Identifying Structural Features of Audio:
Orienting Responses During Radio Messages and Their Impact on Recognition

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Abstract

This paper tests the ability of nine different auditory structural features to elicit orienting responses from radio listeners. It further tests the effect of the orienting response on listeners' memory for information presented immediately following the orienting-eliciting structural feature. Results show that listeners do have significant decelerating cardiac patterns suggestive of orienting for eight of the nine features. Taken as a categorical whole, these features also increase recognition memory for the information presented after their onset compared to information presented immediately before.

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Introduction

In the early 1970s, Watt and Krull (1974) presented one of the first pieces of published research to view media messages not as producers do—as sitcoms, news, pornography, or drama—but as psychologists do. Media, they argued, should not be conceptualized as examples of these “higher order terms” but rather as “a time-varying sequence of visual and auditory stimuli” (Watt & Krull, 1974, p. 48). In the three decades since, many fruitful lines of research have explored how dynamic structural variation can be manipulated to influence audience members' cognitive processing (Anderson & Lorch, 1983; Basil, 1994; Detenber, Simons, & Bennet, 1998; Geiger & Reeves, 1993; Grimes, 1991; Huston et al., 1981; Lang, Bolls, Potter, & Kawahara, 1999; Ravaja, 2004). Research has now even expanded beyond the “higher order categories” associated with delivery systems and has explored the impact of structural change on screens of different sizes (Ravaja, 2004; Reeves, Lang, Kim, & Tatar, 1999) as well as new media formats such as web pages (Schneider, Lang, Shin, & Bradley, 2004; Sundar & Kalyanaraman, 2004; Ravaja, Saari, Salminen, Laarni, & Kallinen, 2006; Chung, 2007) and computer/video games (Ravaja et al., 2006; Ivory & Kalyanaraman, 2007).

Most of this research focuses on dynamic changes in visual structural elements such as cuts, edits, videographics, animation, and download speed. Very little attention has been paid to the auditory structure of television messages but, of course, there has been some attention paid. Grabe, Zhou, Lang, and Bolls (2000), for example, include auditory elements as a subset of structural characteristics representing tabloid-style journalism. Thorson and colleagues (Thorson & Lang, 1992; Thorson, Reeves, & Schleuder, 1985) used the construct *auditory structural complexity* but defined it as representing difficulty in the syntax of verbally-delivered information rather than auditory structural analogues of the visual cut and edit.

Virtually absent from the communications literature, however, is work exploring auditory messages in the same way we now understand television—as rapidly changing streams of structural features which variably tax the limited-capacity cognitive processing system. Radio producers have intuitively acknowledged the important role structural features such as sound effects and vocal delivery play in capturing audience attention (Keith, 1990; Siegal, 1992). And, while Potter has done some work showing cardiac orienting to the individual features of voice changes (Potter, 2000) and sound effects (Potter, 2006), an investigation into which audio elements predictably elicit orienting does not appear in the literature. This study was designed to address this absence in the published record.

Literature Review & Hypotheses

Following Watt and Krull's (1974) petition for reconceptualizing media as psychological stimuli, much of the work focusing on structural or formal features of television explored what aspects of children's programming caused young viewers to look toward the television set itself (Anderson & Levin, 1976; Anderson & Lorch, 1983) It was Singer (1980) who suggested that this physical re-positioning of the head toward the set was indicative of an orienting response (OR). An OR is a reflexive response resulting in automatic allocation of cognitive processing resources to the encoding of the novel or learned stimulus that elicited it (Graham, 1979). Both behavioral and physiological responses have been used as operational definitions of an OR including looking toward the stimulus source, alpha wave decreases in the brain, cardiac deceleration, peripheral vasoconstriction, skin conductance increase, and pupil enlargement (Lynn, 1966; Graham, 1979). Following Singer's (1980) speculation—which did not include psychophysiological data for support—others employed heart rate measures to determine that many visual structural features indeed elicited ORs including cuts (Lang, Geiger, Strickwerda, & Sumner, 1993); negative video (Lang, Newhagen, & Reeves, 1996); videographics (Thorson & Lang, 1992); and character movement (Lang, 1990; Reeves et al., 1985). It seemed as if the introduction of novelty via formal features in media messages was enough to elicit orienting, which had been called the "What is it?" response by Pavlov (1927). Unclear in early work was what the increase—in processing resources to encoding elicited by these structural features—did to memory for the messages in which they occurred (Anderson & Lorch, 1983; Singer, 1980). One possibility was that increased orienting should result in greater cognitive resources devoted to message processing and, consequently, better memory. Another was that involuntary responses would distract viewers from the message content and focus their attention instead on the less central, structural aspects of the message. Data gathered since that time suggests that recognition memory is due to an interaction between the frequency of OR elicitation and the amount of processing resources required to process the content being provided. For example, Thorson and Lang (1992) showed that when viewers watched televised college lectures where the content was familiar and easy, memory improved immediately following an OR induced by the onset of a graphic onscreen complimenting the presented information. However, when the lecture was difficult and/or unfamiliar, memory declined for information immediately following the OR in response to a comparable onset of an onscreen graphic. Similarly, Lang et al. (1993) demonstrated that when the content of either side of a cut was related, memory following the cut increased. However, when the content on either side of the cut was unrelated, memory decreased. Similar results have been found in memory for television messages as a function of how many structural features they contain. If the content of a message is not demanding, then viewers' memory for that content improves when the message contains more frequent structural features and elicits many orienting responses. However, if the message content is demanding, then memory for the content of the message is lower if there is a high frequency of structural features in the message (Lang et al., 1999; Lang, Bradley, Park, Shin, & Chung, 2006).

Work done by Potter and colleagues (Potter, 2000, 2006; Potter & Callison, 2000; Potter & Choi, 2006; Dillman Carpentier & Potter, 2007) has provided some data concerning the ability of auditory formal features to elicit orienting, but the list of specific features tested to see if they result in orienting remains short. The voice change, defined as “the replacement of one person’s voice by another person’s voice in the auditory stream,” was shown to result in a classic S-shaped biphasic orienting response in the six seconds following the speaker change (Potter, 2000, p. 157). Similarly, cardiac response curves were used to show that laser sound effects and echo effects resulted in orienting when used as structural features in radio promotional announcements (Potter, 2006).

Because no work beyond these two studies (Potter, 2000, 2006) provides data explicitly demonstrating orienting to structural features believed to introduce novelty, several subsequent studies (Potter & Callison, 2000; Potter & Choi, 2006 Potter et al., 2006) can be characterized as having their hypotheses based upon logical but assumptive inferences rather than upon published empirical evidence. This report attempts to test these assumptions. The initial question, therefore, becomes the following: Do auditory structural features beyond the voice change, laser effect, and echo effect elicit cardiac orienting responses?

To answer this question, examples of nine such structural features were identified in taped radio broadcasts. Segments in which these features appeared were then systematically edited together to represent a simulated radio broadcast. Specific features were selected based upon both the audio processing literature in psychophysiology (Gang & Teft, 1975; Meyers & Smith, 1986; Fabiani, Kazmerski, Cycowicz, & Friedman, 1996; Bradley & Lang, 2000) and an intuitive sense for what captures attention in radio listeners—based upon the experience of two authors (R.P. & P.B.), both former professional radio producers. The features tested were a phone-ringing sound effect, commercial onset, funny voice, station change/dial tuning, jingle onset, silence onset, and sexual word onset. Also, to replicate earlier work, voice changes and laser sound effects were tested as well.

If orienting responses occur to auditory structural features, aggregating the physiological responses following each of these would result in the exhibition of cardiac deceleration and skin conductance increase within a six-second time window. Thus:

H1: Listeners will exhibit orienting responses following auditory structural features. This will be indicated by significant cardiac deceleration and significant increases in skin conductance levels during a six-second window post onset.

Using the Limited Capacity Model of Motivated Mediated Message Processing as the theoretical guide (LC4MP; Lang, 2006), this report also tests the effects of these structural features on listeners' memory for the content occurring immediately before and immediately after the various auditory features. LC4MP conceptualizes human beings as limited capacity information processors who allocate processing resources in dynamic and varying combinations of controlled and automatic responses. Controlled resource allocation is purposeful and effortful, while automatic responses cannot be suppressed and are relatively cost free (Schneider, Dumais, & Shiffrin, 1984). Within LC4MP the OR represents an example of automatic resource allocation to the encoding process. In other words, when something happens in the mediated environment that has sufficient novelty to elicit an OR, the viewer or listener is unable to suppress the automatic allocation of cognitive resources to at least initially process the novelty within short-term memory. It is therefore predicted that orienting responses to the auditory structural features will increase recognition memory for information immediately following them:

> H2: Information presented immediately after the onset of auditory structural features will be recognized better than information presented immediately before the structural features.

If the combined onset of the ten structural features does show evidence of orienting, as predicted, the next step is to examine each specific structural feature individually to determine which features actually elicit strong enough orienting responses to result in statistically significant physiological changes. Because this second analysis will result in a great reduction in statistical power for some features, the difficult task is predicting exactly which features will introduce enough novelty so that most subjects orient to them. Therefore, a research question is forwarded:

RQ1: Which of the structural features, analyzed individually, result in orienting responses as indexed by cardiac deceleration and skin conductance increase within a six-second window following the onset of an identified structural or content feature?

However, the hypothesis made concerning recognition memory following the structural features that *do* result in physiological orienting responses when analyzed individually mirrors Hypothesis 2:

H3: Information presented immediately after the onset of a specific structural feature will be recognized better than information presented immediately before such a feature.

Methodology

Subjects

Thirty-eight college students (27 female) from a major Midwest university in the United States participated in this experiment in exchange for course credit. All provided informed consent in compliance with Institutional Review Board oversight.

Stimulus Preparation and Description

The experimental design called for the creation of audio stimuli containing elements believed to cause orienting responses in radio listeners. A total of 17 examples of structural features were identified and used for analysis in this study. The final 12-minute stimulus included seven audio messages, six of which were recordings of different radio broadcasts from area radio stations. The seventh message was a rock-and-roll song recorded directly from compact disc. Four orders of presentation were constructed using these seven messages. The song was the fourth element in all four tape orders, with the six broadcast messages being placed in different logical orders around it. No messages appeared exclusively before or exclusively after the song. Also no two message segments were adjacent to each other in more than one tape order. The tape orders were transferred onto the audio track of a VHS videotape which had been blacked and time coded to allow the exact location of the features of interest to be determined.

Dependent Variables

The dependent variables in this study were heart rate, skin conductance, and recognition accuracy. Consistent with many studies in the media processing literature (Lang, Potter, & Bolls, in press), heart rate and skin conductance were used to indicate if orienting occurred. If orienting occurs, there should be a significant deceleration of the heart rate, measured in beats-per-minute/second, occurring in the six seconds following onset of the structural feature (Lang, 1990). A significant increase in skin conductance levels immediately following the onset of the structural feature would also be indicative of the occurrence of orienting (Lynn, 1966).

Recognition memory was measured using a forced choice, yes/no timed recognition test. This test consisted of listening to three-second portions of audio messages. Subjects were told that some were from the messages they had heard previously and others were not. Using a joystick held in their dominant hand, subjects were instructed to press one button if they had heard that segment earlier and another button if they had not. Subjects were told that it was a timed response task and that they should answer as soon as they knew whether or not they had heard the portion earlier.

Experimental Procedure

This study was embedded in a trio of data collection protocols designed to obtain data on human reactions to and memory for television, computer media, and radio. The radio protocol comprising this study was always the second set of procedures in which subjects participated.

Only one subject at a time participated in the experiment. Each was greeted by the experimenter, who explained that the purpose of the study was to gain a better understanding of how human beings react to the media. After obtaining informed consent, physiological electrodes were applied and the subject's questions answered.

The first set of procedures involved either watching a set of television messages or interacting with a computer monitor and keyboard. After these procedures were completed, subjects were told that the researcher needed to take about ten minutes to do some calculations on the data which had just been collected. The researcher told the subject that, in the meantime, they could listen to radio messages that would be played for them. These messages served as the experimental stimuli for this report.

After the radio messages were played, subjects participated in other portions of the protocol dealing with the television and computer interactions. When these were completed, subjects were given a recognition memory test for the radio messages.

After the entire protocol was completed, subjects were debriefed, thanked, and dismissed.

Apparatus

Heart rate and skin conductance were collected from the subjects as they listened to the radio stimulus. The stimulus tape was played by a Panasonic videocassette recorder through the speaker of a 19-inch (48.3 cm) television placed approximately five feet from the subject. The videocassette recorder, experimenter, and physiological recording equipment were separated from the subject by an eight-foot (2.44 m) wall. Nothing appeared on the screen while the stimulus played.

The lab was controlled by a 386-Mhz computer with a LabMaster AD/DA board installed. Coulbourne physiological equipment was used in the collection of data. In order to measure heart rate, two electrodes filled with conductive gel were placed on each arm approximately five inches (13cm) from the wrist. A third electrode was placed on the non-dominant arm approximately three inches (8cm) from the wrist and served as ground. Heart rate was measured as the milliseconds between heart beats and was analyzed as the average heart rate per second.

Skin conductance data were collected by passing .5V across two electrodes attached to the palmar surface of the subject's non-dominant hand. The electrodes were filled with non-conductive gel to improve adhesiveness. Skin conductance data were collected as an analogue signal sampled at the rate of ten times per second.

Recognition responses were recorded using a Sidewinder joystick. Subjects would press the "yes" button on the joystick if they had heard the audio segment before and the "no" button if they had not. Recognition results were coded for accuracy and reaction time based upon the time code on the testing videotape using software by Newhagen (1993).

<u>Analyses</u>

The heart rate data were analyzed using a mixed N (Feature repetitions) X 7 (Time) X4 (Order) ANOVA with a subsequent trend analysis to identify the trend content component of the cardiac response curve. The within-subjects factors were Repetitions (with N levels representing the number of structural features being included in the analysis) and Time (with seven levels representing onset and six seconds following feature onset). The number of repetitions of the feature varied from one to 17 depending on whether repetitions of a single feature or the entire aggregated collection of features was being analyzed. The combined analysis includes all occurrences of each of the nine structural features identified for investigation. For individual features, the numbers of structural features included in the analysis were five voice changes, two examples of silence, two production effects, two commercial onsets, two jingles, one channel change, one telephone ring, one example of sexual content, and one funny voice. Order was a between-subjects factor with four levels representing the systematic presentation orders.

Missing heart rate data were re-coded to the mean heart rate across subjects for that second. Eight values out of 6840 were missing, resulting in 0.12 percent of the heart rate data being recoded to the mean.

The skin conductance analysis was done on the change scores, that is, the extent to which skin conductance levels changed after the onset of the structural feature(s) (Dawson, Schell, & Filion, 2000). The data were analyzed using an N (Repetitions) X 5 (Time) X 4 (Order) ANOVA. The within- and between-subjects factors for this analysis were the same as above except that the Time factor had five levels, representing the change scores for the four seconds following the feature onset. Due to researcher error during data collection, skin conductance data from three subjects were lost. Therefore, n = 35 for the skin conductance analysis.

The recognition data were analyzed using an N (Repetitions) X 2 (Position) X 4 (Order) ANOVA. The within- and between-subjects factors for this analysis were the same as above except for the Position within-subjects factor which had two levels, before and after. These levels corresponded to whether the three-second audio portion being tested occurred before or after the structural feature of interest. Due to researcher error, recognition data from three subjects were lost. Therefore, n = 35 for the memory analysis.

Statistical Power

Because the number of repetitions of the individual auditory features varies, the power to detect effects fluctuates. Those analyses with four or five occurrences of the structural feature are much more statistically powerful than those with a single occurrence. Because the goal of this study is both to investigate if structural features as an aggregate category elicit orienting and to begin identifying other *individual* features that elicit strong ORs, two alpha levels of significance were recognized for this study.

For the combined analysis—the question of whether auditory structural features as a category cause orienting—the power was sufficient to employ the usual alpha of $p < .05$. This was because the cardiac and skin conductance response curves created for the analysis contained the responses of every subject for *all* the repetitions of each structural feature. Similarly, the recognition memory data contained responses obtained for snippets before and after *all* of the structural features.

For the individual feature analyses, however, the response curves submitted to statistical analyses for eight of the exemplars analyzed had two or fewer exposures used to establish physiological response. Similarly, for the memory analyses there were only two or fewer snippets before and after the feature onset to use as comparison. There was, therefore, considerably less statistical power in these analyses. For this reason, along with the fact that the individual-feature analyses were conducted to investigate a research question considered exploratory, the more liberal .10 significance level of alpha was deemed sufficient.

Results

Hypothesis 1—Orienting to Auditory Structural Features

It was predicted that subjects would exhibit increased skin conductance activity and decelerations in heart rate following the onset of auditory structural features selected for their suspected ability to cause orienting responses. Data across the 17 feature onsets were aggregated to a single onset point and plotted over time. Figures 1 and 2 represent these patterns. The main effect for Time was significant for the heart rate response ($F(9, 270) = 5.64$, $p < .001$, $\varepsilon^2 = .12$) and can be seen in Figure 1. Following Graham (1973, 1979), a trend analysis was conducted on the cardiac response curve to show the significant cubic component ($F_{\text{Cubic}}(1, 6) = 11.51$, $p = .007$) indicative of an orienting response. The skin conductance level also increased significantly over time ($F(3, 81) = 2.77$, $p = .047$, $\varepsilon^2 = .02$); this can be seen in Figure 2. Hypothesis 1 is supported.

Hypothesis 2—Improved Recognition Following Orienting

This hypothesis predicted that listeners would recognize the content occurring immediately following the onset of the combined structural features better than the information occurring immediately before their onset. The overall effect of Position on the combined structural features was significant ($F(1, 34) = 9.15$, $p = .005$, $\varepsilon^2 = .13$), with listeners recognizing 77 percent of the content after features compared to 71 percent before. Hypothesis 2 is supported.

Research Question 1

The aim of this research question was to determine which, if any, of the individual auditory structural features elicited orienting responses. Despite the significant combined effect reported in Hypothesis 1, none of the features, when analyzed individually, resulted in significant skin conductance increases within four to six seconds of feature onset. Significant quadratic or cubic trends were found in the cardiac response curves, however, for voice changes ($F_{Quad}(1, 29) = 5.244$, $p = .066$); commercial onsets ($F_{Quad}(1, 29) = 8.01$, $p = .008$); jingle onset ($F_{Cubic}(1, 29) = 3.03$, $p = .093$); silence ($F_{Quad}(1, 29) = 3.24$, $p = .082$); production effects ($F_{Cubic}(1,29) = 3.35$, $p = .018$); phone ringing sound effect ($F_{Cubic}(1, 29) = 2.86$, $p = .10$); funny voice ($F_{Quad}(1, 29) = 4.973$, $p = .033$); and sexual word ($F_{Quad}(1, 29) = 10.05$, $p = .003$). A significant decelerating trend was not found for the station change sound effect. Thus, eight of the nine features tested showed significant cardiac orienting response following onset; these can be seen in Figure 3.

<u>Hypothesis 3</u>

This hypothesis predicted that recognition memory for information presented immediately after the onset of *specific* orienting-eliciting structural features would be statistically higher than for information presented immediately before such a feature. Unlike the second hypothesis, therefore, which aggregated recognition memory before and after all the structural features used as stimuli, Hypothesis 3 addressed each feature individually. The results of these analyses are shown in Table 1. Of the nine separate features tested, three showed significant effects in the predicted direction: voice change ($F(1, 34) = 14.61$, $p < .001$, $\varepsilon^2 = .15$); funny voice ($F(1, 34) = 3.86$, $p = .058$, $\varepsilon^2 = .07$); and sexual content ($F(1, 34) = 4.39$, $p. = 044$, $\varepsilon^2 = .10$). For all of these, recognition memory was better for auditory snippets occurring immediately following the feature than it was for snippets occurring immediately before the feature. Commercial onsets also elicited a significant effect but in the opposite direction from that predicted ($F(1, 34) = 5.11$, $p = .030$, $\varepsilon^2 = .20$), with 54 percent recognition for information presented after the commercial compared to 77 percent before. The remaining five features all had means in the predicted direction but did not reach statistical significance.

Discussion

Overall the results of this study demonstrate that auditory structural features, like their visual counterparts in television, elicit orienting responses in audience members. Furthermore, as would be predicted by a limited capacity model of media message processing (LC4MP; Lang, 2006), the results generally show that these orienting responses increase recognition memory for information that follows orienting-eliciting structural features when the content of the messages is not demanding.

Not only were both cardiac response and skin conductance data supportive of the orienting hypothesis when features were analyzed in the aggregate, but the cardiac response curves showed paradigmatic orienting responses for eight of the nine features studied. None of the features, when tested individually, elicited significant increases in skin conductance. This finding may not be as surprising in hindsight, since studies using mediated messages as stimuli report robust cardiac orienting and use it as a frequent operationalization of this cognitive phenomenon (Lang, 1990; Thorson & Lang, 1992; Lang et al., 1993; Simons, Detenber, Roedema, & Reiss, 1999; Potter, 2000; Diao & Sundar, 2004; Lang, Chung, Lee, & Zhao, 2005; Wise & Reeves, 2007).

It seems, therefore, to be fairly clear that novelty introduced by a wide range of auditory changes in media messages causes orienting. The effects of orienting on memory are, not surprisingly, somewhat less clear cut. Overall, recognition memory is somewhat better for information presented after the feature than it is for content before the feature, as predicted. The main exception occurs for the onset of commercial messages. Several possible explanations might be offered for this. First, as discussed previously, it has been demonstrated (Lang et al., 1993) that when processing television messages, memory for information following a cut decreases if the information is semantically unrelated to what was before the cut. This lack of relation is exactly the condition tested by commercial onsets in radio. In fact, all the other voice changes tested occurred within a single message segment. In other words, the voice introduced was not novel and neither was the subject matter that the “new” voice was commenting on. The beginning of a commercial usually introduces completely new and unrelated information to the listening audience. Thus, following the onset of a completely unrelated message, memory may decline as it does in television.

In response to the initial question motivating this study—whether auditory structural features elicit cardiac orienting responses—the answer is a resounding yes. Not only in the aggregate did such features introduce sufficient novelty, but explored individually we can add (to the previously studied voice changes and production effects) the onset of features as varied as funny voices, jingles, commercials, sound effects such as that of a telephone, silence, and sexual words. The ability of these simple features to induce the automatic allocation of processing resources to encoding—resulting in better recognition memory for message content—should be of interest to message producers across a wide spectrum. Commercial producers will of course be interested due to the possibility of increasing awareness for their clients' products and services. However, producers of instructional media employing systematic use of the auditory medium should take note as well. Auditory features improved memory when the cognitive demands of the message were low—that is, when the feature occurred within a single piece of continuous content. On the other hand, when the focus of the content *changed* and the cognitive demand of the message was therefore substantially greater (as was the case in the commercial onsets), cardiac orienting was demonstrated but memory actually suffered. Therefore, producers should be mindful of the overall cognitive requirements of their message content when considering the extent to utilize these auditory features.

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Table 1: Mean recognition accuracy for auditory selections occurring immediately before and after the structural feature.

Structural Feature	Before	After	*F*	df	*p*
Funny Voice	.771	.914	3.86	1,34	.058
Station change	.514	.600	<1	1,34	.373
Commercial onset	.771	.543	5.11	1,34	.030
Jingle onset	.715	.786	1.98	1,34	.170
Phone ringing	.943	.886	<1	1,34	.422
Laser effect	.629	.714	1.21	1,34	.280
Sexual content	.857	.971	4.39	1,34	.044
Silence	.672	.729	2.32	1,34	.137
Voice change	.552	.762	14.61	1,34	.001
All	.706	.771	9.15	1,34	.005

Figure 1: Cardiac Response Curve Following Auditory Structural Features.

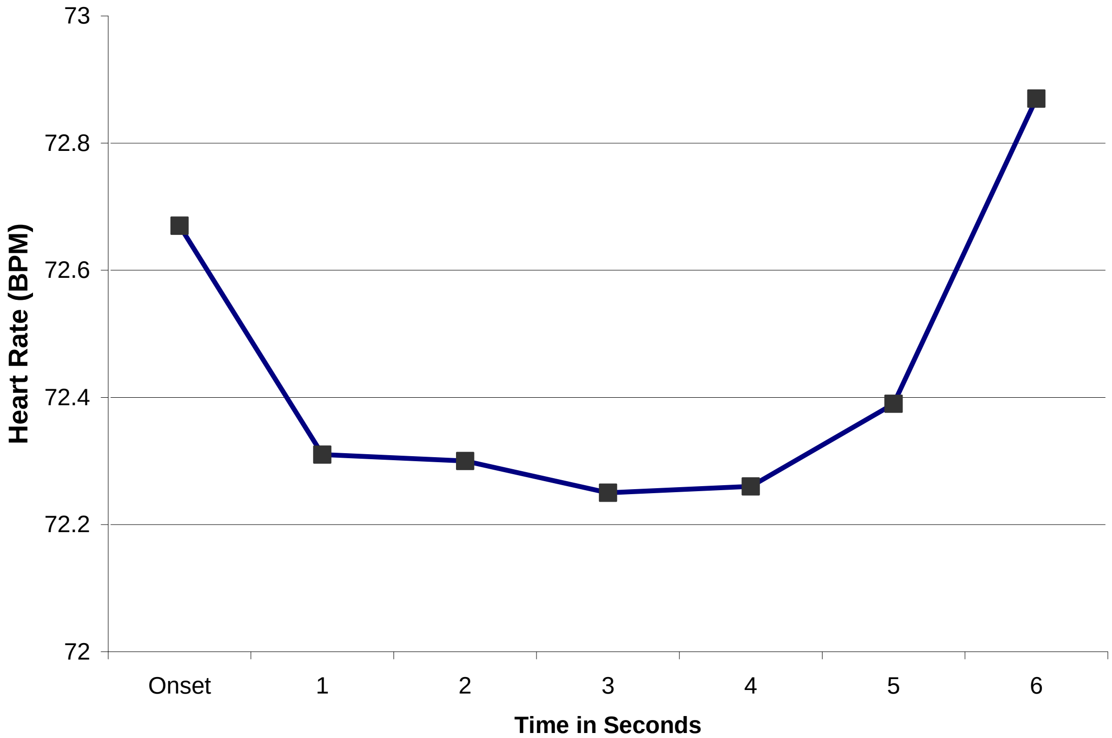


Figure 2: Average Skin Conductance Level Following Auditory Structural Features

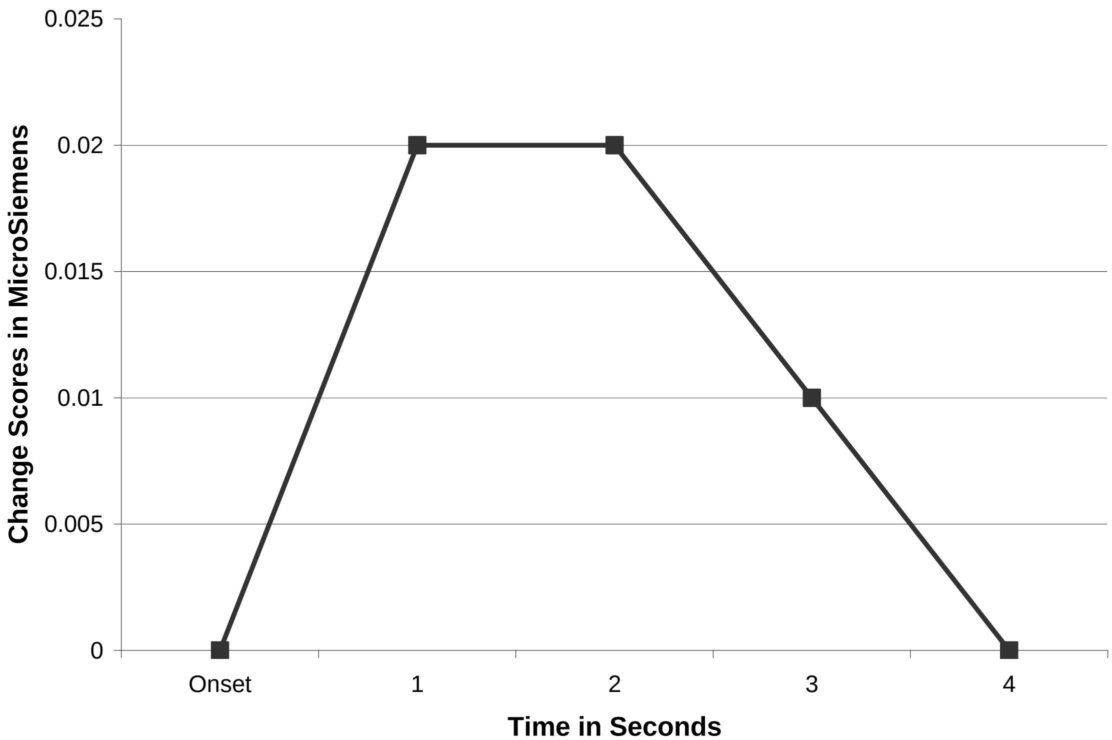
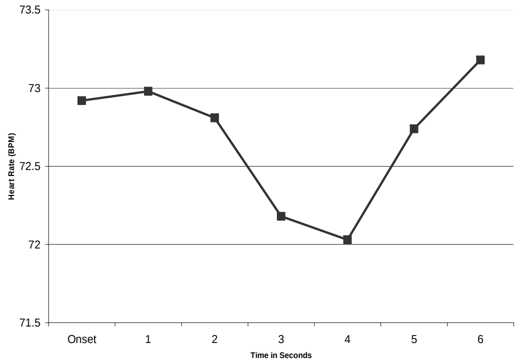
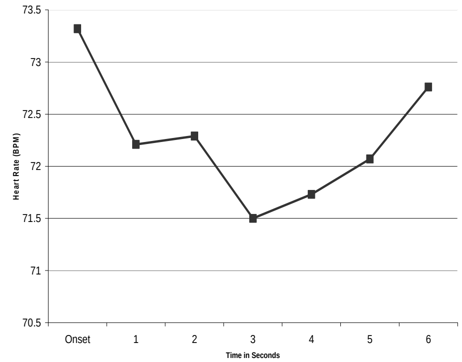


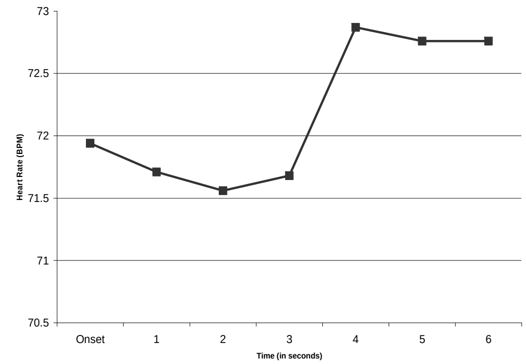
Figure 3: Cardiac-Orienting to the Onset of Individual Auditory Structural Features



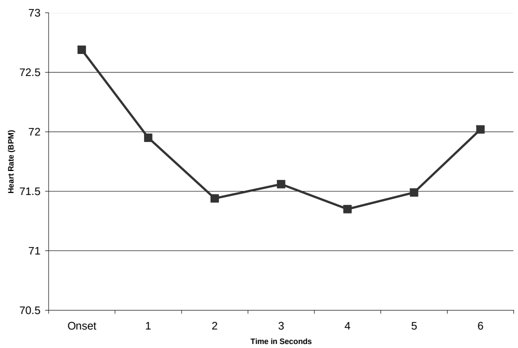
Voice Changes



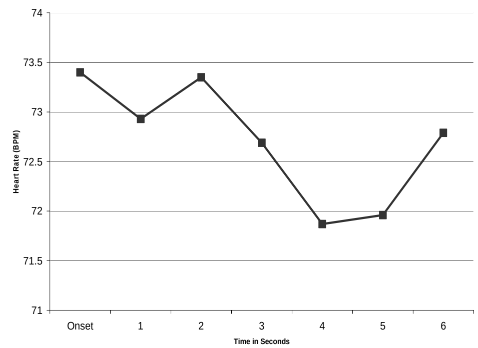
Commercial



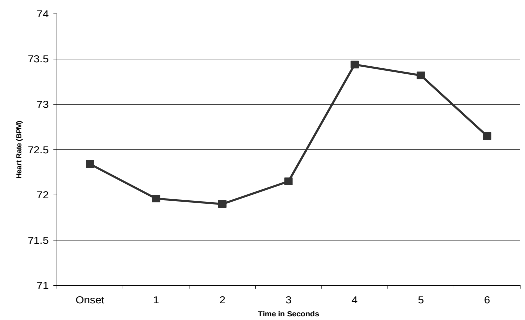
Jingle



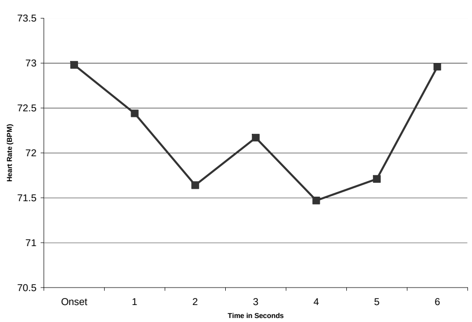
Silence



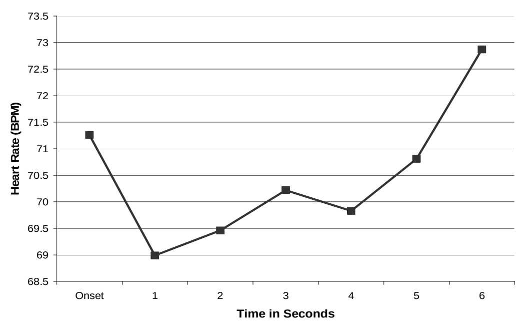
Production Effect



Phone Ringing



Funny Voice



Sexual Word