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The Startle Probe Response: A New Measure of Emotion?

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Twenty undergraduate subjects were presented with unsignaled 50-ms white noise bursts (95 dB) to probe their perceptual processing while viewing 36 colored photographic slides, depicting pleasant/interesting, neutral/dull, or unpleasant/interesting scenes and objects. Startle magnitudes to the noise bursts as measured by the eyeblink response were largest for unpleasant material and smallest for positive material. This effect was independent of measures of orienting, arousal, and interest in the materials. The results reconcile conflicting animal and human research. Alternative attentional and response matching explanations of these startle probe effects were evaluated. The startle probe is proposed as a broadly useful tool for studying emotion, its development and modification, and for the assessment of pathological anxiety.

The amplitude of the startle reflex is influenced by contextual variables in both animals and humans (Anthony, 1985; Graham, 1975; Hoffman & Ison, 1980). Although many of these effects reflect automatic, subcortical mechanisms (Leitner, Powers, Stitt, & Hoffman, 1981), recent studies show that the startle reflex varies systematically with the attentional demands of a coincident information processing task. The present experiment indicates that it is also independently modulated by the affective valence (pleasant or unpleasant) of the stimulus context in which it occurs. Thus, the startle probe could be a significant new technology for directly measuring both normal and pathological states of emotion.

There are several related effects of attention on the startle eyeblink response. When subjects are instructed to attend to the startle stimulus, response amplitude is increased and its onset latency is reduced (Bohlin, Graham, Silverstein, & Hackley, 1981; Hackley & Graham, 1983). When a startle stimulus is presented in a different sensory modality from an "attended to" foreground stimulus, startle is diminished (Silverstein, Graham, & Bohlin, 1981). Thus, the response to an acoustic probe is smaller when subjects are viewing a slide than when they are listening to a melody (Anthony & Graham, 1983, 1985). Startle probe responses also vary with changes in attention to foreground stimuli within a sensory modality. For example, the magnitude of acoustic startle probes is smaller when presented during engaging, interesting pictorial slides than during repetitive, dull slides (Simons & Zelson, 1985).

The aforementioned studies are consistent in demonstrating that the human startle response is augmented or inhibited according to modality-directed attention or the attention allocation demands (interest value) of a foreground task. Nevertheless, a seemingly parallel literature using animal subjects suggests a very different pattern of startle modulation (Berg & Davis, 1984, 1985; Brown, Kalish, & Farber, 1951). In these studies, a light is first made a significant stimulus for a rat by pairing its presence with electric shock. When this significant visual foreground stimulus is subsequently displayed, the startle response to a concurrent auditory probe is facilitated. Response augmentation is a clear function of the fear conditioning, and does not occur with random presentation of light and shock (Davis & Astrachan, 1978), or from previous exposure to light or shock alone. This facilitation effect (when the animals are presumably "attending") is at variance with the finding of startle inhibition in human beings when foreground and startle stimuli are represented in different modalities.

These inconsistencies between animal and human research could reflect idiosyncrasies of the different startle measures (whole body startle vs. eyeblink), or some unknown species-specific interaction between startle and attention. These explanations seem unlikely given the strong parallels between the animal and human startle literature in other areas (Graham, 1975; Hoffman & Ison, 1980). Alternatively, the startle response may be directly influenced in both species by the emotional valence of the foreground stimulus. In this case, it is assumed that the startle itself prompts an aversion reaction, and that the reflex shares aspects of its psychological or neurophysiological structure with other responses to nocent stimuli. Startle facilitation is then an expected additive effect of common valence (of reactivity to the aversive noise burst and to the aversive slide context): the synergistic response matching described by Lang (1985).

The current study examined the attentional and affective match hypotheses for the human eyeblink reflex. The general procedure was similar to that of Simons and Zelson (1985). However, startle probes were presented during three slide sets, distributed along the emotional valence dimension: negative/interesting slides (photographs of fearful or phobic objects similar to those used in previous laboratory studies of anxiety, e.g.,

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Klorman, Wiesenfeld, & Austin, 1975; Öhman, 1979); emotionally positive/interesting slides (including contents used by Simons & Zelson); and neutral/dull slides. In addition to measures of blink magnitude, subjective ratings of slide pleasure and arousal were recorded, as well as three measures of attention: judgments of interest value, a heart rate measure of orienting, and time of slide exposure during a subject-controlled free-viewing period.

Method

Subjects

Subjects were 20 undergraduates (10 male, 10 female) who received experimental credit in their introductory psychology course in return for participation.

Apparatus and Stimuli

The presentation and timing of stimuli and the collection of physiological and self-report data were accomplished under the control of a Terak 8510a microcomputer. The acoustic startle stimulus was a 50-ms burst of 95 dB (A) white noise with an instantaneous rise time, presented binaurally through Pioneer SE-205 stereo headphones. Visual stimuli were 35-mm color slides projected on a screen approximately 1.8 m in front of the subject by a Kodak Ektagraphic slide projector located in the equipment room adjacent to the subject room. There were 12 different slides in each of three affective contents (positive, neutral, negative). The negative and positive slides were equivalent overall in rated arousal, and both of these affect categories were more arousing than the neutral materials. The negative slides included mutilated bodies or faces, a spider, a coiled snake, a gun, and a man receiving an injection. Neutral slides included common household objects—for example, a hairdryer, a book, and a fork. Positive slides included opposite-sex nudes, smiling children, a rabbit, and appetizing food. Most of these slides came from the The International Affective Picture System (Lang & Greenwald, 1988; Lang, Öhman, & Vaitl, 1988), and ratings from the system were used to define affect categories. Slide affect ratings have been psychophysiologically validated in an independent sample (Greenwald, Cook, & Lang, 1986).

Data Collection and Reduction

The eyeblink component of the startle response was measured by recording activity from the orbicularis oculi muscle underneath the left eye with Beckman miniature Ag-AgCl electrodes. The raw electromyogram signal was amplified and frequencies below 90 Hz and above 1000 Hz were filtered out by a Coulbourn HiGain Bioamplifier. This signal was then rectified and integrated by a Coulbourn Contour Following Integrator using a time constant of 200 ms, and digitally sampled at 1000 Hz for 250 ms after the onset of each startle stimulus. For most of the subjects ($n = 16$) the amplifier gain control was set at 6 ($\times$10,000); because of particularly large (exceeding the scale) or small initial startles, the gain was adjusted to 5 for three subjects and 7 for one subject. The startle reflex data were reduced off-line by computer (Balaban, Losito, Simons, & Graham, 1986), eliminating trials with an unstable baseline and scoring each blink for amplitude in arbitrary A-D units. Trials with an unstable baseline constituted 5.8% of all trials and were treated as missing data. On trials in which no scorable blink occurred (3.5% of all trials), amplitude was recorded as zero.

Startle latency was also recorded, and the pattern of latency modulation by foreground stimuli was generally similar to the results to be presented for magnitude. However, these data are not reported: As no latency score could be recorded for both the unstable baseline and no-startle trials, observations per subject were reduced by nearly a tenth, and the data were of borderline reliability for this sample size.

Lead I electrocardiogram was recorded during slide viewing, using Beckman standard Ag-AgCl electrodes filled with Beckman electrode electrolyte and placed on each inner forearm. The signal was filtered through a Coulbourn Instruments Hi Gain Bioamplifier/Coupler, and a Schmitt trigger interrupted the computer each time it detected a cardiac R wave. Interbeat intervals were recorded to the nearest millisecond, prior to and during slide exposure, and subsequently reduced to heart rates per .5 s of real time. Initial orientation to the slides was defined for individuals as the change from the .5 s immediately preceding a slide onset to the slowest interval within the subsequent six .5 s. This is the D-1 measure of orienting (e.g., see Gatchel & Lang, 1973; Winton, Putnam, & Krauss, 1984).

Subjects rated each slide for affect and interest value, using a potentiometer joystick to manipulate a computer-driven, animated graphics display on a video monitor (Hodes, Cook, & Lang, 1985; Lang, 1980). Each rating was digitized into a 0–29 point scale and stored in the computer. Ratings for two subjects were lost to equipment error.

Procedure

Upon arrival in the laboratory each subject was seated in a comfortable reclining chair and physiological monitors were attached. The subject was instructed that he or she would view slides that would vary in content, and that although some slides might be difficult to look at, it was important to attend to the slide during the entire viewing period. Subjects were also told that they would hear occasional noises over the headphones, but that they should ignore them and attend to the slides.

Subjects viewed the 36 slides for 6 s each with an intertrial interval varying from 16 to 24 s. The slides were grouped into three blocks of 12 slides each. Each block consisted of 4 negative, 4 neutral, and 4 positive content slides. For each content, an acoustic startle stimulus was presented .5 s after slide onset for one slide, 2.5 s after slide onset for another slide, and 4.5 s after slide onset for a third slide. One of the four slides in each content was presented without a startle stimulus. In addition, each block included three startle stimuli that were presented during the intervals between slide presentations. These random interslide stimuli served to further reduce the temporal predictability of the startle and to de-emphasize a specific association between slide viewing and startle stimuli: Responses to them were not included in the analysis. The order of slide contents and the order of startle onsets varied unpredictably within and across blocks. Midway through presentation of the 36 slides subjects received a 5-min break.

After all slides had been viewed, the sensors were removed and the slides were presented a second time in the same order. Subjects were told to view each slide for as long as they needed to make their ratings, and then to press the button to turn off the slide and turn on the ratings monitor. Slide viewing time was automatically recorded by computer. Subjects were instructed to rate their feelings by modifying two dimensions of an animated manikin presented on the CRT screen (Lang, 1980): (a) adjusting its facial expression from a deep frown to a happy face, to indicate their response on the pleasure–displeasure dimension; and (b) adjusting its activity level from quiet with eyes closed to extreme agitation, to indicate their response on the arousal–calm dimension. They rated their interest in the slide by moving a cursor on the video monitor along a line anchored at one end with the words *not at all interesting* and at the other end by the words *very interesting*.

Data Analysis

Each dependent variable (startle magnitude, heart rate change [D-1], valence, arousal, interest ratings, and viewing time of the slide during the rating phase of the study) was subjected to a separate, univariate

Table 1
Subjective Ratings, Viewing Times, and Heart Rate Orienting

Slide content measure	Positive	Neutral	Negative	F	p
Valence (0–29)	24.5	14.8	7.8	165.6	.0001
Arousal (0–29)	16.1	2.5	15.8	57.1	.0001
Interest (0–29)	21.7	6.1	14.8	41.3	.0001
Viewing time (in seconds)	9.7	5.2	10.1	10.3	.0004
Heart rate, D-1 (B/M)	−3.9	−4.4	−4.8	0.9	*ns*

Note. The reported F statistic and probability level are for the main effect of slide content. The p values take into account the Greenhouse-Geisser correction for degrees of freedom.

analysis of variance, with slide content (positive, neutral, negative) and startle onset time as within-subjects factors. Greenhouse-Geisser corrections were applied where appropriate. The continuity of response over the three valence levels of slide content was determined by analysis of linear trend.

Results

Slide Ratings and Measures of Attention

Table 1 lists the measures of affect and attentional engagement recorded for the slides. Slide ratings of valence (pleasure–displeasure) were highly consistent with the a priori designation of slide content; that is, ratings of pleasure decreased in an orderly fashion from positive to neutral to negative slides, linear trend analysis $F(1, 17) = 315.2, p < .0001$.

Negative and positive slides produced equivalently high ratings of arousal, whereas the neutral slides were rated as much less arousing. Neither behavioral nor heart rate measures of attentional engagement discriminated among the two high-affect slide categories. During the free-viewing period, subjects chose to look at both positive and negative slides for an equivalent length of time, and viewed the neutral slides for a shorter period. There were no significant differences between any slide categories in D-1 or in the succeeding components of the heart rate waveform (e.g., A-1, D-2, as described by Gatchel & Lang, 1973). Finally, positive were rated as more interesting than negative slides, and both were rated as more interesting than the neutral slides.

Startle Response

Figure 1 shows startle reflex magnitude elicited by all probes during positive, neutral, and negative slides. Clearly, the startle response was smallest when evoked during affectively pleasant slides and largest when evoked during negative slides, slide $F(1.9, 36.3) = 4.70, p < .02$. This difference between contents did not vary significantly with the sex of subjects, $F(1.95, 35.1) = 2.74$, *ns*. Overall startle magnitude appeared to be modulated continuously along the valence dimension, that is, augmented for unpleasant slides relative to neutral, and inhibited when foreground slide content became more positive. This impression was confirmed by an analysis of the linear trend in these data, $F(1, 19) = 8.36, p < .01$.

Startle inhibition was found by Simons and Zelson (1985), specifically to slides of attractive, nude human figures. As a direct replication, responses to startle probes from the present experiment, occurring in a slide foreground of opposite-sex nudes (4 of 12 positive valence slides), were compared with startle responses obtained during slides in the neutral category. The average startle probe magnitude for the nudes was 283 A-D units, significantly less than the average 383 unit response for neutral slides, $t(19) = 2.89, p < .01$. Seventeen of 20 individual subjects produced smaller startles during slides of opposite-sex nudes than during neutral slides. Thus, the previous finding that the acoustic startle response is inhibited by visually interesting foreground stimuli was directly replicated.

Startle inhibition, caused by the onset of a stimulus just prior to a startle probe, is well-documented in work with both animal (Hoffman & Ison, 1980) and human (Graham, 1975) subjects. In the present experiment, slide onset produced a similar prepulse effect. Thus, probes presented immediately after slide onset (.5 s) prompted smaller responses than did probes that occurred later in slide exposure, $F(1.8, 35.0) = 16.3, p < .0001$. Furthermore, when probes of different presentation latencies were separately analyzed, the early (.5 s) startles were not differentiated in terms of affect, $F(1.9, 36.1) = 0.32$, *ns;* on the other hand, probes presented well after slide onset (after 2.5 s) clearly varied significantly in response magnitude according to their emotional valence, $F(1.6, 29.6) = 5.03, p < .02$. These data suggest that the emotional component of slide perception may develop slowly, and that the startle probe could be used to map its course.

Discussion

Negatively valent visual foreground stimuli produced startle reflex facilitation to an acoustic probe relative to neutral or positive visual stimuli. This has not been previously documented

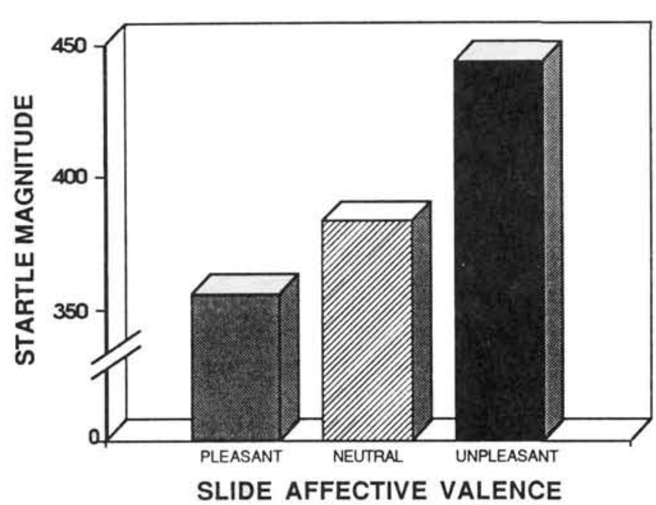

Figure 1. Mean magnitude of the eyeblink response (A-D units) elicited by an acoustic startle probe during viewing of positive, neutral, and negative affective slides.

in humans but is consistent with startle facilitation found as a component of the conditioned fear response in rats (Berg & Davis, 1984, 1985; Brown et al., 1951). This study also replicated acoustic startle inhibition when noise bursts are presented during visually interesting foreground stimuli (Anthony & Graham, 1983, 1985; Simons & Zelson, 1985). The explanation previously offered for this inhibition effect is that positive/interesting slides are highly potent in engaging visual attention, which reduces the attentional resources available for allocation to the auditory (startle input) channel. Consistent with this view, positive slides were rated as more interesting, and were viewed for a longer period of time than neutral slides.

However, this attentional model does not easily explain the startle facilitation observed in the present experiment for negative/interesting slides: Negative slides were also rated as more interesting and were viewed at greater length than neutral slides. Furthermore, negative slides did not differ from positive slides in initial heart rate deceleration (a common measure of orienting), nor in reported arousal, results that would be expected if these contents differentially engaged subjects' attention.

An explanation consistent with both results is that these effects are the product of synergistic response matching (Lang, 1985). In this view startle modification (i.e., facilitation or inhibition) depends directly on the consonance of startle and foreground stimulus valence. The slide's affective valence reflects either an organismic, positive approach response disposition, or a negative withdrawal response disposition (e.g., see Schneirla, 1959, and from a different perspective, Fowles, 1980). The startle reaction is construed as an aversion response, sharing with the response to negative slides psychological, and perhaps, neurophysiological components of avoidance and escape behavior. Thus, startle would be inhibited if the foreground evoked a positive reaction; alternatively, startle is facilitated in a negative context, like the viewer's intense reaction to a sudden noise (the creak of a stair) during an ominous scene in a Hitchcock film.

The present experiment is not, of course, a definitive test of alternative attentional and affective response matching explanations of the startle probe. Although the measures of attention used here are collectively persuasive, each by itself is open to question: (a) Subjective judgments (of arousal, interest, etc.) often show poor covariation with the performance they are supposed to index (e.g., see Lang, 1968). Furthermore, in order not to complicate the slide-startle relation with a special evaluative set, these measures were actually recorded at a second slide viewing, and not during the slide-startle presentations. (b) Viewing times were also assessed during this second phase, and in the context of a meaningful task (i.e., making the evaluative judgments). It is possible that viewing times reflected the varying difficulty or complexity of the judgment task, as well as possible interest differences in the materials. (c) When multiple affective contents are presented within subjects, a significant, relative deceleration in cardiac rate to unpleasant slides is generally observed (e.g., Greenwald et al., 1986; Winton et al., 1984). Though not statistically significant, a similar trend was observed here (see Table 1). Thus, the data in no way suggest less orienting to aversive slides (i.e., less deceleration than to other stimuli), which the attentional explanation appears to demand. On the other hand, the relation between heart rate induced by an affective visual stimulus and coincident auditory stimulus processing is not straightforward. For example, Bradley, York, and Lang (1987) presented subjects with slides like those used here and observed the expected, significantly greater cardiac deceleration to aversive contents. However, recognition reaction times to auditory stimuli presented during slide viewing were sometimes faster and sometimes slower for aversive relative to positive and neutral material. This depended variously on such factors as the nature of the task, previous experience with the slide stimuli, and individual differences in imaginal processing.

A second issue turns on whether it is the sensory or motor side of the reflex that is being modified by affective stimuli. The neuroanatomy of the acoustic startle system would accommodate either interpretation (Requin, 1988). On the sensory side, the augmentation of startle during unpleasant slides could be secondary to a natural, diminished intake of nocent events, relative to positive or neutral stimulation. This was described by Sokolov (1963) as a "defense response." A similar, afferently modulated internal avoidance disposition was proposed by Lacey and Lacey (1970). Assuming this mechanism for visual material, a reciprocal, greater allocation of attention to the auditory channel could then occur. However, this attention shift depends on a secondary hypothesis: that the startle itself is not aversive (otherwise it would also be attenuated), or that it has specific "interrupt" properties that permit it to breach the Lacey-Sokolov defense (Graham, 1979). If these assumptions find supporting data, the observed larger startle responses during aversive foreground stimulation could be seen as conforming to the attentional explanation of previous cross-modality research (e.g., Anthony & Graham, 1983; Simons & Zelson, 1985).

The sensory rejection model seems less parsimonious than that of response matching. Furthermore, despite possible inadequacies in the arousal, orienting, and interest measures used here, it is still true that none support the attentional view. On the other hand, the present experiment does not clearly explicate response matching (i.e., what exactly do aversive dispositions have in common?). It is known that activation of the corrugator muscle of the face increases during aversive stimulation. Does the same thing occur with orbicularis? Is the matching, and the greater startle response then, related to peripheral muscle preparation? More broadly, are there responses to foreground contents other than affective reactions that might be synergistic with startle? Finally, would the same result occur if the startle stimuli were visual, or tactile, and if the foreground were an aurally present narrative—or an image? These are still open questions, but the research path to the answers is direct.

Regardless of how the theoretical issues are resolved, the present experiment does replicate and integrate findings from both animal and human studies of the startle response. Furthermore, it suggests that the startle probe may be a significant new tool for analyzing normal and pathological emotional states. After a half century of study, it appears that we have a psychophysiological measure for discriminating affects, which is independent of arousal. Furthermore, the startle eyeblink is reflexive. Thus, it can be measured without preparatory instruction and is less vulnerable to volitional disguise than most methods of affect evaluation. It has already been shown that startle probes track attention in 4-month-old infants (Anthony & Graham, 1983, 1985); the present results suggest the method will also be valuable in assessing the course of emotional development. Although the present study was not designed to address individual differences, the demonstrated sensitivity to emotional perceptions of the startle probe suggests that it will vary meaningfully with such affect-related dimensions as temperament, sexual preference, and personality. Finally, the exaggerated startle response found in fear-conditioned rats is reduced by diazepam (Berg & Davis, 1984), a common anti-anxiety drug. Considered in the context of the present findings for humans, this suggests that the startle probe would be useful in evaluating treatment methods and in the prognostic assessment of patients with pathological anxiety.

References

Anthony, B. J. (1985). In the blink of an eye: Implications of reflex modification for information processing. In P. K. Ackles, J. R. Jennings, & M. G. H. Coles (Eds.), *Advances in psychophysiology* (Vol. 1, pp. 167–218). Greenwich, CT: JAI Press.

Anthony, B. J., & Graham, F. K. (1983). Evidence for sensory-selective set in young infants. *Science, 220,* 742–744.

Anthony, B. J., & Graham, F. K. (1985). Blink reflex modification by selective attention: Evidence for the modulation of "automatic" processing. *Biological Psychology, 21,* 43–59.

Balaban, M., Losito, B., Simons, R. F., & Graham, F. K. (1986). Off-line latency and amplitude scoring of the human reflex eyeblink with Fortran IV (computer program abstract). *Psychophysiology, 23,* 612.

Berg, W. K., & Davis, M. (1984). Diazepam blocks fear-enhanced startle elicited electrically from the brainstem. *Physiology and Behavior, 32,* 333–336.

Berg, W. K., & Davis, M. (1985). Associative learning modifies startle reflexes at the lateral lemniscus. *Behavioral Neuroscience, 90,* 191–199.

Bohlin, G., Graham, F. K., Silverstein, L. D., & Hackley, S. A. (1981). Cardiac orienting and startle blink modification in novel and signal conditions. *Psychophysiology, 18,* 603–611.

Bradley, M. M., York, D., & Lang, P. J. (1987). Emotion as context in memory [Abstract]. *Psychophysiology, 24,* 581.

Brown, J. S., Kalish, H. I., & Farber, I. E. (1951). Conditioned fear as revealed by magnitude of startle response to an auditory stimulus. *Journal of Experimental Psychology, 43,* 317–328.

Davis, M., & Astrachan, D. I. (1978). Conditioned fear and startle magnitude: Effects of different footshock or backshock intensities used in training. *Journal of Experimental Psychology: Animal Behavioral Processes, 4,* 95–103.

Fowles, D. C. (1980). The three arousal model: Implications of Gray's two-factor learning theory for heart rate, electrodermal activity, and psychopathy. *Psychophysiology, 17,* 87–104.

Gatchel, R., & Lang, P. J. (1973). Accuracy of psychophysiological judgments and physiological response amplitude. *Journal of Experimental Psychology, 98,* 175–183.

Graham, F. K. (1975). The more or less startling effects of weak prestimulation. *Psychophysiology, 12,* 238–248.

Graham, F. K. (1979). Distinguishing among orienting, defense, and startle reflexes. In H. D. Kimmel, E. H. van Olst, & J. F. Orlebeke (Eds.), *The orienting reflex in humans* (pp. 137–167). New York: Erlbaum.

Greenwald, M., Cook, E. W., & Lang, P. J. (1986). Stimulus significance: Cognitive and physiological responses to visual stimuli [Abstract]. *Psychophysiology, 23,* 438.

Hackley, S. A., & Graham, F. K. (1983). Early selective attention effects on cutaneous and acoustic blink reflexes. *Physiological Psychology, 11,* 235–242.

Hodes, R. L., Cook, E. W. III, & Lang, P. J. (1985). Individual differences in autonomic arousal: Conditioned association or conditioned fear? *Psychophysiology, 22,* 545–560.

Hoffman, H. S., & Ison, J. R. (1980). Reflex modification in the domain of startle: I. Some empirical findings and their implication for how the nervous system processes sensory information. *Psychological Review, 87,* 175–189.

Klorman, R., Wiesenfeld, A., & Austin, M. L. (1975). Autonomic responses to affective visual stimuli. *Psychophysiology, 12,* 553–560.

Lacey, J. I., & Lacey, B. C. (1970). Some autonomic-central nervous system interrelationships. In P. Black (Ed.), *Physiological correlates of emotion* (pp. 205–227). New York: Academic Press.

Lang, P. J. (1968). Fear reduction and fear behavior: Problems in treating a construct. In J. M. Schlien (Ed.), *Research in psychotherapy* (Vol. 3, pp. 90–103). Washington, DC: American Psychological Association.

Lang, P. J. (1980). Behavioral treatment and bio-behavioral assessment: Computer applications. In J. B. Sidowski, J. H. Johnson, & T. A. Williams (Eds.), *Technology in mental health care delivery systems* (pp. 119–137). Norwood, NJ: Ablex.

Lang, P. J. (1985). The cognitive psychophysiology of emotion: Fear and anxiety. In A. H. Tuma & J. D. Maser (Eds.), *Anxiety and the anxiety disorders* (pp. 131–170). Hillsdale, NJ: Erlbaum.

Lang, P. J., & Greenwald, M. K. (1988). *The international affective picture system standardization procedure and initial group results for affective judgments: Technical report 1A.* Gainesville, FL: The Center for Research in Psychophysiology, University of Florida.

Lang, P. J., Öhman, A., & Vaitl, D. (1988). *The international affective picture system* (photographic slides). Gainesville, FL: Center for Research in Psychophysiology, University of Florida.

Leitner, D. S., Powers, A. S., Stitt, C. L., & Hoffman, H. S. (1981). Midbrain reticular formation involvement in the inhibition of the acoustic startle. *Physiology and Behavior, 25,* 291–297.

Öhman, A. (1979). Fear relevance, autonomic conditioning, and phobias: A laboratory model. In P. O. Sjoden & S. Bates (Eds.), *Trends in behavior therapy* (pp. 107–133). New York: Academic Press.

Requin, J. (1988, March). *Trans-cortical reflexes: A new way to study cognitive processes in human subjects?* Paper presented at Emotion, image and action: A conference on theory and research in psychopathology, performance, and cognition, Gainesville, FL.

Schneirla, T. C. (1959). An evolutionary and developmental theory of biphasic processes underlying approach and withdrawal. In M. R. Jones (Ed.), *Nebraska symposium on motivation* (pp. 1–42). Lincoln: Nebraska University Press.

Silverstein, L. D., Graham, F. K., & Bohlin, G. (1981). Selective attention effects on the reflex blink. *Psychophysiology, 18,* 240–247.

Simons, R. F., & Zelson, M. F. (1985). Engaging visual stimuli and reflex blink modification. *Psychophysiology, 22,* 44–49.

Sokolov, E. N. (1963). *Perception and the conditioned reflex.* New York: Macmillan.

Winton, W. M., Putnam, L. E., & Krauss, R. M. (1984). Facial and autonomic manifestations of the dimensional structure of emotion. *Journal of Experimental Social Psychology, 20,* 195–216.

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