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Emotion processing in three systems: The medium and the message

ROBERT F. SIMONS,[a] BENJAMIN H. DETENBER,[b] THOMAS M. ROEDEMA,[a] AND JASON E. REISS[a]

[a]Department of Psychology, University of Delaware, Newark, USA
[b]Department of Communication, University of Delaware, Newark, USA

Abstract

In the context of picture viewing, consistent and specific relationships have been found between two emotion dimensions (valence and arousal) and self-report, physiological and overt behavioral responses. Relationships between stimulus content and the emotion-response profile can also be modulated by the formal properties of stimulus presentation such as screen size. The present experiment explored the impact of another presentation attribute, stimulus motion, on the perceived quality of the induced emotion and on its associated physiological response pattern. Using a within-subject design, moving and still versions of emotion-eliciting stimuli were shown to 35 subjects while facial muscle, heart rate, skin conductance, and emotion self-reports were monitored. The impact of motion was dramatic. Self-report and physiological data suggested strongly that motion increased arousal, had little impact on valence, and captured and sustained the subject's attention to the image.

Descriptors: Emotion, Media, Heart rate, Skin conductance, EMG

During the course of the past decade or so, there has been a resurgence of interest in the specific relationships between emotion and its physiological sequelae. Whether emotion is viewed in terms of discrete entities (e.g., Ekman, 1989; Izard, 1997; Tomkins, 1962, 1963) or as a multidimensional space (e.g., Lang, Bradley, & Cuthbert, 1997; Russell, 1997; Russell & Mehrabian, 1977), an overarching goal for many psychophysiological investigators is the profiling of each emotion or emotion dimension by determining the pattern of physiological changes with which these emotion variables are associated.

Although the search for physiological specificity has a long history and remains controversial (for a review, see Cacioppo, Berntson, Larson, & Poehlman, in press), a number of recent studies from both a discrete-emotion and a dimensional perspective have produced positive results. For example Ekman, Levenson, and Friesen (1983; Levenson, Ekman, & Friesen, 1990) have demonstrated that facial expressions indicative of specific emotions such as fear, anger, sadness, and joy can be associated with specific patterns of autonomic activation using their directed facial action task. In a subsequent review, Levenson (1992) described other studies from his laboratory in which similar autonomic nervous system (ANS) specificity was noted when emotion was elicited through a relived emotions task.

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Address reprint requests to: Robert F. Simons, Department of Psychology, University of Delaware, Newark, DE 19716, USA. E-mail: rsimons@udel.edu.

From a different theoretical perspective, Lang (e.g., Greenwald, Cook, & Lang, 1989) and others (e.g., Fiorito & Simons, 1994; Fitzgibbons & Simons, 1992) have provided evidence for specificity among physiological variables and the emotion dimensions of valence and arousal. In these and other studies, specific relationships have been found between facial muscle activity, heart rate, and emotion valence ratings and between the frequency and amplitude of skin conductance responses and emotion arousal ratings. In most emotion studies, the specific content of the stimulus is manipulated, either in imagery or with color slides or film clips. Though such studies have produced interesting data, they have ignored other aspects of stimulus presentation that might also contribute to emotion-response topography. This "noncontent" aspect is the form in which the stimulus is delivered. Structural attributes of the stimulus-delivery system are being studied widely by communication researchers, and these studies have shown that variables such as screen size (Detenber & Reeves, 1996), viewing distance (Lombard, 1995), and color (Sherman & Dominick, 1988) can have a significant impact on how subjects experience and evaluate stimulus content. It is likely that these same formal message properties can influence the physiological aspect of the emotion response as well.

Detenber, Simons, and Bennett (1998) recently reported a psychophysiological study in which a formal presentation attribute served as the independent variable. That study examined how moving versus still emotion messages (i.e., images) influenced people's evaluations of the messages and their psychophysiology. Motion is an essential element of many media presentations and is thought to be particularly potent in emotion elicitation (Arnheim, 1958/1983;

Gianetti, 1976). Motion can also improve memory (Detenber, 1995; Kipper, 1986) and is associated with orienting and greater cortical activation that is indicative of orienting or heightened attention (Reeves et al., 1985).

Motion is a complex variable, for the term can describe many different characteristics of stimuli. Zettl (1991) articulated three distinct kinds of motion that appear in film and television. Primary motion refers to object motion (i.e., things moving in the frame), whereas secondary motion is created by moving the camera (panning, tilting, etc.). Tertiary motion is the apparent motion created through editing (Zettl, 1991). Within each of these broad categories, more elaborate typologies of motion can be described. For example, object motion can refer to direction (vertical, horizontal, or along the *z*-axis, i.e., toward or away from the viewer), speed (slow, fast), or merely presence (there is motion, there is none). In Detenber et al. (1998) and in the present study, the type of motion under investigation was primary, or object motion for several reasons, some of them theoretical, others practical.

The types of motion articulated by Zettl (1991) are embedded in the message, and once they are created by the producer, they are fixed. Motion as it is being studied here (present or not) is interesting because it exists independent of content, and therefore we consider motion to be a formal, rather than a content, variable. Because of the way film and television are constructed, any moving image can become a still image. In either state, the basic semantic meaning of the image or what the image depicts is essentially the same, yet the message is fundamentally different. Motion provides additional information to viewers, and it is possible that motion will modulate the viewers' cognitive and emotional responses. Conversely, still images—events frozen in time—might invite greater introspection and may, for example, prompt consideration of their antecedents or consequences. How moving and still images affect emotional responses during image processing is an empirical question that was the topic of this study.

In Detenber et al. (1998), 18 undergraduates were shown two versions of each of 27 images. One version was still, the second was moving. Selection of image content was guided by the dimensional view of emotion such that one-third of the images were positively valenced, one-third were neutral, and one-third were negative. Images were presented for 6 s, during which heart rate and skin conductance were measured. Subjects rated their response to each image for valence, arousal, and interest shortly after seeing each image.

The results of this initial study were intriguing. Image motion had a significant impact on self-reports of arousal and on the magnitude of the skin conductance response—particularly those associated with images prompting high arousal. Image motion had a much smaller (though still significant) impact on valence ratings and had no impact on the valence-sensitive acceleratory component of the triphasic heart-rate response. Both still and moving images prompted heart-rate deceleration at image onset, but the magnitude of this deceleration was not a function of the motion/still variable. The initial deceleration gave way to the valence modulated midinterval acceleratory component that was, in turn, followed by further deceleration if the image contained motion or a relative return toward baseline if the image was still. That is, heart-rate differences toward the end of the 6-s image presentation period suggested that subjects may have attended more to moving than to still images.

Although these results confirmed the potency of image motion for both self-report and physiological measures, they also raised some questions that need to be investigated further. First, there is the question of specificity. Are the effects of image motion specific to the arousal dimension of emotion? A specific motion/arousal relationship is consistent with both the memory (moving images are remembered better) and cortical activation (moving images prompt greater electroencephalogram [EEG] desynchrony) data described above. That is, high-arousal images are recalled more accurately than low-arousal images, whereas image valence is independent of memory (Bradley, Greenwald, Petry, & Lang, 1992), and cortical desynchrony is generally thought to index activation or arousal. In our previous study, subjects reported moving images to be more arousing than still images, and although they did report that moving images were generally more positive also, the effect on valence was considerably smaller than the effect on arousal reports. In addition, the two physiological measures were consistent with dimensional specificity—that is, heart-rate acceleration (valence) was not affected by motion but skin conductance (arousal) was. Second, there is the question of what the heart-rate data indicate. Though the data were somewhat ambiguous, heart rate *was* influenced by motion, albeit only late in the presentation interval. Typically, changes in heart rate due to valence occur much more quickly (i.e., within 1–3 s). Furthermore, valence effects on heart rate have proven, in general, to be fairly weak relative to some other valence-sensitive measures (e.g., facial electromyogram [EMG]). Given these facts, the interpretation of the heart-rate data by Detenber at al. (1998) was cautious, and further investigation is warranted.

The present study was designed to examine in more detail the relationship between image motion and emotion response topography. It is clear from Detenber et al. (1998) that motion acts to heighten the arousal value of an image and interacts with picture content. It is less clear how, or whether, motion influences the perceived valence of the image. Though Detenber et al. reported a significant enhancement of valence self-report, there was no effect of motion on valence self-report in a previous study by Detenber and Reeves (1996). The purpose of the present study, therefore, was to confirm the significant effect of image motion on arousal-related measures while bringing more power to bear on the relationship between motion- and valence-related measures. This goal was accomplished in two ways. First, the sample size was increased to provide a more sensitive test of heart-rate change—particularly the late-interval deceleration that seemed to characterize the response to images containing motion. Second, an assessment of activity in two facial muscles known to be sensitive to stimulus valence (corrugator and zygomatic) was added. Based on Detenber et al., we hypothesized that the effects of motion would be observed primarily on arousal- and less so on valence-related measures and, furthermore, that motion's effect on heart-rate activity would be distinct from the relationship between heart rate and image valence.

Method

Subjects

Thirty-five undergraduate students at the University of Delaware received partial credit toward the research participation component of their introductory psychology course or extra credit in their mass communication course. Of the original 35 subjects, 1 subject discontinued due to illness, and data from 2 additional subjects were eliminated from heart-rate analysis, 3 from the skin conductance analysis, and 3 from the EMG analysis due to technical problems during data collection. The final sample of 34 consisted of 17 men and 17 women with a mean age of 19.24 years ($SD = 2.35$).

Stimuli

The stimuli consisted of 27 images extracted from films and television programs. The images chosen for use in the present study were a portion of a much larger set previously standardized by Detenber (1995). The present subset of 27 images were identical to those used by Detenber et al. (1998). Selection of images was based upon ratings obtained from the standardization sample on categories appearing in the International Affective Picture System (IAPS; Lang, Ohman, & Vaitl, 1988). To facilitate the formation of valence and arousal categories for statistical analysis, the final 27 images were associated with a wide range of ratings on the emotion dimensions of primary interest in the present study (i.e., valence and arousal).

All stimuli were presented for 6 s and were either moving or still versions of the same image. The still version of each image was simply one of the frames taken from the full motion clip that was highly representative. This technique, known as a video capture, is common in the worlds of multimedia and television production. All images, along with an additional graphic instructing subjects to perform the ratings task, were stored on a video laser disc that was connected to a Macintosh computer. Stimuli were presented to subjects in one of four orders embedded in a Hypercard program used by the Macintosh to control the sequence and the timing of stimulus presentation. For two of the four presentation orders, we created both random picture sequences and a random motion-still precedence order (i.e., whether the moving or still version was shown first). The other two sequences had the same picture order, but reversed the motion-still precedence to counterbalance the variable.

Response Measurement

Self-report. Subjects indicated their emotional reactions to each stimulus by providing valence, arousal, and dominance ratings in response to each of the 54 images on a 9-point paper and pencil version of Lang's Self-Assessment Manikin (SAM; Lang, 1980). Using the SAM, valence is rated by marking on or between five graphics depicting the manikin with facial expressions ranging from a broad smile to a severe frown. Arousal is rated similarly using five graphics depicting the manikin at different levels of visceral agitation, and dominance[1] is rated using manikins that differ in size or prominence in the graphics panel they occupy. Having subjects mark on or between the graphics allows for more finely tuned ratings and yields a 9-point scale for each dimension.

Physiological recording. Heart rate was obtained by attaching a Grass Photoelectric Transducer Model PPS to the subject's right ear lobe. The photocell output was fed into a Grass Model 7P1 Low Level DC Preamplifier and Model 7D Driver Amplifier (bandpass = 1.6–3.0 Hz) and then into a Grass Model 7P4 Cardiotachometer where the interpulse intervals were converted into heart rate in beats per minute.

Skin conductance responses were recorded using a Coulbourn Model S21-22 constant voltage (0.5 V) skin conductance coupler. Before recording, the palm of the nonpreferred hand was cleansed with distilled water. Beckman Standard (0.5 cm^2) Ag/AgCl electrodes were then placed on the thenar and hypothenar eminence of the palm with Johnson & Johnson KY Jelly used as an electrolyte.

EMG recordings from the face were obtained by placing Med-Associates miniature Ag/AgCl electrodes over the subject's left zygomatic and corrugator muscles. The raw EMG (bandpass = 3–500 Hz) was full-wave rectified and integrated (time constant (TC) = 50 ms) using a Grass Model 7P3 Wideband Amplifier/Integrator.

Procedure

Subjects were provided with a brief description of the stimuli, the ratings task, and the recording techniques and then signed an informed consent form. EMG and skin conductance electrodes were then affixed on their respective recording sites, and the subject was led to an adjacent room equipped with a comfortable arm chair positioned approximately 1.4 m in front of the viewing device (Sony 20″ color monitor). The photocell was attached to the ear and the quality of the physiological recordings was inspected. Subjects then received the complete set of instructions and two "neutral" practice trials were delivered. The experiment began if the instructions were understood, if the ratings task was completed properly during the practice trials, and if the physiological recordings were free of obvious noise and artifact.

The experiment proper consisted of 54 trials under the control of two laboratory computers—a 486 PC that initiated each trial and collected the physiological data and the Macintosh that controlled the laser disc player. At the completion of each 6-s clip, the viewing screen was dark for 1 s, and then the instruction to rate their response was presented for 4 s. Subjects were instructed to rate their emotional response to the image on the three dimensions (valence, arousal, dominance) quickly, and to return their eyes to the viewing screen prior to the appearance of the next image. The interstimulus interval varied randomly from 17 to 27 s. Physiological data collection began 2 s prior to the delivery of each image and continued for 10 s. At the half-way point in the experiment, the experimenter reentered the viewing room to provide a short break for the subject and to ensure that the subject was on the appropriate page in the ratings booklet. At the conclusion of the experiment, subjects were debriefed verbally and given a brief written explanation of the experiment along with some relevant citations.

Data Reduction

The skin conductance, cardiotachometer, and two facial EMG channels were sampled at 50 cps. The skin conductance data were displayed graphically, trial by trial, and quantified by visually identifying response onset and the largest peak that occurred with an onset latency of 0.5–4 s following stimulus onset. Skin conductance response magnitude was defined as the difference, in μSiemens, between the identified peak and onset points.

The cardiotachometer data were edited for artifact by visually inspecting each trial. Heart beats with obvious artifacts were generally replaced by the trial average. If, however, the baseline heart rate was bad or if consecutive bad beats were detected during image presentation, the entire trial was deleted and omitted from the appropriate condition average. Heart-rate waveforms were obtained from the edited cardiotachometer record by averaging successive 25 data points, and deviating each half-second average during the 8-s post-onset epoch from the half-second average immediately preceding stimulus onset. Fourteen (7 s) half-second averages, along with the onset point, constituted the heart-rate data that were then submitted to statistical analysis.

Corrugator and zygomatic muscle activity were also examined on each trial. Trials with unstable baseline periods were deleted.

[1] Because the correlation between dominance and valence was $r = .86$, a separate set of analyses based on dominance categories was deemed redundant with the valence analysis and was not pursued.

Trials with obvious artifacts during the viewing period were edited if possible by replacing bad values with the trial average, or deleted if editing was not possible. Corrugator and zygomatic data were then expressed as the difference between the mean value during the 6-s viewing period and the prestimulus mean. A derived "pattern" score was also computed for each trial by first standardizing the data for each muscle within subject and then subtracting the corrugator change from the zygomatic change (Fitzgibbons & Simons, 1992; Greenwald et al., 1989).

Data Analysis

The initial phase of data analysis involved the generation of mean valence and arousal ratings for each of the images collapsed across the moving/still dimension. Valence means were then ranked from most positive to least positive, and then the 27-image set was divided into 9 positive, 9 neutral, and 9 negative images. Likewise, arousal means were ranked from the lowest to highest and the images were divided into 9 low-, medium-, and high-arousal categories, again collapsed across the moving/still dimension.[2]

Each of the dependent measures was analyzed twice using a repeated-measures analysis of variance (ANOVA) with image category (valence or arousal) and motion as the two within-subject variables. Single-*df* orthogonal trends were used to represent the category variable. In this analysis, the linear trend (1, 0, −1) is equivalent to the specific contrast of positive versus negative valence or low versus high arousal, whereas the quadratic trend (1, −2, 1) is equivalent to the contrast of the middle category with the two extremes. The heart-rate analysis also examined single-*df* orthogonal trends across the half-second data points to assess the effects of both image category and motion across time.

Results

SAM Ratings

Valence and arousal ratings as a function of both valence and arousal categories are presented in Figure 1. The two left-hand panels illustrate the impact of image motion on SAM ratings of valence (top) and arousal (bottom). Moving images were rated more positively than still images overall, $F(1,33) = 18.89$, $p < .001$, and motion interacted with linear valence, $F_{lin}(1,33) = 11.57$, $p < .01$; the difference between moving and still images grew as valence became more positive. Moving images were also experienced as more arousing than still images. This effect of motion on arousal ratings was again highly significant, $F(1,33) = 54.54$, $p < .001$, and more dramatic than the effect of motion on valence.

The two right-hand panels of Figure 1 illustrate the relationship between valence and arousal ratings. The relationship between valence category and SAM arousal ratings was quadratic with positive and negative slides rated as more arousing than the neutral slides, $F_{quad}(1,33) = 9.97$, $p < .01$. Likewise, the relationship between arousal category and SAM valence ratings was also quadratic. In this case, slides of medium arousal were rated more pleasant than high and low arousal slides, $F_{quad}(1,33) = 33.5$, $p < .001$. Using a different metric, the Pearson correlation between ratings of valence and arousal in the present study was virtually nil ($r = .03$).

[2]The ranges of SAM valence ratings for each category were: positive (5.91–7.78), neutral (4.51–5.87), and negative (2.40–4.50). The ranges of SAM arousal means for the three arousal categories were: low (2.38–3.43), medium (3.44–4.16), and high (4.47–5.79).

Facial EMG

Figure 2 illustrates the relationship between the facial EMG pattern score and both valence and arousal categories. As expected, the pattern score varied linearly with image valence, $F_{lin}(1,30) = 7.90$, $p < .01$. This linear trend was evident in both of the constituent facial muscles, zygomatic $F_{lin}(1,30) = 4.24$, $p < .05$; corrugator $F_{lin}(1,30) = 9.14$, $p < .01$, with positive images prompting greater zygomatic and negative images greater corrugator activity. The EMG pattern score did not vary significantly with arousal category, though the quadratic trend approached significance, $F_{quad}(1,30) = 4.04$, $p > .05$, with both low- and high-arousal slides evincing a corrugator-type pattern. The unstandardized individual muscle data revealed that this pattern was exclusively due, in fact, to activity in the corrugator, zygomatic $F_{quad}(1,30) = 1.52$, *ns*; corrugator $F_{quad}(1,30) = 6.01$, $p < .05$. Motion did not exert a main effect on facial EMG ($F < 1$) pattern score, and it did not interact with either image valence ($F < 1$) or arousal, $F(1,30) = 2.98$, $p < .10$. In terms of the individual muscles, there was an interaction between motion and arousal category in the corrugator data such that a substantial corrugator response occurred to highly arousing moving images that was absent in response to high-arousal stills, $F_{lin}(1,30) = 5.41$, $p < .05$.

Heart Rate

The heart-rate response to the image stimuli was deceleratory, beginning shortly after stimulus presentation and remaining below baseline for the duration of the recording interval. The half-second by half-second data are presented in Figure 3 as a function of image valence (left-hand panel), image arousal (center panel), and image motion (right-hand panel). The trend ANOVA confirmed the reliability of the deceleration with significant linear, $F_{lin}(1,31) = 41.36$, $p < .001$, quadratic, $F_{quad}(1,31) = 36.88$, $p < .001$, and quartic, $F_{quart}(1,31) = 11.80$, $p < .01$, trends across the presentation period. The linear and quadratic trends accounted for 77% and 17% of the variance across the half-second data points, respectively.

Heart-rate change was significantly related to both emotion properties of the stimuli (i.e., valence and arousal). The relationship between stimulus valence and heart rate was linear, $F_{lin}(1,31) = 8.33$, $p < .05$; $F_{quad}(1,31) < 1$, with the greatest deceleration associated with negative images and the least with the positive images. The development of this between-image differentiation across time is reflected in the significant linear Valence × linear Half-second interaction, $F_{lin}(1,31) = 15.43$, $p < .001$. The arousal properties of the image were similarly related to heart-rate change, though in this case, the relationship was both linear, $F_{lin}(1,31) = 5.63$, $p < .05$, and quadratic, $F_{quad}(1,31) = 6.88$, $p < .05$, reflecting the greater deceleration associated with the most highly arousing images and the lack of differentiation between stimuli rated low and medium in arousal. The development of this association over time was again supported by an interaction of stimulus category (linear arousal) with half-second time points, $F_{lin}(1,31) = 7.98$, $p < .01$; $F_{quad}(1,31) = 7.76$, $p < .01$. Full differentiation of the stimuli by both emotion dimensions was evident in the heart-rate response by midinterval and remained stable until the image was removed.

Motion also had a significant impact on the heart-rate response, $F(1,31) = 10.78$, $p < .01$, with moving images prompting more heart-rate slowing than still images. As Figure 3 illustrates, the impact of motion also developed across time, Motion × linear Half-second $F_{lin}(1,31) = 29.36$, $p < .001$. In this case, however, the differentiation increased throughout the presentation period and was greatest at the end of the period, rather than at midinterval.

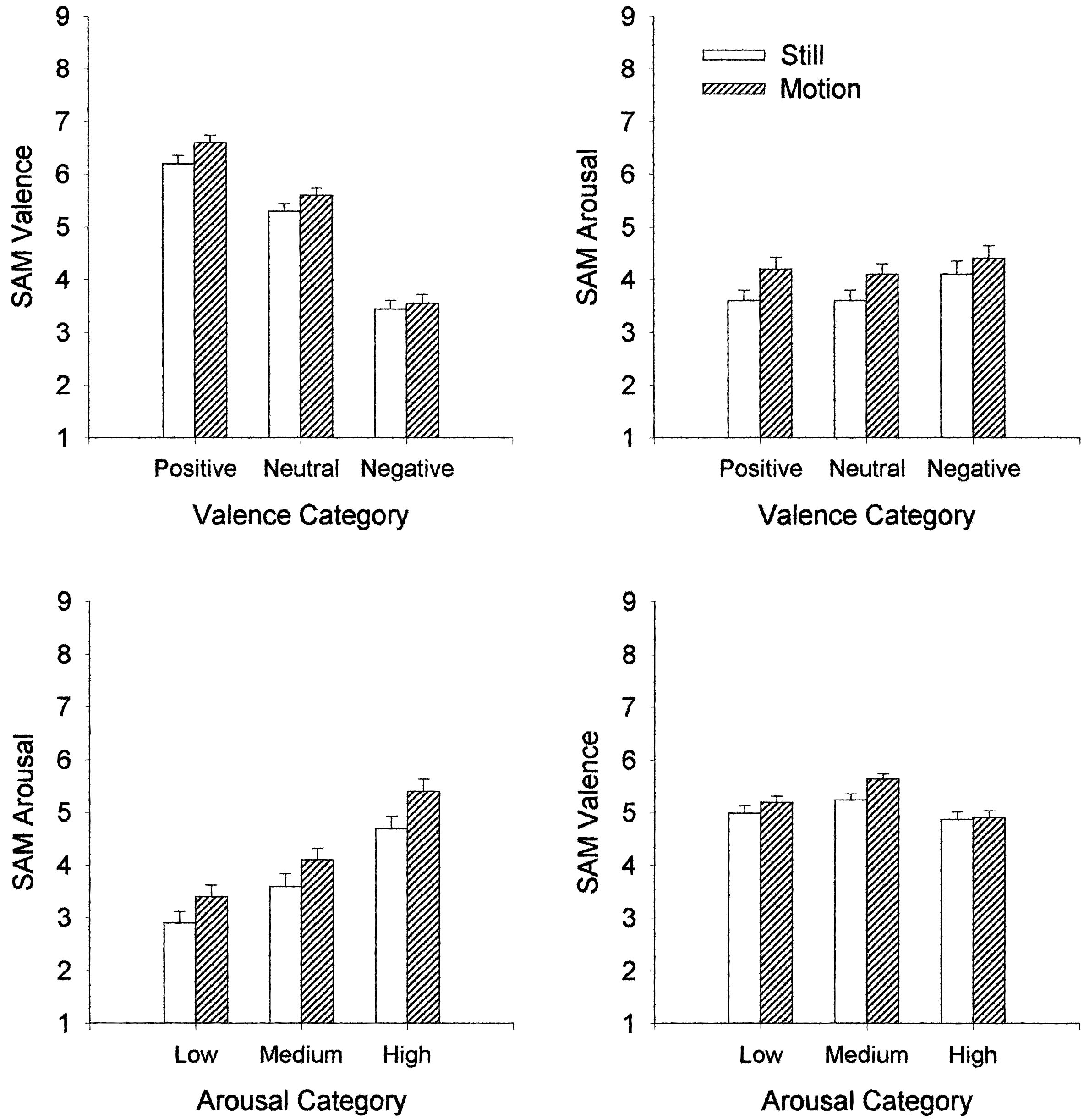

Figure 1. Ratings on the Self-Assessment Manikin (SAM) for moving and still images. On the left, images are grouped into either valence (top) or arousal (bottom) categories with valence and arousal ratings indicated for each category. On the right, arousal ratings are provided for each valence category (top) and valence ratings are provided for each arousal category (bottom).

Motion exerted its effects on heart rate independently; there were no interactions between motion and either of the two emotion dimensions.

Skin Conductance

As expected, skin conductance response magnitude was a function of the arousal properties of the image stimuli. This relationship was primarily linear, accounting for 87% of the arousal-category variance, though the quadratic was also significant, $F_{\text{lin}}(1,30) = 25.39$, $p < .001$; $F_{\text{quad}}(1,30) = 12.31$, $p < .01$. As the right-hand panel of Figure 4 illustrates, high-arousal images evoked particularly large skin conductance responses. The figure also illustrates the highly significant association between image motion and skin conductance response magnitude. Statistically, motion interacted with arousal by accentuating the linear trend, Motion $\times$ linear Arousal, $F_{\text{lin}}(1,30) = 12.31$, $p < .01$. The left-hand panel of Figure 4 depicts the relationship between skin conductance response magnitude and image valence. The relationship was significantly quadratic, $F_{\text{quad}}(1,30) = 7.01$, $p < .05$, most likely reflecting the fact that both positive and negative images tend to be more arousing than the neutral images. Motion did not interact with valence category.

Discussion

The main goal of the present study was to confirm the Detenber et al. (1998) finding that the impact of motion in an emotion-evoking image is primarily on variables associated with emotion's

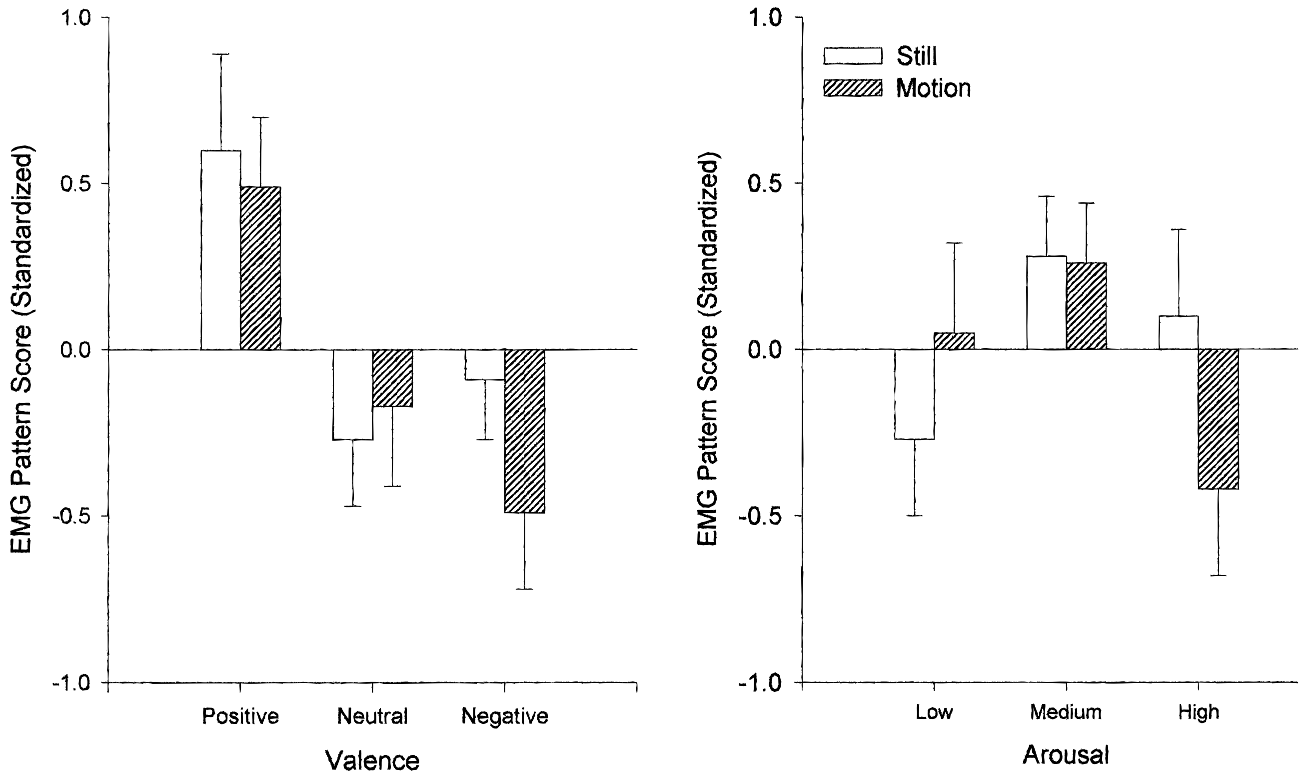

Figure 2. Facial electromyographic pattern score for moving and still images as a function of valence (left) and arousal (right) categories.

arousal dimension. The present results did so. Moving images were once again associated with increases in self-reported arousal and with larger skin conductance responses, particularly when the images were reported to be highly arousing. Motion also prompted a substantial and sustained bradycardia, suggesting that moving images captured more attentional resources.

As in Detenber et al. (1998), there was also a significant effect of stimulus motion on valence self-report. This effect, however,

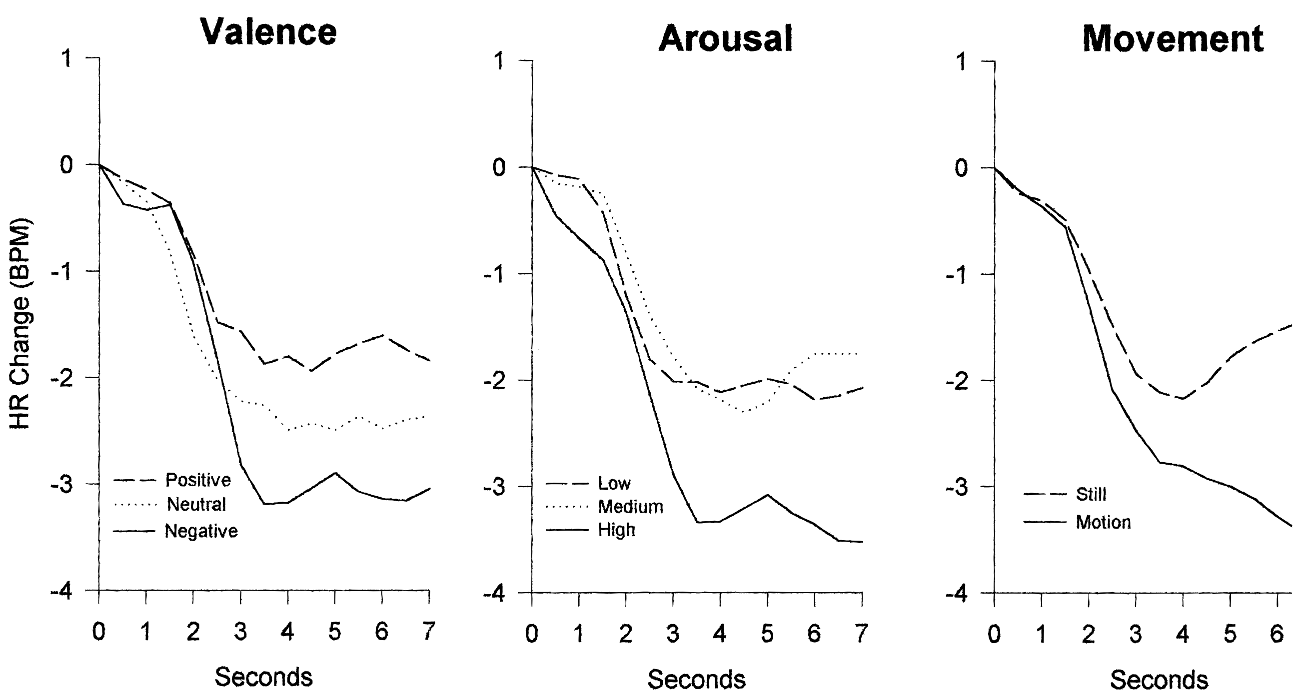

Figure 3. Heart rate response waveforms as a function of valence (left), arousal (center), and image motion (right).

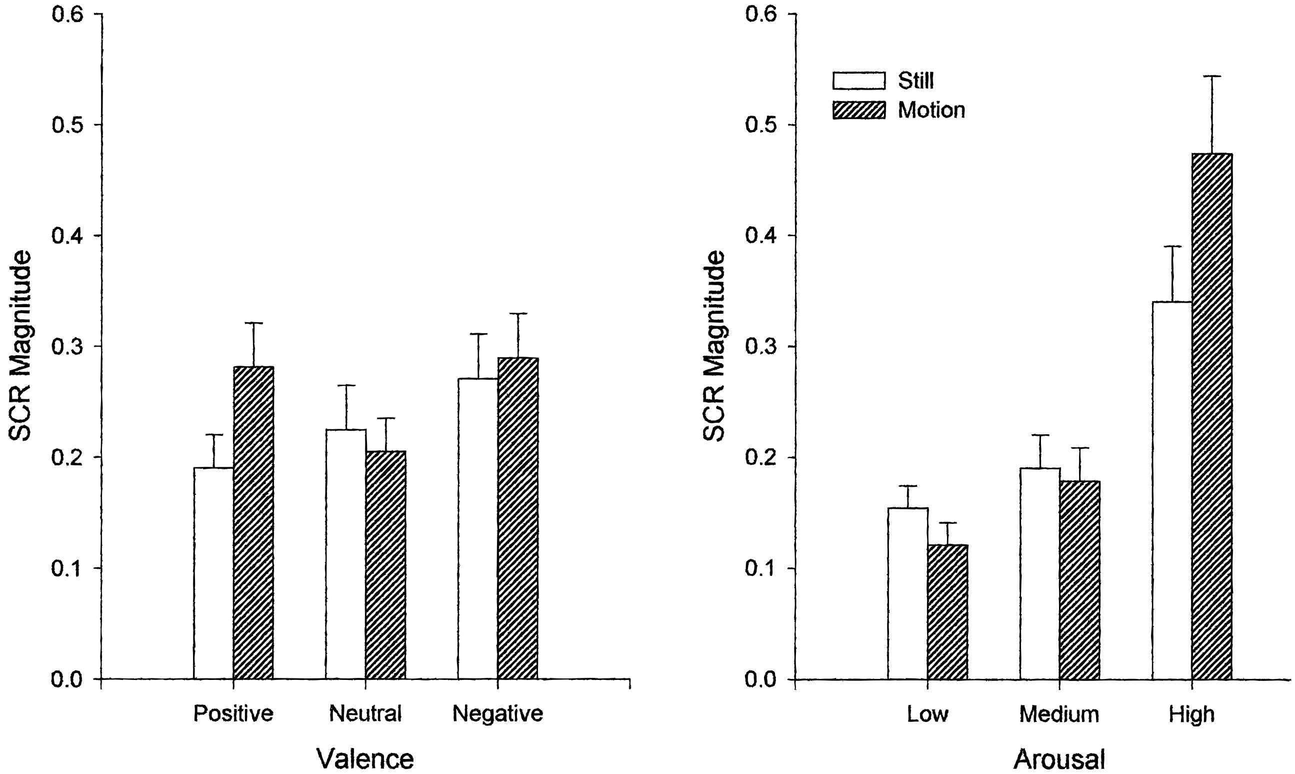

Figure 4. Skin conductance response magnitude for moving and still images as a function of valence (left) and arousal (right) categories.

was much smaller than the arousal effect and did not extend to either the valence-sensitive heart-rate acceleration measure or to facial EMG—perhaps the prototypic nonverbal index of emotional valence. Although both facial EMG and heart-rate acceleration were unequivocally associated with image valence, as expected, these effects were independent of the motion/still manipulation.

Together, the effects reported by Detenber et al. (1998) and those observed in the present study suggest that image motion, an attribute of stimulus presentation independent of content, can have a powerful impact on the experience and physiology of emotion and that this impact can be rather specific. That is, image motion influences the arousal value of the image to a greater extent than it influences the subjects' like or dislike of image content. A similar specificity has been found in studies of screen size; Detenber and Reeves (1996) reported that arousal, not valence, self-report increases when images are presented on large viewing screens, and, more recently, Reeves, Lang, Kim, and Tatar (1997) have shown that the screen size effect is evident in skin conductance and arousal self-reports.

A second major goal of the present experiment was to provide a more complete explication of the difference in the heart-rate response to the moving and still images noted by Detenber et al. (1998). As discussed above, heart rate is reliably associated with stimulus valence in picture viewing and in other emotion-eliciting tasks. This relationship was obvious in the present data as well. The heart-rate waveforms distinguished the positive, neutral, and negative images independent of the motion factor (Figure 3, left). Likewise, image motion exerted a strong effect on the heart-rate response and this effect was independent of stimulus valence. Movement in the image was associated with marked deceleration, and this deceleratory difference between moving and still images grew most pronounced toward the end of the viewing period (Figure 3, right).

Based on these data, it appears that as the heart-rate response unfolds, several processes are reflected, not unlike those described by Bohlin and Kjellberg (1979). First, all stimuli elicit a short-latency deceleration indicative of orienting to image onset (Graham, 1992; Graham & Clifton, 1966). Next, the affective properties of the stimulus dominate, and their impact is most evident around the midinterval acceleratory component. Finally, motion becomes the dominant factor. Heart rate returns to baseline if the image is still, but remains substantially slowed if the image contains motion. This continued bradycardia most likely reflects sustained attention (e.g., Berg & Richards, 1997; Richards, 1997). Thus, it appears that the "message" (i.e., stimulus content) and the "medium" both affect the heart-rate response and that, in this case at least, these effects are independent.

This interpretation of the heart-rate data is consistent with other studies of formal media characteristics and their physiological effects. In general, the onset of new or novel visual information in a mediated presentation has been associated with heart-rate deceleration. For example, Thorson and Lang (1992) found that the introduction of a videographic (i.e., text on the screen) in a televised lecture caused a significant slowing in the viewers' heart rate for several seconds. Similarly, it has been shown that edits in television program segments that involve a change of scene elicit cardiac orienting responses (Lang, Geiger, Strickwerda, & Sumner, 1993). Lang (1990) presented evidence that both the onset and novel structural features (i.e., edits, camera motion, object motion onscreen, etc.) of commercials embedded in a half-hour television program can cause heart-rate decelerations. What distinguishes the present data from the data of Lang et al. is the sustained slowing of the heart. That is, there appears to be an effect of motion beyond simple orienting. We believe that motion, by definition, continues to present new information to viewers, and thereby holds their attention once it has been captured by content.

The present study, then, provides clear evidence that *how* a stimulus is delivered affects emotion-response topography above and beyond the effects of *which* stimulus is delivered. Furthermore, the effects of presentation attributes such as motion and screen size can be fairly specific. Both of the latter effects increase arousal and sustain the subjects' attention (see Reeves et al., 1997, for a more complete discussion of screen size effects) while having little or no impact on image valence. These data have implications for research in the psychology of emotions and for the field of communication. Most media-effects research examines only the content of messages and its impact. Based on present results, media-effects researchers would do well to consider the potential impact of the form of the messages and the possibility of form and content interactions. Media producers concern themselves with message effectiveness. Often, the criterion for effectiveness is the ability to capture and hold the audience's attention. Our studies indicate that motion can play a critical role in eliciting and sustaining attention. Motion can also increase emotional arousal or excitement, which is often another goal of media producers.

Emotion research, similarly, has focused primarily on stimulus content and has paid little attention to the formal properties of stimulus presentation. Given the goal of inducing emotional responses in the laboratory that mimic, as much as possible, those that occur "in vivo," it is important to identify manipulations that may affect the potency of the emotion-inducing stimuli. The present study, and those of Reeves et al. (e.g., Detenber & Reeves, 1996; Reeves et al., 1997), have identified two variables, image motion and screen size, which augment the potency of the stimuli. In both cases, the impact of the variable has been to make the stimuli more arousing. Perhaps other presentation attributes (e.g., color, sound?) might be identified that increase the potency of a stimulus by affecting more specifically its valence—that is, making positive images more positive and negative images more negative. Independent manipulations of valence and arousal through formal presentation properties would have interesting and important implications for basic research in emotion and for research in disordered emotion as well. For example, subjects with physical anhedonia have emotion-processing deficits that are primarily valence related (Fiorito & Simons, 1994; Fitzgibbons & Simons, 1992), and subjects identified as alexithymic have what appear to be arousal-related deficits (Roedema & Simons, 1999). Such an analysis might prove useful with other subject groups as well, and the ability to identify and then target manipulations toward specific emotion dimensions could have theoretical and practical implications.

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