effects of Auditory Structural Complexity on Attitudes, Attention, Arousal, and Memory

Robert F. Potter
Indiana University

Jinmyung Choi
KyungSan KyungBuk, South Korea

Twenty-five participants listened to 8 radio messages—half of which were greater in auditory structural complexity. Physiological measures were taken during message presentation, and self-report measures after each. Results show that increased auditory structural complexity led to higher self-reported and physiological arousal, better attitudes toward the messages overall and toward their nonclaim components. There were no differences in attitudes toward the claims made in the messages at each level of structural complexity. Structurally complex messages were also freely recalled more often than simple messages. The prediction that messages high in auditory structural complexity would result in greater self-reported attention levels received only moderate support. Furthermore, high levels of auditory structural complexity resulted in unexpectedly higher cardiac activity compared to messages low in structural complexity.

A body of work has started to close the gap between the large number of studies conducted on the cognitive processing of television (TV) messages and the comparatively modest number exploring how the human cognitive system responds to exclusively auditory stimuli. For example, Bolls (2002) used a dual-task paradigm to suggest that radio commercials designed to evoke imagery in listeners actually engage visual processing centers in the brain. Similarly, Bolls,

Correspondence should be sent to Robert F. Potter, Indiana University, Department of Telecommunications, 316 Radio-TV Building, 1229 East 7th Street, Bloomington, IN 47405-5501. E-mail: rfpotter@indiana.edu

A. Lang, and Potter (2001) employed facial electromyography to show that radio messages pretested as being more negatively valenced resulted in greater activity in corrugator (frown) muscles than messages pretested as being more positive in their emotional tone. Furthermore, the study replicated findings in the TV literature showing that messages reported as more arousing also elicit greater skin conductance activity and lead to greater subsequent recognition memory.

Another path of research in processing of radio messages focuses not on the impact of content manipulations but, rather, on the impact of auditory structural change on cognitive processing. Media scholars have long recognized the importance of looking at structural features along with content to assess the full impact that a mediated message might have (Huston et al., 1981). Until quite recently, most of the investigations in the area of structural features have focused on how changes in TV message structure affect viewers (Detenber, Simons & Bennet, 1998; Grabe, Zhou, Lang, & Bolls, 2000; Thorson, Reeves & Schleuder, 1986; Watt & Krull, 1974). It is not surprising, given the nature of TV, that visual structure is the primary focus of such studies. However, a number of findings even in this research point to the substantial impact of auditory structural features. Because this study is interested in the concept of auditory structural complexity, it begins by summarizing applicable findings from the TV literature. In general, these suggest that increases in the number of auditory structural features—in other words, increases in the auditory structural complexity—result in a greater call for cognitive capacity to process the message.

RESEARCH ON STRUCTURAL COMPLEXITY IN TELEVISION MESSAGES

For decades the work exploring effects of TV focused on the genre of the content (Bogart, 1958; McLeod, Atkin, & Chaffee, 1971) or time spent viewing (Gerbner, Gross, Signorielli, Morgan, & Jackson-Beeck, 1979). The implication was that one of these factors (or a combination of both) resulted in viewer effects. In 1974, however, Watt and Krull hypothesized that there should be effects induced by "the structural or form characteristics of the program" regardless of content category (p. 45). Borrowing the concept of entropy from Shannon's model of communication, they developed six specific structural concepts they said were iconic to TV: Verbal Incidence Entropy, Verbal Time Entropy, Set Incidence Entropy, Set Time Entropy, Set Constraint Entropy, and Nonverbal Dependence Entropy. Two of these concepts can be understood as an index of auditory change in the TV stimulus. Verbal Incidence Entropy is an indication of the number of different speakers in a TV message and the associated difficulty a viewer has in discriminating between them. Verbal Time Entropy refers to the amount of time that a viewer is given to make such discriminations, in other words, the duration of a speaker's voice prior to its ceasing or being replaced by another voice.

Watt and Krull coded prime time TV from the three networks for these six structural features. The data were submitted to a factor analysis, which determined that more than 75% of the variance of TV's structure could be described using two reduced factors that they termed Dynamics and Unfamiliarity (DYNUFAM, Watt & Krull, 1974). Auditory changes (in the form of Verbal Incidence and Verbal Time Entropy) were a part of the Dynamics factor, along with Set Time Entropy. The authors described a TV program high in this factor as likely taking place on many different sets and having "a large number of characters who verbalized frequently, but for short periods of time" (Watt & Krull, 1974, p. 57). They went on to show that the level of DYNUFAM within programs was superior to program genre as a predictor of nonrandom viewing patterns in adolescents. This suggested that structural complexity ("entropy") elicited predictable effects in viewers and furthermore that auditory change was a substantial component of this complexity.

The same six coding categories were employed by Wartella and Ettema (1974) when exploring the impact of structural complexity on children's cognitive processing of TV commercial messages. In this experiment they began with 40 commercials specifically selected to vary as widely as possible in structural complexity according to Watt and Krull's (1974) definitions. After coding the initial group of 40 commercials, factor analysis showed that audio and visual structural complexity were considered separate dimensions of overall structural complexity in ads.

Wartella and Ettema (1974) then selected 12 commercials from their initial group of 40 according to whether they were for products that were relevant or irrelevant to children. Each was also coded on their level of both visual and auditory structural complexity (High, Medium, or Low). The ads were then embedded into a primetime situation comedy in one of three commercial pods—two containing only relevant products and one containing irrelevant products. This stimulus was shown to 120 children ages 3 to 8. The dependent variable was attention to the commercial, operationalized by having coders categorize the level of attention being paid using a 3-point scale (*full*, *partial*, or *none*) just prior to commercial onset, at onset, and at each subsequent 10-sec mark during the duration of each commercial.

The results show that once again auditory structural complexity had a large impact. In both relevant and irrelevant product categories, the highest mean attention scores were when the complexity of the audio channel was high, regardless of the level of visual complexity. They concluded that "variation in auditory complexity has greater effect on attention behavior than variation in visual complexity in commercials," suggesting that this is due to the fact that audio had the ability of increasing the attention of those who were not looking at the TV in the first place (Wartella & Ettema, 1974, p. 85).

Watt and Welch (1983) suggested a biological process that could be responsible for this auditory-driven redirection of attention toward the TV screen. They developed an independent variable that measured dynamic audio complexity defined as "the randomness over time of the intensity of an audio frequency band" (p. 82). They found that this was positively correlated with children's memory for content of educational programming. In their discussion of these results, they attributed this relationship to the *orienting response* (OR), which is a biologically hard-wired response to novelty or signals in the environment (Graham, 1979). One indicator of an OR is the turning of the body's sensory organs toward the source of novelty (Lynn, 1966; Ravaja, 2004), and it was here that Watt and Welch saw the parallel between the OR and their observations in the TV research lab—unexpected sounds coming from the set would cause the children to turn from whatever else they were doing to see what was occurring on screen. Research showing that the OR resulted in the allocation of processing resources to the task of encoding new information (Ohman, 1979; see also Dawson, Filion, & Schell, 1989) seemed to strengthen Watt and Welch's belief that orienting was the mechanism at work because it nicely explained how TV produced with high levels of dynamic audio complexity resulted in higher memory scores.

Later, researchers used more covert physiological indicators to identify the OR, such as a reliable momentary deceleration in heart rate followed by either a return to baseline or a brief acceleration above baseline levels before stabilization (A. Lang, Geiger, Strickwerda, & Sumner, 1993). Researchers began investigating the impact of structural features in TV searching for this cardiac pattern, realizing that physiological dependent measures allowed them to now identify when momentary increases in attention occurred even in participants already facing the set. Once again, the features explored tended to be those that introduced visual change to the screen—cuts from one picture to another, the onset of graphics, camera zooms to reveal close-up detail of an object, and so forth. Results generally showed that changes in visual structure introduced enough novelty to trigger an OR (A. Lang et al., 1993; Thorson & A. Lang, 1992) and that this was accompanied by an automatic allocation of cognitive resources to message encoding (Geiger & Reeves, 1993).

After researchers identified visual structural features that predictably elicited orienting, they investigated increases in structural complexity of the message by systematically varying the number of times a particular feature occurred (A. Lang, Bolls, Potter & Kawahara, 1999; A. Lang, Zhou, Schwartz, Bolls, & Potter, 2000; Yoon, Bolls, & A. Lang, 1998;). For example, A. Lang et al. (1999) used categorical increases in the number of cuts as an operational definition of increasing the structural complexity of a TV message. They found that doing so resulted in increases in the amount of arousal (both self-reported and physiological) experienced by viewers. Using a theoretical rationale provided by a limited capacity model of TV viewing (see A. Lang, 2000), they also predicted and found that this arousal, in turn, resulted in more processing resources being automatically allocated to storing the structurally complex messages in long-term memory—as indexed by greater levels of unaided recall for these messages compared to structurally simple ones. Contrary to their predictions, they did not find slower heart rates (a physiological indicator of increased attention) during structurally complex messages compared to simple ones. Their discussion suggests this may be due to the innervation of the heart by both the sympathetic and parasympathetic nervous systems, with structural complexity impacting the former and content complexity (i.e., the level of arousal associated with the topic matter) being reflected in the latter.

RESEARCH ON STRUCTURAL COMPLEXITY IN RADIO

Potter, A. Lang, and Bolls (1998) expanded these TV findings in a study designed to find analogs to TV's cuts and edits in the radio medium. Their results showed that listeners exhibited cardiac ORs following a number of structural features that introduce novelty into the audio stream including: sound effects, production effects, voice changes, and music onsets. Later, Potter (1998, 2000) attempted to increase auditory structural complexity in a way similar to studies conducted on visual features in TV: by systematically increasing the occurrences of a specific structural feature previously shown to cause orienting in audiences. In a laboratory experiment participants heard actual (i.e., taped off air during broadcast) 2-min radio messages, which were selected according to their variance in the number of voice changes. The structurally complex messages had very rapid voice changes (> 20 per message), while the structurally simple messages moved at the pace of a more casual conversation (10–15 voice changes per message). Results confirmed that not only did listeners exhibit cardiac orienting at the point where one voice is replaced by another in a radio message, but that orienting to this structural feature did not habituate over the course of 2-min radio messages. In other words, contrary to studies in psychology where cardiac orienting to subtle changes (i.e., frequency variations of brief tones) eventually dissipates, the cardiac pattern indicative of an OR did not cease after multiple repetitions of voice changes in the radio messages (Potter, 2000). Furthermore, though it did not achieve statistical significance, the mean skin conductance data suggested higher arousal during structurally complex radio messages compared to simple ones and free recall memory for information in structurally complex messages was significantly greater than in structurally simple ones (Potter, 1998).

Potter and Callison (2000) explored the impact on listeners of auditory structural complexity in radio promotional announcements (promos). Auditory structural complexity was defined as the extent to which radio messages contained features known to cause ORs—voice changes, music onsets, production effects, sound effects, and so forth. They reasoned that because Potter's (2000) results, which suggested orienting to these features, did not habituate over the course of 2 min, increasing the number of times they occurred during short (35–75 sec) promos would result in repetitive orienting. This assumption guided predictions about listener memory and attitudes toward the promos themselves, as well as the stations they represented. For example, they hypothesized that participants would report being more aroused when listening to structurally complex promos compared to their self-reported arousal state when listening to structurally simple ones. They also predicted that this increase in arousal would lead to higher free recall memory for information contained in the structurally complex messages. Results supported these predictions—self-reported arousal was greater for structurally complex promos, and they were free-recalled better both during the experimental session and when participants were called back an average of 4.5 days later.

Potter and Callison (2000) also used the Elaboration Likelihood Model (ELM, Petty & Cacioppo, 1986) to predict different attitudes in response to structurally complex promotional announcements than in response to structurally simple ones. They reasoned that because radio promos were not the sort of messages that listeners would process centrally, peripheral cues would instead be used to form attitudes. As predicted, their data show that listeners had better overall attitudes toward the structurally complex promos and better attitudes toward the nonclaim components of the complex promos than the structurally simple ones. Consistent with the ELM, however, there was no significant difference in the attitudes listeners had toward the claims made by structurally complex and structurally simple promos.

THIS STUDY—GENERAL DESIGN AND HYPOTHESES

This study is designed to advance understanding of how auditory structural features in radio messages influence the human cognitive processing system. The independent variable is auditory structural complexity, conceptualized as the extent to which a radio message contains structural features of interest—with messages containing many such features being defined as more structurally complex than messages with only a few. This definition is in the spirit of much of the work done on structural complexity in TV messages (Reeves, Thorson, & Schleuder, 1986; Wartella & Ettema, 1974; Watt & Krull, 1974) but follows the distinction of A, Lang et al. (1999) by further defining the important structural features as those previously shown to cause orienting responses in listeners. In audio messages those specific features are voice changes, production effects, sound effects, and music onsets (Potter et al., 1998).

This study adds to the initial work done in the area because, unlike Potter and Callison (2000), it does not rely on self-reported data as the sole index of emotional and cognitive processes. Results have shown that self-report data may diverge from how the body actually responds (A. Lang et al., 1999; Potter, Cummins, Lee, Choi, & Sparks, 2004) for reasons ranging from lack of self-awareness to social biases (Bolls et al., 2001; Stern, Ray, & Quigley, 2001). Still, much of the literature shows that, at least when it comes to a sense of arousal, both self-report and physiology present similar results—greater structural complexity leads to increased self-report and physiological arousal (Lang et al., 1999, 2000). Because past data show that greater auditory structural complexity results in greater self-reported arousal (Potter & Callison, 2000), the following hypothesis is made:

H1: Radio messages high in auditory structural complexity will result in greater arousal in listeners, as indexed through self-reported and physiological measures, than messages low in auditory structural complexity.

Dimensional theories of emotion recognize arousal as a key component in affective response (Bradley, 1994; Mehrabian & Russell, 1974). Furthermore, a long series of work in cognitive psychology by P. J. Lang and colleagues has shown a consistent correlation between highly arousing emotional stimuli and subsequent free recall memory—a correlation present regardless of the valence of the emotion felt (i.e, whether it is positive or negative—see Bradley, Greenwald, Petry, & P. J. Lang, 1992). This relationship between arousal and memory has also been found in response to 6-second audio clips (Bradley & P. J. Lang, 2000), as well as in the TV processing literature (Bolls, Potter, & A. Lang, 1996; A. Lang, Newhagen & Reeves, 1996; A. Lang et al., 2000). Because this study predicts increased arousal during radio messages high in auditory structural complexity, the following hypothesis is also forwarded:

H2: Radio messages high in auditory structural complexity will result in greater free recall in listeners than messages low in auditory structural complexity.

There is reason to predict that listeners will pay more attention to the radio messages that have greater structural complexity than to radio messages that are structurally simple. First of all, the repetition of OR-eliciting structural features would result in a frequent call for processing resources to be automatically allocated to message encoding (Potter, 2000). Secondly, research data have shown a link between messages that result in arousing emotional responses and increases in attention to the messages (Grabe et al., 2000; A. Lang et al., 1999). Therefore, because it is assumed that structural complexity will lead to multiple ORs and predicted that this will lead to an increase in arousal responses in listeners:

H3: Radio messages high in auditory structural complexity will result in greater attention in listeners than messages low in auditory structural complexity.

The final hypothesis of this study looks to replicate the attitude findings of Potter and Callison (2000). In that study they argued that listeners would not likely become highly involved in radio promotional announcements. Therefore, the ELM predicts that peripheral processing of the messages should dominate, and structural cues have maximum effect. Their data support the argument—with results showing that participants had significantly more positive overall attitudes toward nonclaim components of the radio promos high in auditory structural complexity compared to those low in auditory structural complexity. No significant differences were found between participants' attitudes toward the claims in the promos of either level of complexity (Potter & Callison, 2000).

This study will expand on Potter and Callison (2000) by using a variety of radio stimuli—promos and advertisements for products and services. Still, considering that the content of these stimuli will feature radio stations and advertisers located in distant locales from the city in which the experiment is taking place, it is reasonable to believe that involvement with the messages will be low. Furthermore, no experimental manipulation will occur to increase involvement, such as those used in experiments designed to encourage central processing (Petty, Cacioppo, & Schumann, 1983). Therefore, with participants expected to process the radio messages peripherally, the following hypothesis is made:

H4: There will be a main effect of auditory structural complexity on attitudes such that listeners will have significantly more positive overall attitudes and more positive attitudes toward nonclaim components for radio messages high in auditory structural complexity than messages low in auditory structural complexity. However, there will be no significant effect of auditory structural complexity on attitudes toward claim components of the radio message.

METHOD

Design

This experiment utilized a 2 (Auditory Structural Complexity) × 4 (Message) × 2 (Order of Presentation) mixed analysis of variance design. The first within-subjects factor was Auditory Structural Complexity, with two levels—high and low. Message was the second within-subjects variable in the design, with four levels representing the different messages serving as repetitions of the two levels of the auditory structural complexity factor. The only between-subject factor was Order of Presentation, with two levels corresponding to the two systematic orders created to control for sequence effects on attitude and memory.

Participants

Twenty-five undergraduates from a large university in the southeastern United States participated in this experiment. All received either course credit or extra credit in a Mass Communications course in exchange for their participation. All provided informed consent prior to completing the experimental protocol.

Experimental Stimuli

Stimulus messages were chosen from compact discs obtained through a subscription to *Radio and Production* magazine. This monthly publication targets radio production professionals and includes discussions of the latest in audio production equipment and techniques. A regular feature of the magazine is a compact disc that provides samples of audio productions created and submitted by subscribers. These include promotional announcements, as well as commercials, station identifications, and music sweepers.

After previewing several of these compact discs, four messages considered high in auditory structural complexity and four considered low were selected. Three of the selected messages in each group were 60 sec in duration and one was 30 sec. This was done in an attempt to prevent participants from anticipating when each would end during the experimental presentation. The messages were pretested by a group of people (N = 30) with demographic and psychographic profiles expected to be similar to the participants in the final experiment. The pretest consisted of completing the six, 7-point semantic differential items originally used by Potter & Callison (2000) to ascertain the perceived auditory structural complexity of the messages. The six scale items were later reduced to mean complexity ratings. As suspected, the two groups of messages were significantly different in perceived complexity, $F(1, 29) = 366.100$, $p < .001$, with the group that was originally identified as high in auditory structural complexity receiving higher ratings (M = 5.93), than the other group (M = 2.69).

These eight messages were then placed in two systematic orders of presentation to ensure that a single message did not occur exclusively in the first and/or last quarter of presentation to prevent memory distortion. Furthermore, across the two orders no pair of messages occurred in the same sequential order of presentation. At the beginning of each order of presentation, a ninth message was placed as a practice stimuli to help participants become accustomed to completing the questionnaires and to acclimate them to the psychophysiological data collection situation.

Dependent Variables

This study is interested in the effects of auditory structural complexity on listener arousal, memory, attention, and attitudes. We conceptually defined arousal as the excitatory emotional response a participant experienced while listening to an audio production. Operationally, arousal was measured using both retrospective self-report and a real time index of autonomic nervous system activity. The self-report scale used in the study was the arousal component of the Self-Assessment Manikin (SAM, P. J. Lang, 1980). SAM measures the three attributes associated with most dimensional theories of emotion—Valence, Arousal, and Dominance—using separate 9-point pictorial scales. The arousal scale of SAM is anchored by Calm/Relaxed/Sleepy and Aroused/Excited/Agitated. Real-time arousal was measured using skin conductance activity. Skin conductance has been recognized as an index of the activation of the autonomic nervous system (Hopkins & Fletcher, 1994; Reeves, Lang, Kim, & Tartar, 1999).

Attention was also operationalized using retrospective scale measures and real-time physiological indexes. Participants were asked to complete four questions concerning the amount of attention they paid to a radio message. Three of them ("How much did you pay attention to the radio message you just heard?", "How interesting did you find the radio message you just heard?", and "How much did you concentrate on the radio message you just heard?") provided 7-point scales anchored by *not at all* and *very much*. The final question ("How much thought did you put into evaluating the radio message you just heard?") provided participants with a 7-point scale anchored by *none* and *a lot*.

Attention was measured in real time during the stimuli presentation by monitoring participant cardiac activity. Tonic heart rate has been identified as a physiological index of attention to media messages over time, with slower heart rates being indicative of greater attention (A. Lang, 1994). So, our third hypothesis would specifically call for participants to have lower heart rates during complex messages than during structurally simple ones.

Memory was conceptualized for this study as the linking of information from the audio productions into the long-term memory networks of the participant's cognitive system. The success of this placement was operationalized using a free recall questionnaire (A. Lang, 2000; Zechmeister & Nyberg, 1982). Following a distraction task, participants were presented with a single sheet of paper giving the following instructions: "Earlier in the experiment you heard eight radio messages. In the blanks below, list and/or describe as many of the messages as you can remember." Below these instructions were eight blank spaces for participants to list/describe what they remembered. Participants were reminded not to list the practice ad, and then they were left alone in the lab to complete this instrument. The participants informed the researcher when they were completed with the task (i.e., could remember no more messages) through an audio monitor. No one was allowed to spend more than 5 min on this portion of the experiment.

When measuring participant attitudes, we relied heavily on the concepts of Attitude toward the ad (Aad), Attitude toward the claim components of the ad (Aad-c) and Attitude toward the nonclaim components of the ad (Aad-nc) developed by Lutz (1985). We furthermore made an assumption that radio promos were, in essence, advertisements for the radio station itself, and, therefore, the same constructs developed by Lutz could apply (see Newton & Potter, 2000). Following each radio message participants were asked to differentiate between two basic components—the claims made and the "remaining elements within the commercial such as voices, music, and sound effects." Participants then filled out self-report attitude measures. The scales included the following:

> *Attitudes toward the claim components of the message:* The anchors of the 7-point scales were Unpersuasive/Persuasive, Uninformative/Informative, and Unbelievable/Believable.
>
> *Attitudes toward the nonclaim components of the message:* The anchors of the 7-point scales were Negative/Positive, Bad/Good, and Unfavorable/Favorable.
>
> *Overall attitude toward the message:* Participants were asked how they would evaluate the message overall. The anchors of the 7-point scales were Unattractive/Attractive, Depressing/Refreshing, Unappealing/Appealing, Unpleasant/Pleasant, Dull/Dynamic, and Not Enjoyable/Enjoyable.

Apparatus

Both orders of presentation were recorded onto separate compact discs for playback to participants. Playback took place using a portable boombox CD player placed on a table approximately 6 feet from the participant, who was seated in a comfortable living room chair.

Heart rate data were collected using three standard-sized (8 mm recording surface) AG/AGCL electrodes filled with conductive paste. One was attached to each of the participant's forearms, with the third serving as a connection to ground and placed approximately 2 inches below the wrist on the participant's nondominant forearm (Stern et al., 2001). Prior to attaching the cardiac electrodes, the participant's forearms were rubbed vigorously with a clean paper towel dampened with distilled water to remove dead skin cells. Signals from the heart rate electrodes were transmitted to a Coulbourn S-75-01 bioamplifier, and then to the data collection computer via a Scientific Solutions AD/DA board. The physiological data collection program was VPM, which determined the milliseconds between heartbeats (Cook, 1999). The data were stored for later cleaning and analysis.

Skin conductance data were collected using a Coulbourn S-71-22 skin conductance coupler sampling conductance levels 20 times per second from two standard-sized (8 mm recording surface) AG/AGCL electrodes filled with electrode paste closely resembling human sweat in salinity levels (Dawson, Schell, & Filion, 2000). These electrodes were placed on the palmar surface of the participant's nondominant hand after it had been cleaned with a paper towel dampened in distilled water.

Experimental Procedures

Participants completed the experimental protocol individually. At the beginning of a testing session, the participant was greeted and taken into the lab and seated. He or she was informed that the experiment would be about how people process media messages and would take 75 min, during which time the participant would hear nine messages from actual radio stations. It was explained that during the listening period heart rate and skin conductance would be recorded using small sensors attached to their forearms and nondominant hand. The participant signed a consent form and the electrodes were attached. After applying the electrodes, the experimenter gave the participant a packet containing the evaluative and SAM scales. Participants were told that the first message was not truly a part of the experiment, but merely played to help them practice using the questionnaire and to allow the researcher to answer any questions they may have about the self-report data they were providing. The practice message was played, and once all of the participant's questions were answered, the experimenter left the room and started the experiment.

During the experiment, physiology data were collected just prior to the onset of each stimulus message (to obtain baseline data), as well as for the duration of the messages. Between messages, the CD was paused, and participants filled out self-report measures of emotional response and attitudes. After the nine messages had been listened to and evaluated, participants completed a distraction task that consisted of viewing four movie clips preceded by music. This task is part of the protocol for another experiment, and the results are not reported here. Following completion of the distraction task, the electrodes were removed and memory tests for the radio messages administered. Participants then completed dependent variable procedures for the distraction task, were debriefed, and dismissed.

Data Cleaning, Reduction, and Analysis

Physiology data were edited using modules of the program VPM (Cook, 1999). Cardiac data were lost for one participant and skin conductance data from two others due to operator error. Cardiac data ($n = 24$) were converted from interbeat intervals to average cardiac levels (in beats-per-min) for each second of each stimulus. Similarly, the 20 Hz samples of skin conductance ($n = 23$) were aggregated to an average autonomic arousal level for each second of each message. For both the cardiac and skin conductance data, change scores were calculated by subtracting the baseline level of each measure 1 sec prior to stimulus onset from each subsequent sec during the duration of the message. For analyses using skin conductance and cardiac level data, only the three 60-sec messages in each level of the complexity factor were used. Change scores for these six messages were aggregated across 5-sec blocks resulting in 11 data points per message.

Autonomic arousal was also operationalized by counting the frequency of skin conductance responses (SCRs). An SCR was defined as an increase in a participant's skin conductance of at least .05 μS over 2 sec or less during the presentation of a radio stimulus. SCR frequency data were collected and analyzed for all eight messages.

After finding high reliability between elements in the self-report measures (Cronbach's alphas ranging from .91 to .94), single indexes of overall attitudes toward the messages, attitudes toward claim components, attitudes toward non-claim components, and self-reported attention were created by computing means. Finally, the free recall responses were coded by scoring "1" for each message that the participant was able to freely recall and "0" for those they were not.

All effects of the between-subject variable Order of Presentation were found not to be statistically significant during initial analyses, and all data were therefore collapsed across this factor.

RESULTS

H1—Arousal Responses to Auditory Structural Complexity

Increased structural complexity was expected to lead to higher self-reported arousal levels and greater activation of the autonomic nervous system as measured through skin conductance. Self-reported arousal levels using the SAM scale were submitted to a 2 (Auditory Structural Complexity) × 4 (Message) repeated measures multivariate analysis of variance (MANOVA). The results support the hypothesis, with self-reported arousal levels being significantly higher for radio messages with high auditory structural complexity ($M = 4.560$, $SD = .268$) compared to those with low auditory structural complexity ($M = 3.848$, $SD = .238$; $F(1, 24) = 11.427$, $p = .002$, $\varepsilon^2 = .2943$).

Activation of the autonomic nervous system was determined by measuring skin conductance responses and overall tonic skin conductance level. The frequency of SCRs per message was submitted to a 2 (Auditory Structural Complexity) × 4 (Message) repeated measures MANOVA. Results approach a marginally significant effect (F (1,22) = 4.249 p = .107, ε^2 = .0737) with participants having more skin conductance responses during messages high in auditory structural complexity (M = 5.076, SD = .652) than during those low in auditory structural complexity (M = 4.337, SD = .516).

The skin conductance level (SCL) analysis was conducted on the three 60-sec messages in each level of the complexity factor. SCL change scores were aggregated into eleven 5-sec segments and these were submitted to a 2 (Auditory Structual Complexity) × 3 (Message) × 11 (Time) repeated measures MANOVA. Results show no statistical main effect for auditory structural complexity. However, there was a significant Auditory Structural Complexity × Time interaction, $F(10, 220) = 2.316$, $p = .013$, $\varepsilon^2 = .0585$. The regular and expected decrease in skin conductance levels over time can be seen in Figure 1 across both levels of auditory structural complexity. However, beginning approximately after the first 30 sec of the messages, the SCLs diverge and the messages with high structural complexity lead to less rapid declines in autonomic arousal, even increasing during the last 5-sec block.

Therefore, the hypothesis that participants would experience greater arousal during radio messages with high auditory structural complexity found mixed results. The prediction was supported with self-report data but only found to a moderate extent in the physiological data.

H2—Auditory Structural Complexity and Memory

It was hypothesized that the increased arousal exhibited in response to auditory structural complexity would cause cognitive resources to be automatically allocated to storage of memory traces for the messages. This would make later search for messages heard during the experimental protocol easier for structurally complex messages than for structurally simple ones. This hypothesis was tested using the free recall data, which were submitted to a 2 (Auditory Structural Complexity) × 4 (Message) repeated measures MANOVA. The results show a significant effect of auditory structural complexity on the free recall data, $F(1, 24) = 8.727$, $p = .007$, $\varepsilon^2 = .2361$, with mean analysis showing a greater percentage of messages high in structural complexity recalled (M = 76, SD = 16.89) compared to those low in structural complexity (M = 56, SD = 24.24). H2 is supported.

H3—Effects of Auditory Structural Complexity on Attention

The third hypothesis predicted that multiple occurrences of auditory structural features previously shown to cause orienting responses would lead participants to

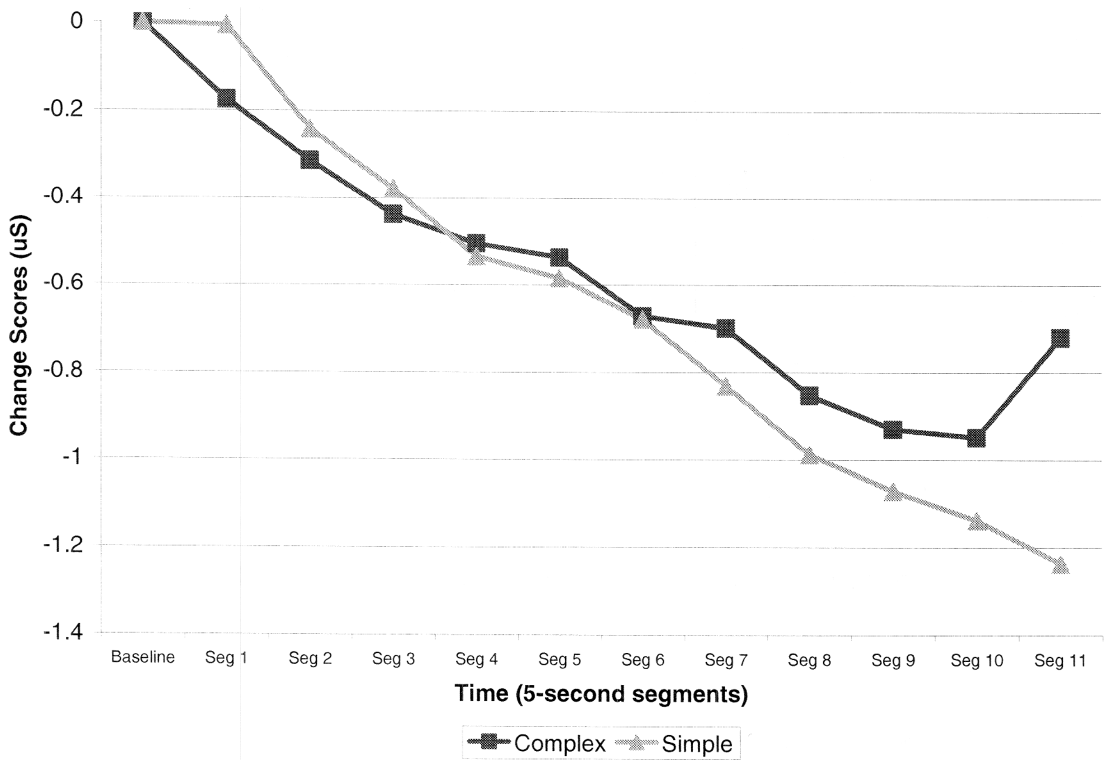

FIGURE 1 Effects of auditory structural complexity on skin conductance level.

pay greater attention during messages high in structural complexity compared to those low in complexity. This hypothesis was tested with two different dependent variables: self-reported attention and tonic cardiac activity. Responses to the 4 items of the attention scale were collapsed into a single mean index and submitted to a 2 (Auditory Structural Complexity) × 4 (Message) repeated-measures MANOVA. The results were marginally significant, $F(1, 24) = 3.405$ $p = .077$, $\varepsilon^2 = .0761$, with means in the predicted direction showing greater self-reported attention to the structurally complex messages ($M = 5.375$, $SD = .186$) than the structurally simple ones ($M = 5.043$, $SD = .241$).

Individual item analyses of the four attention-related questions show that two revealed an effect of structural complexity, and two did not. Participants reported paying significantly greater attention to the complex messages ($M = 5.820$, $SD = .179$) compared to the simple ones ($M = 5.456$, $SD = .234$; $F(1, 24) = 4.082$, $p = .038$, $\varepsilon^2 = .1320$) and concentrating more on the complex messages ($M = 5.424$, $SD = .198$) than the simple ($M = 4.995$, $SD = .259$; $F(1, 24) = 4.188$, $p = .052$, $\varepsilon^2 = .2331$). There were no significant differences between-subject' self-reported interest in the structurally complex versus simple messages ($p = .264$), nor in the reported amount of thought they put into evaluating the two different types of messages ($p = .367$).

The tonic heart rate analysis was conducted on the change scores for each 5-sec segment of the three 60-sec messages in each level of auditory structural complexity. The analysis was a 2 (Auditory Structural Complexity) × 11 (Time) repeated measures MANOVA. There was a main effect for structural complexity on heart rate levels, $F(1, 22) = 7.992$, $p = .010$, $\varepsilon^2 = .2331$. This main effect can be seen in Figure 2. Contrary to prediction, there was greater cardiac activity during the messages with high levels of auditory structural complexity compared to those with low levels of structural complexity. There was also a significant Auditory Structural Complexity × Time interaction, $F(10, 220) = 2.829$, $p = .003$, $\varepsilon^2 = .0777$, with high structural complexity messages leading to increases in heart rate levels and low structural complexity messages leading to cardiac decreases over the 60 sec. H3 is not supported.

H4—Effects of Auditory Structural Complexity on Attitudes

The last hypothesis predicted that audio productions high in auditory structural complexity would affect listener attitudes. Specifically, it was predicted that messages high in auditory structural complexity would lead to greater Attitude toward the Ad measures and greater Attitude toward the Nonclaim Components compared to messages low in auditory structural complexity. We also predicted structural complexity would not have a significant effect on listener attitudes toward the claims made in the messages.

To test these hypotheses the composite attitude scores were subjected to a 2 (Auditory Structural Complexity) × 4 (Message) repeated-measures MANOVA.

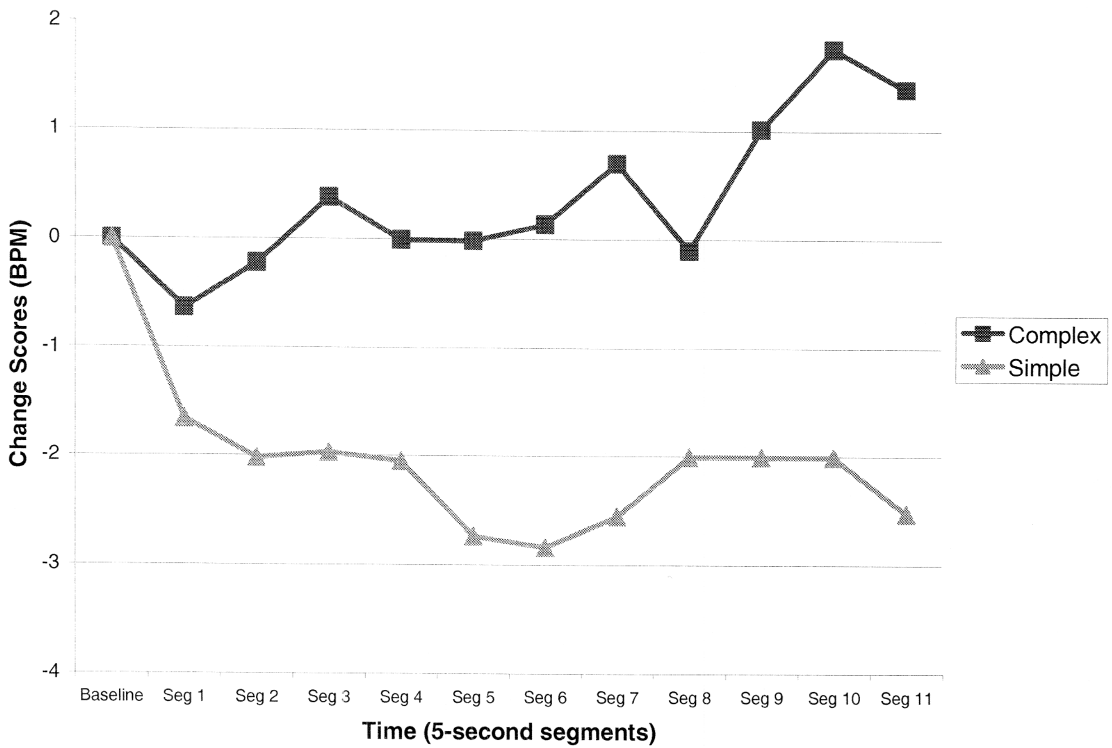

FIGURE 2 Effects of auditory structural complexity on tonic heart rate.

Results show that, as predicted, participants reported greater Aad values for highly complex messages (*M* = 4.600, *SD* = .171) compared to low complexity messages (*M* = 4.185, *SD* = .168), and this difference was significant, $F(1, 24) = 6.163$, $p = .020$, $\varepsilon^2 = .1712$. Participants also had greater Aad-ncl responses for the messages high in auditory structural complexity (*M* = 5.090, *SD* = .166) compared to those low in structural complexity (*M* = 4.423, *SD* = .193; $F(1, 24) = 8.559$, $p = .007$, $\varepsilon^2 = .2298$). Also as predicted, auditory structural complexity did not have a significant effect on the participant's attitudes toward the claims made in the messages ($p = .138$). H4 is confirmed.

DISCUSSION

This study sought to expand understanding of the impact of auditory structural features on human processing of radio messages. Specifically, we explored differences in listener processing of messages made with either high or low structural complexity, with this independent variable defined according to the relative number of orienting-eliciting auditory features the messages contained. In other words, structurally complex radio messages contained multiple voice changes, sound effects, music onsets, and/or production effects while structurally simple messages contained only a few such features. In all, the impact of auditory structural complexity was statistically confirmed or marginally supported for 10 out of 13 dependent variables. Furthermore, there was a significant difference between complex and simple messages in a twelfth measure—listener tonic heart rate activity; however, the direction of the change scores was opposite that hypothesized. Table 1 provides a summary of our findings, which we believe stress the importance of considering auditory structural complexity when investigating the cognitive and emotional processing of audio.

Though some of our results replicate those from an earlier experiment (Potter & Callison, 2000), this study expands the external validity of the results by using a wider variety of auditory productions. Furthermore, this study provides more detailed physiological evidence concerning the underlying biological processes accounting for self-reported reactions to, and improved memory for, audio messages created with intricate structure. In short, the primary effect of such complexity seems to be increases in listener arousal. Participants reported being more aroused by structurally complex messages, and there were marginally significant increases in the number of skin conductance responses during messages containing a high number of auditory structural features compared to those containing only a few such features. Analysis of tonic skin conductance change scores gave further support to the notion that repetitive auditory structural features result in increased arousal and that listener arousal responses to structure increases over time. Figure 1 shows little difference

TABLE 1
Summary of Results

Prediction	*H#*	*DV*	*Supported?*	*Effect Size*
Complex structure will increase arousal	1	Self-report	Yes	.29
		Skin Conductance Response	Marginal	.07
		SCL Change Scores × Time	Yes	.06
Complex structure will improve memory	2	Free Recall	Yes	.24
Complex structure will increase attention	3	Overall Self-report Scale	Marginal	.08
		Attention sub-item	Yes	.13
		Concentration sub-item	Yes	.11
		Interest sub-item	No	—
		Thought sub-item	No	—
		HR Change Scores	No[a]	.23[a]
Complex structure will impact attitudes:	4			
Better attitudes overall		Aad	Yes	.17
Better attitudes toward non-claim attributes		Aad-nc	Yes	.23
No Impact on attitudes toward ad claims		Aad-cl	Yes	—

Note. DV = dependent variables; Aad = attitude toward the ad; Aad-nc = attitude toward nonclaim components of the ad; Aad-cl = attitude toward claim components of the ad.

[a]Auditory structural complexity did result in significant differences in cardiac change scores, but not in the predicted direction.

between complex and simple messages in skin conductance level change scores for the first 30 sec. After that point, however, the levels during messages containing high auditory structural complexity begin to diverge from those without it. The necessity of sustained exposure to this complexity for the autonomic arousal response to "kick in" is likely a contributor to the small effect sizes for complexity on skin conductance response and level (ε^2 values of .07 and .06, respectively). It is difficult for us to declare these significant effects as unimportant, however, simply due to small effect sizes—primarily considering the largest obtained effect size in this study was for the impact of structural complexity on self-reported arousal. Even the small effect of complexity found on the autonomic nervous system was interpreted to a substantial degree as arousal by listeners who experienced the messages.

The fact that structure seemed to have a more intense impact on listener processing beginning at the 30-sec point is very interesting. Even though we aggregated our data into 5-sec increments, if the point of divergence had been at any other point—20 sec or 35 sec—it would have been much less intriguing considering that the stimulus messages are radio advertisements and promotional announcements—both of which are commonly produced in the United States in either 30- or 60-sec durations. It is possible, but well beyond what the current data set can speak to, that the reason tonic skin conductance effects were more pronounced after 30 sec is that radio consumers are cognizant of the fact that radio ads are either "short" or "long" and that while they may be willing to participate in controlled processing for the "short" duration, once they realize that the message was going to continue for a "long" time, they disengage from controlled processing. This would leave the cognitive system comparatively more open to being guided by calls for automatic allocation of resources delivered by the orienting eliciting changes in structure. This possibility is even more interesting considering participants, in fact, heard both "long" and "short" messages in this experiment; being exposed to this duration distinction over the course of the protocol may have further primed them to these broad categorical differences in expected durations of radio messages and caused them to be more likely to disengage from controlled processing once the "second-half" of a long message began.

To a certain extent, the impact of this 30-sec mark was seen in the cardiac level data as well. We predicted that the constant calls for orienting made by structural features in the complex messages, and the subsequent related arousal, would cause listeners to pay more attention to them. Using slower heart rate as an index of increased attention, we therefore expected listeners to have less cardiac activity during complex messages compared to simple ones. Contrary to this prediction, the results show that participants had significantly *greater* heart rates during the structurally complex messages (see Figure 2). This increase in heart rate had a positive linear trend, but one that showed a substantial increase in slope beginning at the 30-sec point—the position at which the skin conductance level data suggests disengagement from controlled processing and an increase in the influence of structural change. It is also following the 30-sec point that the heart rate stays consistently at or above baseline levels. Once again, these results cause us to wonder whether listeners disengaged from processing the messages after they felt like they had the "gist" of the meaning being conveyed. Future research should consider testing recognition memory for information taken at consistent time intervals across messages to see whether memory levels for information after the 30-sec mark significantly differ from those taken before. If disengagement was indeed occurring, then the expectation would be that recognition data would be significantly greater for messages during the first 30 sec compared to the second.

Our cardiac results seem consistent with the explanation given by A. Lang et al. (1999) that structural pacing impacts the sympathetic nervous system—as indexed by increases in skin conductance activity and *increases* in heart rate—while content arousal influences the parasympathetic system, which is identified through heart rate deceleration. In fact, given this explanation of their TV findings, and the fact that we purposefully selected radio messages that did not contain particularly arousing subject matter, our 20/20 hindsight leads us to believe we could have predicted increased heart rate in response to structural complexity because there was little in our messages to engage sympathetic activation. This would also explain why heart rate activity was always greater for complex messages compared to simple.

How do our findings relate to the interpretations of earlier researchers who suggested that audio plays an important part in increasing attention to TV messages (Wartella & Ettema, 1974)? On the one hand, our self-report measures would mostly support them. We found that participants gave higher scale responses to structurally complex messages than structurally simple ones—suggesting they felt as if they paid more attention to the messages high in what Watt and Welch (1983) might have called auditory entropy. Even though the combined scale data returned only marginally significant results, analysis of what is arguably the items most related to attention itself (How much did you pay attention to the message? and How much did you concentrate on the message?) showed statistically greater self-reported attention being paid to the structurally complex messages. On the other hand, as mentioned above, our cardiac data did not indicate increased attention to the complex messages. There may be other reasons for this than the one provided by A. Lang et al. (1999). For example, something about these messages may have caused participants to engage in greater levels of mental imagery. Generating mental images results in increases in cardiac activity over time (Bolls, 2002; A. Lang, 1994); and because these messages were not pretested and controlled for their level of imagery, the cardiac results may be confounded. Future research should attempt to replicate this cardiac finding, while ensuring that messages used as stimuli are matched on mental imagery generation. Another possibility is that our experimental participants were all low sensation seekers. Those scoring low on the sensation seeking scale have been shown to be more prone to exhibiting startle responses to auditory stimuli that would typically cause orienting (Ridgeway & Hare, 1981). Though we did not measure listener personality type in this study, it may prove interesting for future studies to investigate possible individual differences in processing auditory structural complexity using either a traditional sensation seeking scale (Zuckerman, 1994) or other motivation measures (e.g., A. Lang, Shin & Lee, 2005).

The practical implications of this study seem to be a continued suggestion to producers of radio messages to respect the power of structure—while, of course, not neglecting the importance of copy content. At least in the demographic used in this experiment (college undergraduates), the more complex a messages was structurally, the more positive the attitudes, the greater the arousal and self-reported attention resulted, and the greater the memory. It is imported to recognize, however, that there is nothing in the current data set to limit the logical extension of the results to larger populations. Earlier work has shown that the structural changes do not have to be overly obtrusive to generate orienting responses. Something as simple as a change from one announcer to another does the trick (Potter, 2000). And while this study utilized messages appropriate for a college-aged audience (e.g., using production effects and fast-paced music), future research should test the impact of structural complexity on older radio listeners using messages containing structural changes more appropriate for the demographic and psychographic qualities of that audience.

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