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RIGHT HEMISPHERIC EMOTIONAL MEDIATION IN CLASSICAL CONDITIONING OF THE SKIN POTENTIAL RESPONSE IN HUMANS

by

Hans O. Beihl

A thesis
presented to the University of Manitoba
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
in
Clinical Psychology

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THE UNIVERSITY OF MANITOBA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a Ph.D. thesis entitled: Right Hemispheric Emotional Mediation in Classical Conditioning of the Skin Potential Response in Humans

submitted by Hans Beihl

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Hans O. Beihl

A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

DOCTOR OF PHILOSOPHY

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ABSTRACT

Laterality research indicates that the right hemisphere and associated limbic structures have specialized capabilities in the processing of affect. Other research in conditioning points to the importance of limbic functions in learning. On the basis of these two principal lines of evidence, it was hypothesized that right hemispheric emotional processes play a prepotent role in autonomic classical conditioning in humans. Using a between subjects design and a differential conditioning procedure, word CSs and the UCS (110 dB. of white noise) were presented to either the left or the right hemisphere (i.e., right visual field/right ear or left visual field/left ear). SPRs were recorded during acquisition and extinction phases. SPR responses in both the first latency interval (.5-5.5 sec. following CS onset) and second latency interval (5.5-9.5 sec.) were examined. Findings for first interval responses were opposite to predictions. Greater differential conditioning of the positive component of the SPR was found for CSs flashed to the right visual field as opposed to the left. For the second latency interval responses, predictions were partly supported. Larger conditioned responses were obtained for the right hemisphere-of-presentation condition on early trials. Among other findings, the semantic content of verbal stimuli was found to influence the electrodermal response. Conditioning effects were interpreted as consistent with a cognitive processing viewpoint in which, for verbal stimuli, the semantic systems of the left hemisphere appear to serve an important function. However, emotional processes of the right hemisphere also appear to contribute to the conditioned effect, and may be particularly active for high intensity stimulations. Models to account for the hemispheric effects were discussed, and future directions in research were proposed.

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Introduction

Research on the specialized functions of the cerebral hemispheres has become increasingly popular over the past two decades. A number of journals, including Neuropsychologia and Cortex, are devoted almost exclusively to this topic. This explosion of interest has its share of drawbacks. There is a strong tendency to "explain" complex phenomena from learning disabilities to hypnosis in terms of simplistic right/left dichotomies. Yet, this intense research activity has also opened the doors to new areas of knowledge, and has made it increasingly clear that hemispheric lateralization is much more complicated and puzzling than first thought. Current researchers are wrestling with the inadequacies of existent explanations in accounting for laterality effects, bringing into focus the complexity of factors influencing differential functioning of the hemispheres (Cohen, 1979; Hellige, Cox & Litvac, 1979).

The present study was aimed at investigating an area in laterality research which has received relatively little attention; namely differential hemispheric influences in conditioning. In brief, it was postulated that the right hemisphere serves an important mediating role in classical conditioning with aversive stimuli by virtue of its relatively specialized capabilities in emotional processing. This is not to say that left hemispheric processes are not capable of generating a conditioned response. Rather, it was posited that conditioning is relatively greater for right hemispheric involvement due to a more elaborate or extensive mediation of emotional processes in conditioning for that hemisphere. Emotional processes, in this view, were thought to mediate conditioning, and their unequal influence across hemispheres to result in differential conditioning effects. As a point of clarification, "mediating" emotional processes refers to intervening neural events between the stimulus and response, primarily involving the limbic system. These intervening events may include the activation and processing of memories relating to the aversiveness associated with the stimulus. These intervening activities of the limbic system and associated areas are considered to be a necessary condition in classical conditioning.

In what follows, the discussion begins with a general overview of research on the specialized functions of the cerebral hemispheres, and then leads to a more specific focus on the special role of the right hemisphere and subcortical systems in emotional processing and expression. Theoretical notions pertaining to emotional processing and the role it may play in conditioning are examined. Attention then turns to an examination of several studies which have shown differential hemispheric effects in conditioning, and finally, the present study is outlined in terms of aim and general approach.

Cerebral Lateralization

An abundance of research on cerebral lateralization has shown a general left hemisphere advantage for verbal stimuli or tasks and a right hemisphere advantage for nonverbal stimuli or tasks (Allard, 1971; Galin, 1974, 1975; Galin & Ellis, 1975; Galin & Ornstein, 1972; Kinsbourne, 1972; Ley, 1979b; Ley & Bryden, 1979a, 1979b; Ornstein, 1975; Pirozzolo, 1977; Sperry, Gazzaniga & Bogen, 1969; Wexler, 1980). Whereas the left hemisphere seems to be more accurate or faster in discriminating and identifying words, the right appears to be relatively better in processing faces (Geffen, Bradshaw & Wallace, 1971; Gilbert & Bakan, 1973; Hines, 1978), tactile patterns (Milner & Taylor, 1972), visual and spatial information (Geffen, Bradshaw & Nettleton, 1972; Gross, 1972; Ratcliff, 1979), melodic patterns and nonspeech sounds (Goodglass & Calderon, 1977; Kimura, 1973), and emotions (Ley & Bryden, 1979a, 1979b). The expressive capacity and syntax comprehension of the right hemisphere has been found to be highly limited (Gazzaniga & Hillyard, 1971; Levy, Nebes & Sperry, 1971). Although it is capable of voluntary action under certain condiions, generally, the right hemisphere plays a subservient role to the left in the initiation and control of voluntary motor activity (Zangwill, 1974).

A number of models have been devised to account for laterality effects. Kimura (1961, 1973) has proposed a directness-of-pathway model based on verbal/nonverbal stimulus classification. According to this model, performance is superior for a direct pathway as opposed to an indirect pathway to the appropriately specialized hemisphere for verbal or visuospatial processing. This model fails to recognize that any number of task requirements may be imposed on a given stimulus. In an attempt to address this problem, some theorists proposed that hemispheric asymmetries depend not on stimulus classification per se, but on the extent to which the processing "style" of the hemisphere is matched to the task requirements (Galin, 1974; Ley, 1979b; Ley & Bryden, 1977b). It has been argued that the left hemisphere tends to process stimuli in a logical, analytical, sequential fashion for which words are best suited, and the right tends to process stimuli in a diffuse, synthetic, gestalten way for which nonverbal stimuli are most appropriate (Carmon & Nachshon, 1971; Cohen, 1973; Levy-Agresti & Sperry, 1968; Martin, 1979; Nebes, 1971). Although some findings suggest a distinction along these lines, the evidence is sparse. Moreover, it is difficult to imagine what the neurophysiological parallel is for this difference in processing style. Rather than positing differences in processing style, it seems more defensible to argue on the basis of differences in memory content. That is, hemispheric facility in carrying out a task may largely depend on the fit between task requirement and the specific content of the memory systems of the hemispheres. Since task requirement tends to be correlated with stimulus class, the left hemisphere usually shows a verbal stimulus advantage and the right hemisphere a nonverbal stimulus advantage--in accordance with Kimura's model. It has been demonstrated, however, that there are numerous exceptions to this general pattern. As Marshall (1973) has correctly pointed out, the labels "linguistic skill" and "visuospatial skill", in themselves, offer little clarification of the formal nature of these abilities. Along similar lines, Vygotsky (1965) has indicated the need for a structural-psychological analysis of these functions.

Other explanations have been proposed to deal with the shortcomings of a verbal/nonverbal or analytical/gestalt dichotomization (Cohen, 1979; Hellige, Cox & Litvac, 1979). Kinsbourne (1970, 1975) has developed a hypothesis of selective perceptual orientation. According to this hypothesis, hemispheric differences depend on the balance of hemispheric activation. A gradient of attention exists across the sensory field, with attention greatest in the field contralateral to the most activated hemisphere. Performance is superior from those locations in space contralateral to the more activated hemisphere. The distribution of attention across the hemispheres is thought to be governed by concurrent work load and cognitive set. Although support exists for this model, conflicting results have been found for the effects of work load and cognitive set on hemispheric asymmetries which raise doubts regarding the posited mechanism of attentional shifts (Cohen, 1979).

Coding strategy may be another variable which needs to be taken into account. For example, Seamon and Gazzaniga (1973) found that hemispheric advantage could be reversed by switching from a verbal to an imaging coding strategy. To further complicate the matter, it appears that concurrent work load, task requirements, cognitive set, and coding strategy are not independent of each other. A successful explanation of laterality effects is also complicated by our limited understanding of hemispheric interactions and the role of the corpus callosum (Guiard, 1980). Evidence showing that the magnitude and direction of laterality effects can shift with changes in subjects, task, practice, stimuli, instructions, motivation, cognitive set, and experimental design has made it increasingly clear that hemispheric specialization is a Janus of many faces.

Emotion and the Right Hemisphere

Recent evidence has shown a right hemisphere advantage in processing emotions (Campbell, 1982; Ley & Bryden, 1979a). Dichotic listening studies have examined differential effects in processing auditory stimuli. King and Kimura (1971) demonstrated a left ear/right hemisphere (LE/RH) advantage in the identification of dichotically presented nonverbal sounds such as laughing and coughing. Carmon and Nachshon (1973) dichotically presented subjects with sounds of crying, shrieking, and laughing, and had them respond by pointing to a pictorial representation of the corresponding auditory stimulus. The greatest LE/RH advantage occurred for the "crying" stimulus, and smaller advantages were found for "laughing" and "shrieking". Ley (1980) reported a LE/RH advantage for judging the emotional tone of sentences (happy, sad, angry and neutral), and a right ear/left hemisphere (RE/LH) advantage for verbal content judgments. Haggard and Parkinson (1971) also found a LE/RH superiority for processing emotional tones in spoken sentences. Safer and Leventhal (1977) presented sentences, varying in emotional content and emotional tone of voice, monaurally to subjects. They found that subjects on their own accord used tone of voice cues in judging LE stimuli, and content cues in evaluating RE stimuli. Sugarman, Ley and Bryden (1980) reported an interesting dichotic study in which subjects had to identify emotionally positive, negative, and neutral sounding tone sequences (previously rated as such by another group), as well as rate each on an affect scale. A LE/RH advantage was shown; affect ratings, in either the positive or negative direction, were more extreme for the musical tone sequences presented to the LE.

Emotional processing has also been studied using conjugate lateral eye movement (LEM) as the dependent variable. Right or left gazing is taken as a sign of contralateral hemispheric activity. Although criticisms have been raised that the inferred link between LEM patterns and hemispheric activation remains unsubstantiated (Ehrlichman & Weinberger, 1978), these findings nonetheless show consistencies with other research worthy of attention.

It has been observed that left LEMs occur more frequently under stress than non-stress conditions (Tucker, Roth, Arneson & Buckinham, 1977), and in situations requiring subjects to recall emotional experiences and differentiate emotional words (Ley, 1979a; Schwartz, Davidson & Maer, 1975). These results seem to suggest that the generation of feelings is mediated more by the right than the left hemisphere. Other evidence in LEM research also suggests special involvement of the right hemisphere in emotions, although inferences are more indirect. Studies have demonstrated that left gazers are more emotional and internally oriented, and less verbal and analytical than right gazers (Gur, 1975; Meskin & Singer, 1974). Right hemisphericity has been found related to internalized anxiety (Day, 1964), self-reporting of more psychosomatic symptoms, greater repression, denial, negation and reaction formation as measured by a test of defense mechanisms (Gur & Gur, 1975), hysterical personality characteristics (Smokler & Shevrin, 1979), and greater hypnotic susceptibility (Bakan, 1969; Gur & Gur, 1974).

Tachistoscopic studies have investigated differential hemispheric performance in the processing of visual stimuli expressing different emotions (Dimond & Farrington, 1977; Ley & Bryden, 1977a, 1979a; Suberi & McKeever, 1977). In a typical study, cartoon drawings depicting different emotions were projected to the left or right hemisphere (Ley & Bryden, 1979a). Subjects were required to make "same" or "different" responses to a centrally presented face following each visual half field presentation. A left visual field/right hemisphere (LVF/RH) advantage was found for this task. Although there was no significant visual field difference for the mildly positive, neutral, and mildly negative emotional expressions, there was a strong LVF advantage for extremely positive and negative emotional expressions. Suberi and McKeever (1977), in a similarly designed study, also found that LVF/RH advantages were greater for emotional as compared to neutral faces. Using a somewhat different approach, Dimond and Farrington (1977) presented a humorous film (Tom and Jerry cartoon), a travel film, and a surgical operation film to the right or left hemisphere. They observed that heart rate was greater when the surgical film was presented to the right hemisphere. They also observed that significantly more ratings of "unpleasant" and "horrific" were made in judgments of the emotional content of both the Tom and Jerry film and surgical film, when projected to the right as opposed to the left hemisphere. Another study (Sackheim & Gur, 1978) reported that sadness, disgust, fear and anger intensity ratings of face composites were higher for RH projections, whereas happiness ratings were higher for LH projections. Ley and Bryden (1979c), in a novel study, showed that the right hemisphere advantage in a face recognition task was selectively augmented through the prior presentation of word stimuli high on imagery and emotional valence. They postulated that the word stimuli generated a mood shift, which favored right hemispheric activation.

The results of the dichotic and tachistoscopic studies suggest that emotional information conveyed by certain sound patterns and visuospatial configurations is processed better or more efficiently by the right hemisphere. It seems plausible that certain memory systems or schemata are activated by these patterns and configurations in the identification or discrimination process. That is, relevant visuospatial or acoustic patterns are activated along with affective memories of what they signifiy. This activation of visuospatial and sound patterns and associated affective experiences may not require verbal mediation. The schemata of associated experiences and feelings may have evolved as a separate system out of the explorations of the prelinguistic child in his visual, acoustic and affective environment (Brown & Jaffe, 1975; Ley, 1979b). Whereas language, by virtue of its symbolic nature, seems relatively far removed from the sensory experience of the world, the visuospatial, acoustic and affective memories attributed to the right hemisphere, seem a more direct representation of the world of experience.

It is particularly interesting that more extreme emotional stimuli lead to increased RH advantages (e.g., Carmon & Nachshon, 1973; Suberi & McKeever, 1977) and that RH projections produce more extreme emotional ratings (Dimond & Farrington, 1977). This may be explained in terms of a regulatory control of the left hemisphere over the emotional processing activities of the right; this control mechanism is circumvented through direct projections to the right hemisphere. There may also be a tendency for the left hemisphere to produce a "neutral" or "positive" response bias. It should be pointed out that some studies have yielded results which do not readily fit the interpretation that the right hemisphere is superior in processing emotions (e.g., Dimond & Farrington, 1977; Harman & Ray, 1977). For example, Dimond and Farrington reported that heart rate was higher when the Tom and Jerry cartoon was projected to the left as opposed to the right hemisphere. Harman and Ray have observed that the left hemisphere more than the right reflects changes in emotionality, as measured by EEG amplitude changes.

A few other studies with normals provide additional support for the notion that the right hemisphere is superior in emotional processing. Cohen, Rosen and Goldstein (1976) reported an increase in EEG amplitude in the right parietal regions of the brain during orgasm in normal males and females. Corteen and Wood (1972) had subjects shadow prose with the right ear in a dichotic listening task, while previously shocked words along with neutral words were presented to the left ear. Conditioned GSR responses to the shocked words were obtained. Interestingly, however, these authors observed that a reversal of ear presentations failed to produce a reliable effect (as cited in Martin, Stambrook, Tataryn & Beihl, 1980). The special role of the right hemisphere in emotional processing of the aversive significance of the words may account for this. Finally, one group of studies reported that the right extremities have a significantly higher pain threshold than the left (Haslam, 1970; Murray & Hagan, 1973; Murray & Safferstone, 1970).

It is interesting to note that dreaming, hypnotic susceptibility (Bakan, 1969, 1975, 1978; Graham, 1977; Graham & Pernicano, 1979), and imaging (Davidson & Schwartz, 1976; Morgan, McDonald & MacDonald, 1971; Robbins & McAdam, 1974) also appear to involve the right hemisphere relatively more than the left. Dreaming, in particular, may be closely related to affective experiences. The involvement of the right hemisphere in these activities along with visuospatial and emotional processing is perhaps interpretable in terms of adaptive significance. Visuospatial, acoustic, and other sensory processing is crucial for knowledge of the environment. Affect, from an evolutionary perspective, may well be an essential component of sensory processing and memory to direct the organism away from danger and engage it in those activities important for survival (Flor-Henry, 1979). Toda (1980), in the context of decision making processes, has attributed a similar importance to emotions. In contrast, the analytical decision system is viewed as a later evolutionary development which is less fundamentally linked to perception. Based on the significance attributed to emotions for effective interplay with the environment, one might postulate that conditioning is mediated by emotional processing systems and affective memory.

Emotional Disorders and Related Clinical Research

Depression. Studies of patients with various functional and neurophysiological disorders have provided a further understanding of functions of the hemispheres in emotional processing and expression. Research in which ECT was administered to depressed patients has revealed hemispheric differences. One set of studies (Deglin, 1973; Deglin & Nikolaenko, 1975) reported that shock induction to the right hemisphere produced smiling, joking, laughter and exclamations of joy. Greater difficulty identifying vocal intonations reflecting different emotions was also noted. Dominant ECT shock led to depression, anxiety, dysphoria, and fearful behavior. Deglin and Nikolaenko (1975) concluded, on the basis of these observations and EEG data, that the dominant hemisphere plays the principal role in the regulation of mood. The emotional reactions reported in these studies closely parallel those found in patients with unilateral brain lesions, and patients who have received unilateral intracarotid injections of sodium amytal.

The weight of the evidence suggests that unilateral nondominant ECT is at least as effective in relieving depression as bilateral shock induction (Cronin, Bodley, Potts, Mather, Gardner & Tobin, 1970; Flor-Henry, 1979; Galin, 1974; d'Elia, 1970; Robertson & Inglis, 1977; Sand-Stromgren, 1973). Gruzelier and Venables (1974) reported that electrodermal response amplitudes in depressed patients were greater on the left side. Myslobodsky and Horesh (1978) found that depressives produced more left LEMs, and higher electrodermal activity in the left hand than normals in a variety of tasks. Mandel (1975) reported success in relieving chronic pain, including backache and headaches in depressed patients through nondominant ECT. All these findings suggest that the nondominant hemisphere is fundamentally involved in depression.

Unilateral brain lesions. Different emotional reactions have been observed with left and right hemisphere lesions. Left hemisphere damage has been found to be associated with "catastrophic" reactions, characterized by crying, swearing, anxiety reactions and aggressive behaviors. In contrast, right hemisphere damage is associated with "euphoric" or "indifferent" reactions, characterized by indifference, jokes, minimizations, denial, and unawareness of obvious physical disabilities (Gainotti, 1969, 1972; Goldstein, 1939; Hecaen, 1962). Patients who have received intracarotid injections of sodium amytal have shown similar patterns of reaction to respective hemispheric inactivation (Ley, 1979b; Rossi & Rosadini, 1967).

Some studies have reported that patients with right parietal and temporal-parietal lesions demonstrate an impaired ability to evoke and discriminate between affective intonations (Heilman, Scholes & Watson, 1975; Tucker, Watson

& Heilman, 1977). Gardner, Ling, Flam and Silverman (1975) observed that right hemisphere lesioned patients reacted with more excessive mirth than left lesioned patients to humorous material. Loss or reduction of dreaming has also been found to be related to lesions of the right hemisphere (Humphrey & Zangwill, 1951; Nielsen, 1955).

It seems evident that emotional reactions differ markedly for right and left brain lesions. Hypotheses have been proposed to account for these patterns. Ley and Bryden (1979b) have postulated that the right hemisphere is mainly involved in the recognition and reception of emotional stimuli, whereas each hemisphere plays a role in expression. Along similar lines, Flor-Henry (1979) maintains that the neural substrate of emotions is localized in the nondominant hemisphere, and that each hemisphere is involved in the regulation of emotions. Euphoric or indifference responses in right brain lesions may be due to the dysfunction of affective memory in the nondominant hemisphere and a related contralateral loss of neural inhibition. This may evoke abnormal activation of the dominant hemisphere resulting in an acceleration of verbal thoughts and speech. On the other hand, the dominant hemisphere possibly regulates mood stability and dysphoric emotions. Damage to the dominant hemisphere may not only lead to language disorganization, but also to disinhibition of emotional activities of the opposite hemisphere, resulting in the emergence of negative reactions. In this schema, inhibitory or regulatory processes serve an important function in emotional expression. Observations that verbal abilities in the right hemisphere are improved in commissurotomized patients as compared to normals has been interpreted as support for the notion that the left hemisphere normally exerts inhibitory influences over the right (Moscovitch, 1976). Studies which have demonstrated that the corpus callosum can exert inhibitory and excitatory influences over the contralateral cortex (Asanuma & Osamu, 1962; Eidelberg, 1969) also make plausible the above hypotheses.

Schizophrenia and affective disorders. Flor-Henry (1976) has argued that the schizophrenic syndrome and psychopathy are manifestations of neuronal disorganization in the dominant frontotemporal regions, whereas affective disorders reflect perturbation of the nondominant anterior limbic areas. His conclusion is based, in part, on evidence showing a relation between schizophrenia and dominant temporal epilepsy, and to a lesser extent, a relation between affective disorders and nondominant temporal epilepsy. A more recent extensive analysis of neurophysiological, anatomical, and psychological data (Flor-Henry, 1979) gives further support to his contentions. Bakan (1978) has suggested that schizophrenia may be partly determined by a spill-over of right hemispheric hallucinatory and fantasy content into the left hemisphere, due to a breakdown of inhibitory controls. The findings that the brains of chronic schizophrenics have significantly enlarged corpus callosums (Rosenthal & Bigelow, 1972) and that surgical transection of part of these connecting fibres resulted in a reduction of hallucinations and anxiety (Laitinen, 1972) supports the idea that inhibitory mechanisms are dysfunctional between hemispheres. It appears, then, that the emotional quality of the schizophrenic's experience may, to some extent, be a consequence of an impairment of left hemispheric control over right hemispheric emotional processing.

Commissurotomies. Clinical observations of commissurotomized or "split-brain" patients have yielded important information about hemispheric functions. In split-brain patients, the two cerebral hemispheres appear to operate independently of each other, as if each person had two separate consciousnesses. Under special conditions (e.g., visual half field or dichotic presentations) it has been demonstrated that the one side of the brain is unable to know what the other side is doing (Sperry, 1966, 1968; Sperry, Gazzaniga & Bogen, 1969). The following is a popular example: During an experiment, a split-brain patient was flashed a picture of a nude woman to the LVF/RH. The patient responded that she saw nothing, but almost immediately smiled and chuckled. When asked what she was smiling about, she replied, "I don't know...nothing...oh, that funny machine" (Gazzaniga, 1967). The right brain apparently activated emotional, gestural and facial prompts which the left brain interpreted as best it could, unaware of the right brain's experience. In effect, the left hemisphere "rationalized" the emotional response of the right. This particular observation demonstrates the ability of the right hemisphere to independently generate an emotional response to an evocative stimulus. It also illustrates how the subtle expressive reactions of the right hemisphere can be overshadowed by the ascendancy of the dominant hemisphere in verbal expression. Hoppe (1978) reported that split-brain patients experience a paucity of dreams, fantasies and symbols, and that they have a high degree of alexithymia (impairment in the discrimination and evocation of emotions). This suggests that the dominant hemisphere, which does the reporting, no longer has access to the emotional and imagic processing capabilities of the nondominant hemisphere. Split-brain studies, then, add further support to the contention that the right hemisphere has an ascendant function in emotional processing.

Conversion hysteria and psychosomatic disorders. Ferenczi (1926) was one of the first to note that hysterics display a preponderance of left-sided conversion symptoms. Recent research has confirmed this observation (Galin, Diamond & Braff, 1977; Ley, 1978; Stern, 1977). A higher percentage of left-sided symptoms has also been reported for "hypochondriacal states" (Kenyon, 1964) and "nonarticular rheumatism" (Halliday, 1937). The predominance of left-sided symptoms and the tendency of hysterics to show indifference, denial or unawareness are characteristics not unlike those found in brain lesions of the nondominant side. Hoppe (1978) has viewed psychosomatic and conversion disorders in terms of a "functional commissurotomy", characterized as an interruption of preconscious streams of communication between hemispheres which leads to impoverished symbolization and the somatization of emotions. In these psychological disorders there may well be some kind of dysfunction in the right hemisphere, resulting in increased inhibitory influences of the left over emotional processes in the nondominant side. One can speculate that in neurotic anxiety fear arousing memories activated in the right hemisphere are inhibited by the left, and so denied symbolic verbal processing. The finding of alexithymic characteristics in psychosomatic patients (Sifneos, 1973) is consistent with these notions.

Other clinical observations. The special role of the right hemisphere in emotional processing is indicated in a number of other studies. Morgenstern (1970) showed that in 154 patients with unilateral or bilateral limb amputations, pain was significantly greater for left-sided amputations. Agnew and Merskey (1976) in a study of 128 patients found significantly greater pain experience occurred on the left side in both functional and organic illnesses. These findings are consistent with those obtained in investigations of pain tolerance in normals. Finally, Wechsler (1973) reported that right brain lesioned patients were somewhat more impaired than left brain lesioned patients in the recall of affective matarial.

Emotions: Theoretical Considerations

Theories of emotion have seen significant advances since the original formulation proposed by James (1884) that the content and nature of emotional experience is determined wholly by particular visceral and overt reactions to certain stimuli. Cannon (1915) laid James' theory to rest when he showed that only two broad patterns of autonomic discharge exist, dependent on the relative activation of the sympathetic and parasympathetic systems (Bindra, 1970). These two diffuse response patterns could not account for the variety of emotions that one experiences. This is not to say, however, that visceral reactions are unimportant in emotional experience (e.g., Cantril & Hunt, 1932). The importance of higher cerebral processes in emotional experience was demonstrated in the classic study of Schachter and Singer (1962). They showed that the same visceral reactions (produced through adrenaline injections) could lead to different emotional experiences (anger or euphoria), depending on the instructions given to the subjects, and the nature of the social situation. Cognitions, then, appear to be involved in the elaboration of emotions.

More recent neurophysiological and psychophysiological research has identified limbic systems as serving an important function in emotional processing. The limbic system includes the limbic lobe, neocortical structures and basolateral regions. The limbic lobe forms a mantle on the medial aspect of the cerebral hemispheres and includes the cingulate gyrus, septal area and hippocampal region. These structures have extensive interconnections with the neocortex, thalamus, and autonomic-neuroendocrine systems. The neocortical structures include the orbital frontal, insular and anterior temporal cortex as well as the amygdaloid bodies. There are considerable interconnections between these structures, the hypothalamus and limbic midbrain region (Gardner, 1975). Descending and ascending reticular systems have also been posited to play a significant role in mechanisms underlying emotional behavior (Lindsley, 1970). Descending pathways from higher cortical centres can generate arousal activity in the reticular formation, which can modify visceral and somatosensory activity, and ascending pathways can influence cortical excitability and inhibitory control.

The limbic system occupies both sides of the brain; however neurophysiological and psychological evidence indicates an asymmetrical distribution with the anterior limbic system displaced to the nondominant side by dominant structures associated with language (Flor-Henry, 1979). Clinical and anatomical research points to a special role of the left parieto-occipital and right fronto-parietal axis in human emotions. Lesions in the frontal limbic system, or disconnection of that system from the rest of the limbic circuits through interruptions in neocortical or subcortical regions appear to alter emotional organization. In a comprehensive analysis of the research, Flor-Henry (1979) concludes that the localization of cerebral systems regulating emotion is bilateral, whereas the neural substrate determining emotions is found in the nondominant anterior limbic system. As discussed earlier, this kind of conceptualization is successful in accounting for a variety of emotional reactions observed in patients with unilateral brain lesions, commissurotomies, schizophrenia, depression and related affective disorders, and conversion symptoms. Experimental studies attributing importance to right hemisphere in emotional processing are also consistent with the notions put forward by Flor-Henry, Ley and Bryden (1979b) and others.

A contralateral release hypothesis of the kind proposed by Flor-Henry is not the only plausible interpretation of the data. Indeed, the large inferential gap between molar behaviors such as the EEG and neurophysiological processes leaves much room for theorizing. Tucker (1981) makes a good case for an ipsilateral release hypothesis to account for emotional effects. According to this view, a unilateral lesion could result in the disinhibition of ipsilateral subcortical emotional processes and arousal systems. Tucker suggests that the depressive-catastrophic reaction following left hemisphere damage could reflect exaggerated functioning of the left hemisphere due to disinhibition of associated subcortical brain processes integral to anxiety or vigilance functions. This heightened arousal of left hemisphere processes could supress right hemisphere processes thus accounting for the depressed component of the emotional reaction. That is, suppression of right hemisphere arousal levels are thought to produce a depressed mood. This view is diametrically opposed to the contralateral release hypothesis, in that the latter holds that depression is related to the increased influence of right hemispheric processes over those of the left. For the case of right hemisphere damage, Tucker (1981) proposes that the positive emotional reaction found in patients may be due to an elevation of mood associated with the exaggeration of that hemisphere's arousal level. A relative decrement in the left hemisphere's contribution to affect and cognition may be manifested by a lack of anxiety.

Associated with the question of intra- and interhemispheric interaction in emotional behavior is that regarding the relative involvement of the right and left hemispheres in the generation of positive and negative emotions. Much of the experimental evidence seems to favor the view that positive emotions are under the control of the left hemisphere, and negative under the control of the right (e.g., Dimond & Farrington, 1977; Sackheim & Gur, 1978; Tucker, 1981). However, rather than slicing emotions in this artificial manner and attributing a different class to each hemisphere, it may be more accurate to view mood generation as under the control of right hemispheric processes (relative to the left) and mood expression as under the regulating influence of both hemispheres. The emotional valence observed in studies will depend on where in the emotional system probes are made, but this does not point to distinct neural substrates for positive and negative emotions. Rather, it seems to indicate the net influence of right hemisphere mood generation at that point in the system. Thus, for example, probes made to the left ear or left visual field will come in more direct contact with mood generation processes than those to the opposite side. It is not surprising, then, that affect ratings are often observed to be more extreme for RH as opposed to LH projections of emotional stimuli (e.g., Dimond & Farrington, 1977; Ley & Bryden, 1980). It is contended that the more extreme ratings are the consequence of more directly accessing right hemispheric emotional processes; projections to the left hemisphere are subject to less extreme ratings due to the inhibitory influences of the left over the right hemisphere. The left hemisphere is thus more positive than the right in certain situations not because of special processing capabilities for positive emotions, but because of the attenuated influences of right hemispheric emotional processes over left hemispheric projections.

Emotions and conditioning. Emotions, both from a phylogenetic and an ontogenetic perspective, seem basic to survival. Arnold (1970) has argued that all experiences arouse not only memory of similar things, but also the corresponding affect. It would seem that the capacity to differentiate between "pleasant" and "unpleasant" experiences is essential to the survival of the organism. This capacity may be closely related to learning and conditioning. It seems plausible that an important aspect of learning involves the emotional mediation of sensory and perceptual experiences--knowing what is "good" and what is "bad", knowing what to approach and what to avoid. It is perhaps not surprising, in view of the posited fundamental importance of affective knowledge for adaptive functioning in the environment, that some evidence does indeed suggest a relation between learning and emotions.

Bernstein (1979), Douglas (1972), and Fuster and Uyeda (1971) are among those theorists who have postulated that motivational/emotional systems play an intricate role in informational analysis and conditioning. Fuster and Uyeda

(1971) trained monkeys to press separate levers in response to two different visual stimuli. Correct response to the one stimulus resulted in food reward, and correct response to the other led to the avoidance of shock. Single cell activity in the limbic brains of these monkeys was recorded as they performed the discrimination task. Findings showed that the reactivity of limbic units to signals was higher in animals performing discrimination than in nonperforming animals. The researchers concluded that limbic structures, and particularly the amygdala, play an essential role in the identification of the motivational significance of stimuli. Other studies which have examined the effects of lesions also seem to indicate that the amygdala may be involved in the evaluation of the significance of sensory stimuli (Schwartzbaum, 1960; Ursin, 1965). In a recent study, Berger, Clark and Thompson (1980) examined neural activity in the hippocampus and other limbic system structures of the rabbit during classical conditioning of the nictitating membrane response. They concluded that the limbic system seems to play an important role in modulating subcortical brain mechanisms critical to conditioned behavioral responding. Lissak and Endroczi (1967) demonstrated that stimulation of limbic structures can affect conditioned responding. In this study, rats were trained to avoid shock by jumping to the sound of a bell. Subsequent stimulation of the dorsal hippocampus, the amygdaloid complex of nuclei and the basal septal region led to a gradual inhibition of the acquired conditioned response. After a 10 minute period of electrical stimulation, reestablishment of the CR required as many trials with reinforcement as had been given to the naive animals. Animal studies have also demonstrated that lesions in the septum, hippocampus and orbitofrontal cortex can result in the failure to avoid shock or acquire a conditioned emotional response to an aversive CS (Brady & Nauta, 1953; Duncan, 1971). Gorenstein and Newman (1980) suggest that the lack of response suppression represents a specific inability to learn the connection between the CS and shock. These kinds of findings seem to suggest a close connection between emotional processing and motivational factors on the one hand, and conditioning on the other.

In the longstanding debate over the nature of the conditioning process, different schools of thought have disagreed, generally speaking, on two fundamental theoretical issues, namely, the nature of the associative process, and the importance of reinforcement as a motivational construct in behavior change. The brief historical perspective which follows provides some context for the view adopted in the present study that conditioning is essentially a central associative process involving complex, and widespread neural events. These events are thought to be mediated in a crucial way by motivational/emotional processes of the limbic system and related structures; other systems such as those involving cognitive processing may also contribute in conditioning in humans.

In the conditioning controversy, two distinct streams of thought developed regarding the nature of the associative process in conditioning, identified as S-S and S-R veiwpoints. The former is essentially a a cognitive conception of learning emphasizing the reorganization of relationships among events. Such a cognitive viewpoint is not incompatible with a neurophysiological conception of conditioning (e.g., Maltzman, 1979). In contrast to the S-S position, the S-R viewpoint regards learning in terms of direct associative bonding between stimulus and response at a reflex or "cellular" level. Although historians are not in complete agreement, Pavlov, Lashley, Tolman, Guthrie and Hebb have been collectively viewed as early proponents of the S-S position. Generally, S-S theorists have minimized or rejected the notion of reinforcement as a motivational construct, whereas S-R theorists have emphasized the importance of this construct. Tolman (1932) provided the first full elaboration of an S-S theory. Central to his view was the concept of expectancy: the organism as it learns comes to behave in ways which seem to it to be consistent with anticipated consequences (Kimble, 1961). Thorndike, Hull and Skinner are key proponents of the S-R position. Kimble (1961) also views Guthrie as belonging to this group, although Razran (1955) places Guthrie in the S-S group.

Both Guthrie and Skinner have eschewed motivational constructs in their theorizing. Thorndike (1911) in his law of effect was the first to expound in detail the motivational role of reinforcement in conditioning.

Although S-S and S-R distinctions still persist today, a gradual convergence of these two schools of thought appears to be taking place (Kimble, 1961). Research on the limbic system points to the importance of motivational constructs in conditioning theory. Other research in the areas of conditioning without responding (i.e., experiments on drug paralyzed animals), latent learning, and perceptual learning has revealed the shortcomings of S-R viewpoints which focus mainly on events along efferent/afferent pathways. Much evidence indicates that learning is essentially a central process as opposed to peripheral (Kimble, 1961). Conditioning in the intact animal does not seem to be a simple matter of forming S-R bonds, but rather appears to involve widespread changes in neural activity as stimuli acquire informational significance (John, 1971; Livanov, 1977; Maltzman, 1979; Thompson, Patterson & Taylor, 1972). Studies which have demonstrated conditioning through electrical stimulation of the spinal cord, cerebellum and other structures (Brogden & Gantt, 1937; Finch, 1938; Loucks & Gantt, 1938) suggest that afferent pathways of the CS and UCS are not crucial in conditioning. Brickman and Schneiderman (1977), for example, classically conditioned blood pressure decreases in rabbits by pairing a tone with stimulation of the posterior lateral hypothalamus. Other studies suggest that the locus of conditioning is not to be found in efferent pathways. Hilgard and Allen (1938), for example, showed that conditioning does not occur if the UCR is directly elicited by stimulation of the motor pathway, but only if excitation is initiated by way of the CNS. Another group of studies ,in which animals paralyzed with curare or similar drugs were conditioned, indicate that occurrence of the overt response is not necessary for conditioning to take place (Beck & Doty, 1957; Brogden, 1947). Although a neuroanatomical locus of conditioning has by no means been established, it is clear that central associative processes of some kind play an important role in conditioning. It seems that a conception of conditioning in terms of direct stimulus-response connections is inadequate and must be replaced by one which acknowledges the importance of complex intervening neural events such as those of the limbic system. Recent research is increasingly moving in this direction. The function the hippocampus serves in the registration of temporal relationships between CS and UCS (Solomon, 1980) is one such area which is receiving much attention.

Given the importance of central associative processes in conditioning, it is not surprising that cognitive processes have been shown to play a mediating role in conditioning in humans. The weight of the evidence indicates that the verbalization of contingencies coincides with conditioning (e.g., Biferno & Dawson, 1977; Chatterjee & Erikson, 1960; Dawson, 1973; Dawson & Furedy, 1976; Maltzman, 1979). Whether contingency awareness is a necessary condition for conditioning is questionable (e.g., Martin, Stambrook, Tataryn & Beihl, 1980), nonetheless, the frequent correlation found between awareness and conditioning suggests that active perceptual and cognitive processes (and their neurophysiological counterparts) play an important function in classical conditioning in humans.

Conditioning Across the Hemispheres

It has been known for some time that both hemispheres are capable of learning. Experiments with commissurotomized cats and monkeys have demonstrated that conditioning and memory can occur independently in the separate hemispheres (Gazzaniga, 1971; Johnson & Gazzaniga, 1971; Myers, 1955, 1956; Sperry, 1959). Studies using potassium chloride to induce spreading depression in the separate hemispheres of rats have shown similar results (Ross & Russell, 1964; Russell & Ochs, 1961). These studies also demonstrated that transfer of learning from the trained hemisphere to the previously depressed hemisphere occurred in essentially an all-or-none fashion, following a single reinforced response. These results suggest that in intact brains, transfer of learning occurs spontaneously, without deliberate effort, from one hemisphere to the other.

In view of the fact that both hemispheres appear capable of conditioning, a question of interest is whether the left and right hemispheres mediate conditioning in ways commensurate with their relative verbal and emotional processing capabilities. In the case of the discriminative tasks performed by animals, conditioning likely does not depend on any specialized hemispheric functions; however, in humans there may be a basic bias to relatively greater RH conditioning modulated by such factors as the type of stimuli used (i.e., verbal or nonverbal) and their emotional significance. Individual differences in coding strategy and other specialized processing capabilities may also involve the left and right hemispheres in unequal ways in learning.

Few studies in the area of laterality research have examined differential conditioning effects across the two cerebral hemispheres. Von Wright, Anderson and Stenman (1975) reported lateralized differences in autonomic conditioning as an unexpected effect. In this study, different groups of subjects were required to shadow words in either the right or left ear, with identical word lists presented to both groups. One of these words was paired with shock. Following conditioning, a test phase was presented in which the CS occurred without shock, along with other filler words. Findings showed that 21/24 subjects who shadowed the left ear, but only 9/20 who shadowed the right ear, conditioned reliably to the CS in the attended channel. This differential conditioning effect is open to a number of interpretations.

One interpretation centres around the asymmetrical application of shock. All subjects were shocked in the left hand. Contralateral effects of aversive shock stimulation may be stronger than ipsilateral effects, resulting in the observed poorer conditioning in the left hemisphere. A second explanation hinges on response asymmetries. Von Wright et al. (1975) recorded SPRs from the right hand. Evidence indicates that unilateral hemispheric stimulation inhibits the contralateral electrodermal response to an alerting stimulus (Wilcott, 1969; Wilcott & Bradley, 1970). Hence, the CS presented to the right ear (left hemisphere) may have attenuated electrodermal responses in the right hand relative to the left. A third explanation implicates the special role of the right hemisphere in emotional processing, and its sensitivity to pain stimulation. For example, Haslam (1970) showed that in normals the nondominant hand had a lower pain threshold than the dominant. Shock stimulation may be processed as more aversive in the right hemisphere and as a consequence the CS acquires greater aversive significance for left ear presentations. These various explanations are not necessarily mutually exclusive.

Hellige (1975) examined individual differences in differential classical eyelid conditioning across the hemispheres. In this study, subjects were classified as either C-form or V-form responders based on their eyelid conditioning topographies. Considerable evidence indicates that C-form and V-form responders differ in consistent ways (Grant, 1968, 1972, 1973). V-form responders show rapid conditioning, more complete eyelid closure, and earlier onset latency than C-form responders. V-form responders also appear to be more influenced by the semantic features of stimuli during conditioning than C-form responders. Saltz (1973) postulated that the conditioning performance of C-form responders is less mediated by left hemispheric processes than it is for V-form responders.

On the basis of these distinctions between C-form and V-form responders, Hellige (1975) hypothesized that during conditioning C-form responders would show greater responsiveness to the semantic attributes of verbal stimuli when projected directly to the left hemisphere, since this would engage verbal processes normally relatively quiescent. No similar facilitation was predicted for V-form responders since they already made use of left hemispheric verbal processes. In the conditioning experiment, word stimuli were briefly flashed to either the left or right visual field. For half the subjects the word "BLINK" served as the CS+ and "DON'T BLINK" as the CS-; the reverse contingency applied to the other subjects. In the former instance, then, the words were congruent with the UCS (airpuff), and in the latter they were not congruent. The eyelid response served as the dependent measure. Subjects were classified as either C-form or V-form responders according to objective criteria.

A number of reliable effects were found. Among the more important, a significant 3-way interaction of reinforcement contingency (CS+ = BLINK vs. CS+ = DON'T BLINK) by eyeblink topography (C-form vs. V-form) by conditioning (CS+ vs. CS-) was obtained. Essentially, this revealed that conditioning, as measured by differential eyeblink responses, was much greater for V-form than C-form responders in the CS+ = BLINK group, but, slightly greater for C-form than V-form responders in the CS+ = DON'T BLINK group. This result is consistent with others (e.g., Bunde, Grant & Frost, 1970) and indicates that V-form responders are more influenced by the semantic content of verbal stimuli than C-form responders.

A small but statistically significant main effect was found for hemisphere-of-presentation. More conditioned responses occurred for stimuli projected to the left as opposed to the right hemisphere. Hellige (1975) interpreted this as reflecting a left hemispheric excitatory or positive response bias. This interpretation is likely incorrect in view of the hemisphere-of-presentation interaction effect obtained. This interaction showed that for C-form, but not for V-form responders, in the CS+ = BLINK group, the difference between CS+ and CS- eyeblink responses was significantly greater for the left hemisphere. Conditioned responses in the CS+ = DON'T BLINK group revealed no differences between the left and right hemispheres for either the C-form or V-form responders. The main effect, then, essentially reflects the increased conditioned responses of C-form responders to left hemisphere presentations of the CS+ = BLINK. The interaction effect, itself, supports the original hypothesis that conditioning for C-form responders as compared to V-form responders is normally less mediated by verbal processes since direct left hemispheric presentations of the CS resulted in a facilitation effect. V-form responders, on the other hand, may normally have a relatively higher level of left hemispheric activation.

These findings, in the context of the present study, are important in that they demonstrate that it is possible to obtain different conditioning effects across the left and right hemispheres using tachistoscopic techniques. This procedure is apparently quite robust. Hellige (1975) presented the same CS+ to the left and right hemispheres on a randomized basis. One would think that such a procedure would obscure differences, since at any point in the CS presentation series the history of the CS included "bilateral" presentations. Not only were both hemispheres likely continuously activated, but also each CS presentation was contaminated by its learning experience in the opposite hemisphere. The present study is designed to minimize this problem. Hellige's results are also important in suggesting that the mediating role of the two hemispheres may be determined by their specialized processing capabilities. In particular, conditioning was shown to be mediated by the semantic processing capabilities of the left hemisphere. The extent of the mediating role of the two hemispheres in conditioning may well depend on the conditioning contingency and individual differences in specialized processing capabilities. The conditioning procedure used by Hellige seems to involve semantic processing in a crucial way by virtue of the symbolic relationship between the verbal stimuli and contingency arrangement used. This bias may attenuate RH advantages in conditioning. It was postulated that a conditioning procedure relying more on emotional as opposed to semantic processing would favor right hemispheric mediation in the acquisition of the conditioned response.

A group of conditioning studies investigating a model of repression reported laterality effects which are of interest here (Hawryluk, 1977; Martin, Hawryluk, Berish & Dushenko, 1980). In one experiment, subjects were required to learn to criterion an A-B paired associate list consisting of nonsense syllable/real word pairs (e.g., CEF-STEM). Subsequently, with shock electrodes attached to their left hand, subjects were exposed to a list of distant (D) associates (e.g., SMELL, which through the inferred link of FLOWER is associated with STEM), receiving shock for some of these words. After conditioning was established according to a predetermined criterion, the nonsense syllables of the original A-B list were again presented (under a "no-shock" condition); however, this time they were flashed to either the right or left hemisphere on any given trial. Subjects were asked to verbally recall the real word associated with each nonsense word presented. Results showed a trend of reduction in the percentage recall of shocked versus nonshocked words for the LVF, but not for the RVF. In a second experiment, Martin et al. (1980) were able to demonstrate a similar, but significant, effect using a loud tone (110 db) as the UCS rather than shock stimulation. For the LVF, recall of the distant associates of the CS was 37.5%, and recall of the control words was 58.3%. For the RVF, 58.3% of the distant associates, but only 41.6% of the control words were recalled.

These findings may be interpreted as follows. The relatively poorer recall of the CS associated words as compared to the control words for LVF presentations may depend on the special mediating role of the right hemisphere in affective memory. Activation of the unpleasant memory regarding the CS association with shock may have led to inhibition effects, perhaps controlled by the left hemisphere or corpus callosum. Reduced recall of the CS associated words did not occur for RVF presentations since the affective memory system of the right hemisphere was more indirectly accessed. This indirect access to the affective significance of the CS associated words may have imbued them with sufficient emotional salience to facilitate recall over and above that for the control words. As a final comment, it is noteworthy that tasks of the kind used in the above experiments involving remembering familiar words are episodic as opposed to semantic (Kihlstrom, 1980; Tulving, 1972). That is, the words used in the studies are familiar ones whose meanings are well-established in memory. The task is not one of learning word meaning but one of remembering the special significance of the words in terms of their experimental context. Tulving (1972) has characterized this kind of remembering as episodic memory. This posited memory system is one concerned with personal experiences, which includes such aspects as reference to the self and a particular spatiotemporal context. This hypothesized episodic memory system has interesting parallels with the specialized capabilities of the right hemisphere. Thus, what ostensively appears to be a verbal task in the above experiments may involve specialized mediating activities of the right hemisphere.

Although the evidence is clearly limited, a few studies do suggest that the two hemispheres serve different mediating functions in conditioning. It may be that stimulus characteristics such as emotional significance and symbolic form (i.e., verbal versus nonverbal) and individual differences in processing capabilities and strategies are factors which influence the nature of the mediating roles of the two hemispheres in conditioning.

The Research Question

Given the importance of central associative processes and motivational/emotional functions in conditioning, left and right cerebral hemispheric processes--in particular, those involving the limbic system--may mediate differentially in classical conditioning. The present study is designed to investigate this mediating role in autonomic classical conditioning. On the basis of the evidence that the limbic system appears to be implicated in conditioning, and that the axis of the limbic system is displaced toward the right hemisphere in humans, the postulate was advanced that stimuli presented to the LVF may be conditioned more strongly than those presented to the RVF. In this central processing view, classical conditioning is regarded as an emotional appraisal process in which the limbic system plays a role in evaluating the emotional significance of stimuli. This appraisal process may involve some kind of stimulus matching with affective memory. The existence of more integrated and extensively elaborated affective schemata along with specific response labels in the right hemisphere may account for superior stimulus appraisal and conditioning predicted for that side of the brain.

Words were used as CSs in the present study. This choice was based on the consideration that verbal stimuli would allow for a rigourous test of the hypothesis of greater conditioning for LVF presentations. Since semantic processing of verbal material tends to be more efficiently accomplished by the left hemisphere, obtaining a finding of superior conditioning for right hemispheric presentations could not be reasonably attributed to the verbal nature of the stimuli. Unlike Hellige's (1975) study, there is no semantic relationship in the present study between the verbal stimuli and the response of the subject in the conditioning contingency. The view was taken that semantic processing is not necessary for conditioning to occur in the present study, since all that is required to differentiate the CSs is to note their differing perceptual configurations. For this reason, even though verbal materials were used as stimuli, the influence of verbal processes of the left hemisphere was considered to be minimal. The position was taken that the word stimuli would acquire significance through an emotional appraisal process more under the influence of the right than the left hemisphere.

The type of learning involved in the present study, which utilizes an aversive classical conditioning paradigm, must be distinguished from paired-associate learning. It seems likely that paired-associate learning relies, to a relatively greater extent, on verbal processes of the left hemisphere. For this reason, it is not surprising that the following two studies failed to obtain a right hemispheric effect in learning.

In one of these hemispheric learning studies (Dimond & Beaumont, 1974a), subjects performed an incidental learning task in which a series of 4-digit strings were presented to either the left or the right visual field, with digits occurring in one of 4 colors. During the experiment, subjects were required to recall the four digits after each string presentation. Also, at the end of the experiment, subjects were required to recall the color in which each digit occurred. No hemisphere differences were found in recall of digits or colors. The authors concluded that apperceptive processes of learning are equally efficient for the left and right hemispheres. In a second study (Dimond & Beaumont, 1974b), subjects were given a paired-associate learning task in which digit/key symbol pairs were flashed to either the left or right hemisphere. The reseachers found a superiority for the left hemisphere for both right and left handers. They suggested that this type of learning is an effortful intentional one favoring the symbolic capabilities of the left hemisphere.

The present study consists of a pilot experiment and a main experiment. The pilot experiment was conducted for two reasons: first, to determine if the verbal stimuli that were to serve as conditioned stimuli in the main experiment were neutral in emotional valence and semantically unassociated with each other; second, to test for the possibility that the UCS (a loud noise) may be experienced as more aversive or unpleasant when presented to the one ear rather than the other. These checks were intended to eliminate those factors likely to confound results by virtue of their differential hemispheric influences in the processing of information.

A between-subjects design was used in the main experiment, with one group having word stimuli presented to the left visual field (LVF), and the other to the right visual field (RVF) during the acquisition and extinction phases of conditioning. The design used in the present study is unique in its use of separate groups for the presentation of conditioned stimuli to the one or the other hemisphere, thus minimizing possible confounding of left and right hemispheric conditioning effects with the history of CS presentations to the opposing hemispheres. The UCS was presented to the same side as the CS; that is, left ear (LE) for left visual field conditioned stimulus presentations, and right ear (RE) for RVF presentations. For either the left or the right visual field condition, then, visual CSs (the words

CROWD and CLOTH) and the auditory UCS directly activated the same contralateral hemisphere. Although ipsilateral and contralateral pathways are activated by unilateral auditory stimuli, animal research (Rosenzweig, 1951) and clinical evidence (Penfield & Rasmussen, 1950) indicates that the contralateral pathways from the ear to the auditory cortex are stronger than ipsilateral pathways. This procedure of presenting the CSs and the UCS directly to a single hemisphere, and so largely initiating activation in either the left or right side of the brain, has been found to be sufficient in producing laterality effects in conditioning and learning in the intact brain (e.g., Martin, Hawryluk, Berish & Dushenko, 1980), even though there is no assurance that the opposite side of the brain was inactive or uninvolved.

The main dependent measure used in the present study was the skin potential response (SPR), an endosomatic measure of electrodermal activity. Although the skin conductance response (SCR) is the electrodermal measure typically used in human conditioning research (e.g., Hammond, Baer & Fuhrer, 1980; Maltzman, Langdon, Pendery & Wolff, 1977; Ohman, Fredrikson, Hugdahl & Rimmo, 1976; Von Wright, Anderson & Stenman, 1975), the SPR has a number of theoretical and practical advantages (Glaus & Kotses, 1974). In contrast to the SCR, the SPR is a more direct measure of cellular activity; the SPR is free of possible artifactual influences due to the distortions in cellular activity which might arise from the passage of an electric current through the skin. In addition, it may potentially yield additional information beyond what the SCR provides (Edelberg, 1967). That is, the positive and negative components of the complex SPR wave form may respond differentially to stimulus parameters. For example, researchers have postulated that the positive component of the SPR reflects defensive responding (DR) and the negative component, orienting responses (ORs) (Raskin, Kotses & Bever, 1969; Tataryn, Stambrook & Martin, 1980; Uno & Grings, 1965). The SPR has also been found to have a more stable baseline and reduced electrode polarization problems (Burstein, Bergeron & Epstein, 1965; Venables & Christie, 1973).

In view of the above advantages, and the fact that successful research has been carried out in this experimental laboratory using the SPR, it was considered an appropriate dependent measure in the present study. Since there is little agreement on what the wave components signify (Glaus & Kotses, 1974; Holmquest & Edelberg, 1964), and how best to measure the SPR, several response measures of the SPR were examined. It was also thought that a comparison of these measures might serve to clarify issues surrounding the interpretation of this electrodermal event. In the present study, the SPR was measured in terms of latency, frequency, probability, magnitude, and amplitude. Except for latency, measures were applied separately to the positive and negative components of the SPR; separate analyses of the first and second latency intervals following the onset of the CS were carried out. The reader is referred to Appendix F for an extended discussion of problematic issues relating to the measurement of the SPR.

The "amount" or extent of conditioning was determined by differential responding to the CS+ and CS-. One of the main advantages of using a discrimination or differential conditioning approach is that the subject serves as his own control.

Sensitization effects, if they differ across conditions, can lead to interpretative difficulties. Sensitization, here, refers to the strengthening of an original response to the CS through its pairing with the UCS (Prokasy & Kumpfer, 1973); that is, the response may be due to the appearance of the CS and not necessarily the UCS. As a check on sensitization effects, responses to the CS- were compared across conditions.

In addition to the use of the SPR as a dependent measure, semantic differential ratings of the CS words were also used. These pre- and post-conditioning ratings of the CSs on a 7-point scale were included in the present study to provide a measure of conditioning independent of electrodermal responding. It was thought that such data on evaluative shifts in the significance imparted to simuli through the process of conditioning might provide further information on the nature of the central processes involved in conditioning. In sum, the present study takes the position that aversive classical conditioning in humans is a complex central associative process. It is posited that the right hemispheric emotional appraisal processes involved in the evaluation of stimulus significance play a prepotent role in conditioning; this, however, does not exclude a contribution of other important processes such as, for example, cognitive ones.

Hypotheses

1. A hemisphere-of-presentation by conditioning interaction effect was predicted, with greater differential conditioning for stimulus presentations to the right as compared to the left hemisphere. A similar effect was predicted for extinction, with more resistant extinction for right as compared to left hemisphere presentations of the CS. This hypothesis is based on the posited special role of right hemispheric emotional processes and affective memory systems in autonomic classical conditioning.

2. A hemisphere-of-presentation by conditioning by trials interaction was predicted. Acquisition was expected to be quicker and extinction slower for stimulus presentations to the right as compared to the left hemisphere.

3. It was predicted that the verbal stimuli that had been paired with the loud noise (UCS) during conditioning would be affectively experienced as more "unpleasant" following conditioning as compared to those verbal stimuli that had not been paired with the loud noise.

4. It was predicted that there would be a direct relation between how aversively the loud noise was experienced and the size of the mean differential response to the CS+ and the CS-.

5. It was predicted that there would be a direct relation between how aversively the loud noise was experienced and the size of the maximum SPR during conditioning.

6. It was predicted that there would be a direct relation between how affectively "unpleasant" the CS+ was experienced and the size of the mean differential response to the CS+ and the CS-.

7. It was predicted that there would be a direct relation between how affectively "unpleasant" the CS+ was experienced and the size of the maximum SPR during conditioning.

PILOT STUDY

Purpose

The pilot study was conducted for two reasons. One of these was to determine if the conditioned verbal stimuli to be used in the main experiment were neutral in emotional valence and verbally unassociated with each other. The other reason was to determine if the UCS, a burst of 110 dB. of white noise, was experienced as equally aversive or unpleasant for left and right ear presentations. If not, this would lead to difficulties in interpretation of results found in the main experiment, since any differences in conditioning effects found across the hemispheres would be confounded by level of aversiveness of the UCS.

Method

Subjects. Sixteen male students in introductory psychology were tested. All had normal hearing and vision, and were right-handed on at least 12 out of 14 criterion questions (Raczkowski, Kalat & Nebes, 1974), with the condition that writing, throwing, and kicking were among the right-handed activities.

Apparatus. Subjects were tested in a sound-proof chamber with controls situated in an adjacent room. Comfortably seated, subjects were exposed to 1 second bursts of white noise at 110 dB. delivered by a Grason-Stadler model 901B noise generator via headphones. A Vector Graphics microcomputer was used to control noise presentations.

Stimuli and materials. In addition to the loud noise stimulus, subjects were required to complete three questionnaires, two relating to the verbal conditioned stimuli to be used in the main experiment, and one dealing with the loud noise presentations. One questionnaire required subjects to free associate to a given word (one of the four words, CLOTH, CROWD, COAST and CHAIN to be used as verbal stimuli in the main experiment) and to write down the first ten of these associations as they came to mind. The four words, themselves, were chosen from a word frequency list compiled by Kucera and Francis (1967). This word list or "corpus" is a body of words of natural-language text sampled from a wide range of subject matter and prose style. The four words chosen, are equal in length, all begin with the same letter, and have approximately equal word frequencies. The respective frequencies of the four words CROWD, CLOTH, COAST and CHAIN are 53, 43, 61 and 50. These frequencies are based on a corpus of over one million words.

The second questionnaire required subjects to rate a number of words along a dimension of "pleasant/unpleasant" in order to determine the emotional valence of the words. The four verbal stimuli to be used in the main experiment were embedded among other words of positive, negative, and neutral connotations to provide a context for rating (see Appendix A). The ratings of the filler words were of no interest in the present study.

The third questionnaire required subjects to record their ratings of the loud noise. During presentations of the white noise stimulus, subjects were to rate each occurrence of the noise along a dimension of painfulness ("extremely painful" to "not at all painful"). A 7-point rating scale was used for this purpose, with "1" representing "extremely painful".

Experimental design. With regard to the word association questionnaire, 4 subjects were assigned the word CLOTH, 4 subjects were assigned CROWD, 4 subjects were assigned COAST, and another 4 subjects were assigned CHAIN. This was done on a random basis. (Note: Each subject was only assigned one word to avoid the possible problem of associations carrying over from one word to another.) With regard to the loud noise presentations, each subject was exposed to 12 bursts, 6 to one ear followed by 6 to the other ear, with an ITI of 1, 1.5 or 2 minutes ($M = 1.5$). First and second ear of presentation were counterbalanced across subjects.

Procedure. Subjects were told that the purpose of the experiment was to learn something about people's reactions to certain kinds of words and noises. Subjects were first given the word association questionnaire. Subjects were then asked to follow the instructions of the emotional valence questionnaire, rating words in terms of "unpleasant"/"pleasant". Next each subject was taken to an adjoining sound-proof chamber for the loud noise presentation phase of the experiment. The subject was seated comfortably in a chair and was told that he would hear periodic short blasts of noise at loud but safe levels through a set of headphones he would be wearing. He was told that he would first hear the noises through one ear and then the other. The subject was given the noise rating questionnaire, and told to rate each noise in terms of "painfulness" according to the instructions. Each noise was rated immediately following its presentation. At the end of the experiment subjects were debriefed. All subjects were tested individually.

Results and Discussion

Inspection of responses to the word association questionnaire revealed that none of the four verbal stimuli (CLOTH, CROWD, COAST and CHAIN) had common associations. The most frequent associations to each of the four words are to be found in Appendix B.

The same four words were analyzed in terms of emotional valence based on responses to the emotional valence questionnaire. Table 1 below provides the means and standard deviations of the pleasantness ratings of these words. The word CLOTH was closest to the neutral point: CHAIN and CROWD received negative ratings, although close to the neutral point, and COAST received the most positive rating, although only a point past the neutral point. The standard deviations suggest a good deal of overlap of distributions of ratings for the four words. A t-test for correlated samples revealed no significant differences in emotional valence ratings for the words CLOTH and CROWD, $\underline{t}(15) = 1.85, \underline{p} = .08$. T-tests of other word pairs showed significant differences for some and no differences for others. For example, pleasantness ratings for COAST and CLOTH were found to be significantly different, $\underline{t}(15) = 2.30$, $\underline{p} < .05$.

Although there may have been carryover effects in the sequential ratings of words on the stimulus list, it is unlikely these effects distorted the ratings of the key words to any significant degree. This conclusion rests on two points. One, subjects were required to read over the entire list of words prior to rating individual words; it would thus seem that this would provide a cognitive set with clear positive and negative bounds to orient individual stimuli in terms of emotional valence. Second, results reported below for the main experiment indicate essentially

TABLE 1

Ratings of Four Words on a 7-point Scale having the Polar Adjectives "unpleasant" (1) and "pleasant" (N = 16)

Word	Mean	Standard Deviation
CHAIN	3.50	0.63
COAST	5.19	1.05
CLOTH	4.50	1.00
CROWD	3.63	1.45

identical ratings for the words CLOTH and CROWD as obtained in the pilot study. In the main experiment, however, no filler words were used in the rating questionnaire.

Results were also analysed in terms of painfulness ratings of the bursts of loud noise presented to the left and right ears. No significant difference was found between left ear (M = 3.54, SD = 1.38) and right ear (M = 3.30, SD = 1.05) presentations, t(8) = .96, p = .36. Analysis of data also revealed no significant difference between ratings of the noise presented to the first ear and second ear of each subject, t(8) = .80, p = .45. Note that these results are based on a sample size of 9 rather than 16. Originally the rating scale for the loud noise had the polar adjectives "unpleasant"/"pleasant". Due to a ceiling effect at the negative pole, it was decided to change the polar words to "extremely painful"/"not at all painful" to allow for a greater spread in responses. This made it necessary to reject the noise ratings of the first 7 subjects who were given the original scale.

In sum, the findings indicate that the four words CROWD, CLOTH, COAST and CHAIN are verbally unassociated, and neutral or close to neutral in emotional valence. In addition, the noise ratings suggest that there are no significant differences in experienced aversiveness for the right and left ear presentations.

Although there are differences among the four words in terms of their emotional valence, none of them have extreme means. This is unlike a word such as VOMIT whose emotional valence was found to be extremely negative (close to 1 on the 7-point scale). That the words fall close to the neutral point is sufficient for the purposes of the main experiment. It was decided to use the words CLOTH and CROWD as the CSs since there is considerable overlap of individual ratings both above and below the neutral point of 4 on the semantic differential scale. The difference between the mean ratings of these two words was found to be nonsignificant.

MAIN EXPERIMENT

Method

Subjects. Forty male students in introductory psychology were tested. All had normal hearing and vision, and were right-handed on at least 12 out of 14 criterion questions (Raczkowski, Kalat & Nebes, 1974), with the condition that writing, throwing and kicking were right-handed activities.

Apparatus. Subjects were tested in a sound-proof chamber with controls situated in an adjacent room. A Scientific Prototype, Model GB, 3 channel tachistoscope was used to present stimuli to the right and left visual fields. It was important that the stimuli were placed at the correct degree of eccentricity from the central fixation point to ensure nonfoveal vision. It has been found that foveal and parafoveal vision extends as far as 2.5 degrees either side of the fixation point, and that acuity falls off quite rapidly at distances greater than 5 degrees off centre (Bouma, 1976). White (1972) has suggested that the inside edge of the stimulus should subtend at least 2 degrees of visual angle. In light of this, stimuli were placed off-centre so as to subtend 2.75 degrees of visual angle. Cohen

(1977) has noted that for visual half field presentations, the exposure duration of the stimulus should be limited to a time less than latency of eye movement, estimated at 180 to 200 msec. Stimuli were therefore exposed for a duration of 150 msec. A Grason-Stadler Model 901B noise generator was used to deliver 1 sec. bursts of white noise (UCS) at 110 dB. via headphones to either the left or right ear. A Cyborg SPR P505 was used to record electrodermal responses from the right hand. A Vector Graphics microcomputer was used to control the stimulus presentations and record electrodermal responses.

Stimuli. The verbal stimuli consisted of the words CROWD, CLOTH, COAST, and CHAIN. All words appeared in black print on a white background; one set of words was positioned in the left visual field and the other in the right visual field. The words were individually mounted on 17.8 X 12.7 cm. white cards; the letter type consisted of 42 point Microgramma Bold Extended (Letraset) with letters measuring 1.4 cm. in height. Instead of the usual horizontal placement, words were vertically positioned to avoid visual field overlap, and they were read from top to bottom. The centre point of the letters of the words were positioned 5.5 cm. off-centre and subtended 2.75 degrees of visual angle. The inner edge of the letters was no less than 4 cm. off-centre, subtending a visual angle of 2 degrees. Stimulus cards, when positioned in the tachistiscope, appeared at a viewing distance of 114.3 cm. from the subject.

For each subject, one of the two words CLOTH and CROWD served as the CS+ (i.e., it was paired with the UCS) and the other served as the CS- (i.e., it was not paired with the UCS). These two conditioned stimuli were counterbalanced across subjects in terms of which served as the CS+ and the CS-. The CSs were always projected to a single hemisphere (left or right) for any given subject. The two words COAST and CHAIN served as the diversionary stimuli, and were always projected to the opposite hemisphere for any given subject. These stimuli were never associated with the UCS. Their appearance in the opposite hemisphere was intended to avoid eye drift to the side of the visual field involved in conditioning, so as to ensure that the conditioned stimuli were projected directly to only the one hemisphere.

Procedure. Prior to conditioning, the subjects were asked to indicate on separate 7-point rating scales how "pleasant" or "unpleasant" they experienced each of the four verbal stimuli. This served to establish if the words were neutral in emotional valence.

Following this, subjects were asked to wash their hands with soap and water (Venables & Christie, 1973) to ensure good electrode contact. Subjects were then taken to an isolated soundproof chamber where they were comfortably seated in front of the tachistoscope. Subjects were told that the purpose of the experiment is to learn about the ways different kinds of people react to very fast presentations of verbal stimuli. They were informed that words would be flashed very quickly at irregular intervals through the tachistoscope, and that at times a burst of loud noise would also be presented through a pair of headphones. It was emphasized to the subjects that they relax throughout the stimulus presentations and that they fixate on a central dot which would appear prior to each stimulus presentation; fixation is important, it was explained, so that the image of what they are looking at always occurs at a specific location on their retina. It was suggested to subjects that being able to predict when the loud noise will occur may make it less aversive; they were told to try to find the relation between the loud noise and the words so that they would be able to predict when the noise would occur. Once testing was in progress, subjects were reminded at various points to ensure that they attend properly and fixate on the central dot.

Prior to electrode attachment, subjects were told that the purpose of the electrodes is to measure their reactions to the words they see. They were assured that they would receive no shock and that the electrodes actually measure changes in cell activity in their hands. It was also explained to each subject that a very small area on the back of his right hand would be rubbed shiny to ensure that electrode contact with his skin is good. The electrodes used were spring-loaded hand assemblies for the Cyborg SPR P505.

The electrode cups were filled with Beckman electrode-electrolyte paste, and the spring-loaded assemblies were then attached to the subject's right hand with the white electrode located on the palm and the black electrode on the back of the hand. Each subject was informed that he should place his hand in as relaxed position, so that he would feel comfortable throughout the session. A pair of headphones were placed on his head after having been told that he would hear bursts of loud noise at various intervals through one of his ears.

Subjects were tested one at a time in a session lasting about 75 minutes. During both acquisition and extinction phases of conditioning, CSs were immediately preceded by a centering dot which lasted for .5 sec. For any given subject, CSs were presented to only one visual field, and the diversionary stimuli were presented to the opposite hemisphere. Each presentation of the CS+ was followed by a 1 sec. burst of white noise, presented to the same side (i.e., LVF CS+/LE UCS and RVF CS+/RE UCS). By limiting all stimulus presentations to one side, it was hoped that the lateralization effects in conditioning, predicted to occur, would be maximized. The UCS followed the CS+ 5 sec. after onset. This interval was considered sufficient to allow the SPR to the CS+ to develop ahead of any response which may be induced by the UCS. The ITI was 35 to 45 sec., with a mean of 40 sec. For each subject, skin potential responses were sampled 50 times per second by microcomputer across an 11 sec. interval for each trial. Figure 1 depicts the sampling interval used, and indicates the points at which the CS and the UCS (acquisition only) occurred.

The acquisition phase in conditioning consisted of 15 trials of the CS+ and 15 trials of the CS-. This phase was immediately followed by an extinction phase (without the subject having been told that the UCS would no longer be presented) consisting of 10 nonreinforced trials for each of the CS+ and CS-. Diversionary stimulus presentations were interspersed among the CS presentations; however, they always occurred in the opposite hemisphere and were never associated with the UCS. The order of stimulus presentations for the CS+ and CS- were randomized with the restriction that the same stimulus not occur more than twice in succession in that particular visual field. The two diversionary stimuli were similarly randomized, with the restriction that the same stimulus (e.g., the word CHAIN) not occur more than twice in succession in that particular visual field (which was the one opposite from the visual field in which the CSs appeared). The order of conditioned/ diversionary stimulus presentations (which amounts to the same thing as the order of visual field activation by the stimuli) was randomized with the restriction that no diversionary stimuli (or CSs) occurred more than twice in succession in the complete sequence of all verbal stimuli

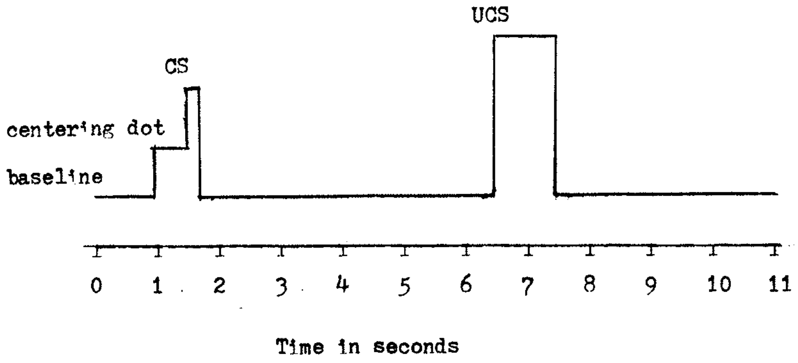


Figure 1. A schematic of the 11 second data collection interval for each S on each trial during which skin potential responses were sampled 50 times/second. A baseline was recorded for 1 sec. prior to the appearance of the centering dot. The CS immediately followed for 250 msec. The UCS followed the CS by 5 sec. and was 1 sec. in duration.

presented to the subject. Subjects on a randomized basis were presented one of two prepared sets of stimulus sequences. Each stimulus set consisted of 25 presentations each of the CS word CLOTH and CS word CROWD, and 25 presentations each of the diversionary word COAST and the diversionary word CHAIN. Appendix C provides the presentation sequence of the four words in each of the two stimulus sets. One half of the subjects in each experimental condition received the one set of stimulus sequences and the remaining half received the other set of stimulus sequences. For the one stimulus set the first presentation of the CS+ preceded the first presentation of the CS-, whereas for the other stimulus set the first presentation of the CS+ followed the first presentation of the CS-. In effect, then, half the subjects in the experiment were exposed to the CS+ first and half to the CS- first. (This order of initial exposure applies to the CSs taken in isolation of the diversionary stimuli. In fact, however, diversionary stimuli were interspersed among CSs and in the case of the one stimulus set the first stimulus presentation was a diversionary one.)

Following the acquisition and extinction trials, subjects were told to indicate on 7-point semantic differential scales how "unpleasant" or "pleasant" each of the four word stimuli were experienced and how "painful" the UCS was experienced.

Response definition. A Vector Graphics microcomputer was used to sample and record the raw SPR data. For each subject, the raw data was sampled 50 times per second across an 11 second interval. The waveform from each subject was inputed to the computer through an A/D converter (8 bit). The A/D sensitivity value was empirically determined; using a voltage generator, voltage signals of known magnitude were input to the computer through the A/D converter and the descrete values (D.V.) output by the computer were recorded. The D.V.s were found to be a linear transformation of the millivolt units. Appendix D illustrates the linear relationship between the two units. The A/D sensitivity value was found to be .16 mV./D.V. All SPR statistical analyses were carried out on scores in D.V. units and the corresponding findings were reported in those units. Reporting results in D.V. units rather than millivolts does not affect interpretations and had the advantage of facilitating referral back to the original raw data records for the purpose of exploring response patterns and cross-checking means.

A microcomputer program written in BASIC was used to generate latency and wave deflection values from the raw data for each subject for the 15 acquisition trials and the 10 extinction trials. Only deflections representing an absolute change of .5 mV. or greater from the baseline were counted as responses. The choice for this response criterion was based on both an inspection of the raw data for patterns of random fluctuation about the baseline and the fact that this criterion has been used in other studies investigating the SPR (e.g., Gaviria, Coyne & Thetford, 1968; Glaus & Kotses, 1974). The base level at stimulus onset on each trial served as a reference from which the polarity of subsequent phasic responses was determined. Virtually no shifting of baseline levels occurred across trials. Uniphasic potentials were scored as negative or positive responses, respectively, according to whether wave deflection was in the direction of increasing or decreasing negativity relative to the reference level. In the case of multiple responses to the stimulus, the following criteria were applied. In the region of increased negativity relative to the reference level, successive negative-going deflections (i.e., successive troughs of which only the last returned to baseline) were scored as separate negative responses, provided that two conditions were met. One, each of the successive negative-going deflections had to show a partial return to the baseline from its low point by an amount which reflected at least a .2 mV. change in potential. Second, each successive trough had to show at least a .2 mV. decrease in potential from any preceding partial return to baseline of the negative wave. In short, these to conditions required a decrease in potential of at least .2 mV. in the approach to a trough and an increase in potential of at least .2 mV. in the return to baseline, for the trough to be counted as a separate wave deflection. Any approach to a trough or partial return to baseline which constituted less than a .2 mV. change in potential was interpreted as random noise in the system. The same .2 mV. criterion was adopted for deflections in the positive region. Successive peak to trough deflections which crossed the reference level were scored--as in the case of uniphasic responses--according to the polarity of the region in which each occurred. Figure 2 illustrates the application of these scoring criteria for typical deflections. No wave deflection that occurred prior to .5 sec. after stimulus onset was counted as a response; this was intended to avoid scoring possible artifactual responses.

Trials were blocked in groups of three, and the computer-generated response data was scored in terms of latency, frequency, m-amplitude, and probability. (See Appendix F for a more extensive discussion of these response measures.) These dependent measures were analyzed separately and in combination using a multivariate approach. Frequency was measured as the average number (for the trial block) of positive- or negative-going deflections in any given response to the CS presentation. Latency was defined as the average time (for the trial block) between CS onset and the point at which the first response exceeded .5 mV. Probability was measured as the proportion (for the trial

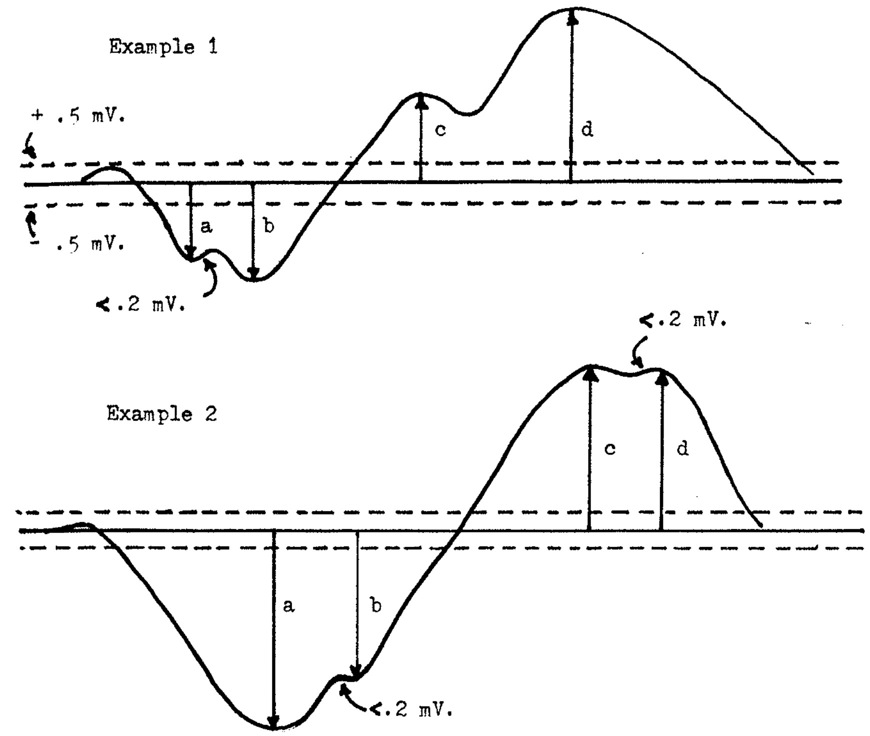


Figure 2. Several examples of how scoring criteria were applied to SPR wave forms. In example 1, deflection (a) is not counted as a response since the partial return to baseline is less than a .2 mV. change. However, (b), (c) and (d) are recorded as responses. In example 2, (b) is not counted as a response since the approach to the trough represents less than a .2 mV. change from the preceding partial return to baseline. Deflection (d) is not accepted as a response since the approach to the peak represents less than a .2 mV. change from the preceding return to baseline. Deflections (a) and (c) are acceptable responses.

block) of wave deflections greater than a set criterion. Wave size was measured using m-amplitude scores. Separate analyses of the positive and negative wave components were done for each of the frequency, probability, and m-amplitude measures. For the m-amplitude measure, the size of deflection of the negative component was defined as the difference between the baseline and the trough. The size of the deflection of the positive component was defined in two different ways in view of differing opinions on how best to measure this aspect of the wave form. On the basis of evidence reported by Gaviria et al. (1969) and the suggestions made by Edelberg (1972), the positive component was defined, in one way, as the total difference between the first negative deflection (trough) and the first positive deflection (peak). The positive component so defined will henceforth be referred to as the "complex-positive" component. Venables and Christie (1973), however, eschew this method of measuring deflection size for the reason that there may be reciprocal attenuation effects between the two components. They suggest that the positive component may be less susceptible to this type of contamination as compared to the negative component. In light of this, the positive component was also defined apart from the negative one as the difference between the baseline and the deflection size of the positive peak. Separate m-amplitude scores were calculated for the positive component based on either the one or the other definition, and these in turn were entered in separate analyses.

In the present study, a 9.5 sec. latency interval (i.e., the interval of time following the CS during which responses were recorded) was used in which the UCS occurred 5 sec. after the onset of the CS. This 9.5 sec. latency interval was divided into a first and second latency interval. First interval responses were defined as those occurring .5-5.5 sec. after CS onset; second interval responses were defined as those occurring 5.5-9.5 sec. after CS onset. This partitioning of the total latency interval was based in part on an inspection of the distribution of responses following CS onset, and on the fact that the UCS occurred 5 sec. after CS onset. Since during acquisition the UCS was presented on each trial, a first interval extending much farther than 5.5 sec. would result in the contamination of responses to the CS with those to the UCS. (See Appendix F for a further discussion of latency intervals.) Separate analyses were performed on responses occurring in the first and in the second latency intervals.

Experimental design. Subjects were assigned randomly to one of two experimental groups, with the proviso that 20 subjects were in each group. The one experimental group had all CSs projected to the left hemisphere, and diversionary stimuli to the opposite side; the other experimental group received the reverse arrangement. CS+ and CS- were counterbalanced within each experimental group.

The basic design consists of four factors, two of which are between-group factors and two of which have repeated measures. The between-groups factors include Hemisphere-of-presentation (H) with two levels (left or right hemisphere) and CSword (W) with two levels (CLOTH+ and CROWD+). This latter factor is based on the counterbalancing of CS+ words; either the word CLOTH served as the CS+ (and CROWD as the CS-) or the word CROWD served as the CS+ (and CLOTH as the CS-). Repeated factors included Conditioning (C) with two levels (CS+/CS-) and Trial blocks (T) with trials blocked in groups of three. For the acquisition phase there were 5 trial blocks and for the extinction phase there were 3. (The tenth extinction trial was omitted from any further analysis in the interest of maintaining equality in size of the trial blocks.)

Multivariate analysis of variance (MANOVA) was used to test the primary hypothesis regarding differential hemispheric effects in conditioning. The choice of MANOVA over the usual repeated measures analysis of variance (ANOVA) was based on the less stringent assumptions required by the former (McCall & Appelbaum, 1973). MANOVA requires multivariate normality but makes no assumptions regarding covariance structure. On the other hand, repeated measures analyses, in addition to the usual assumptions of normality and homogeneity of within cell variances, also require the assumption of homogeneity of covariances between all pairs of levels of the repeated factor (Keppel, 1973). Box (1954) has indicated that violations of these assumptions can lead to artifactually large F values resulting in an increase in Type I errors. In view of the shortcomings of Box's (1950) procedure for testing covariance assumptions (Davidson, 1972) and the questionable tenability of homogeneity of covariance in the present study, a multivariate approach was taken in accordance with the suggestions of Harris (1975) and McCall and Appelbaum (1973).

This approach to a repeated measures design linearly combines the response variables on the repeated measure in such a way as to maximize treatment effects. The variables in the response vector represent an independent set of contrasts generated from the original repeated measures. The repeated measures problem becomes one of testing the hypothesis that the scores on the contrast variables of a response vector represent a sample drawn from a multivariate normal population having a mean vector of zero (McCall & Appelbaum, 1973).

Multivariate effects were tested for significance using Pillai's (1967) criterion. This test statistic, sum of $\lambda_i/(1 + \lambda_i)$ where λ_i represents the ith eigenvalue, can be approximated by an F variate. For small sample sizes, Pillai's criterion has an advantage over other test criteria (such as Wilks' Lambda and Hotelling's trace) in robustness and good power (Olson, 1976). It should be noted, however, that in the present experimental design, the hypothesis degrees of freedom (df_h) equals 1. In this special case, the above mentioned test criteria all follow the F distribution and lead to identical conclusions.

The statistical interpretation of the results produced by a multivariate analysis of repeated measures needs some clarification. F-test results obtained for between-groups effects are identical to those that would be obtained in a conventional univariate analysis of variance (ANOVA). This arises from the fact that repeated measures are, in effect, collapsed across groups, and hence, the multivariate analysis reduces to a univariate one based on the subjects' mean scores across groups. As well, the test of the conditioning effect (CS+/CS-), although involving repeated measures, in multivariate analysis produces results identical to that of an ANOVA. This is because the repeated factor has only two levels, and hence, the multivariate analysis involves but a single contrast variable generated from the original two variables of the repeated measure. For similar reasons, interactions between the conditioning factor and the grouping factors also produce F-test results identical to the univariate case. It should be noted, however, that for sources of variation involving the Trial blocks factor, the F-variate is not equivalent to the univariate F since more than one contrast vector is entered into the multivariate analysis. Table 2 lists the sources of variation in the

MANOVA and the corresponding F statistic (univariate or multivariate). A variety of analyses were performed on the SPR data measured in terms of latency, frequency, amplitude, and probability. Separate analyses were carried out for acquisition and extinction trials.

Unless otherwise indicated, amplitude scores were range-corrected according to suggestions by Lykken (1972). This procedure has been found useful in removing individual differences in physiological reactivity not related to psychological processes of interest (Lykken, 1972). From a statistical point of view, this procedure can result in a reduction in error variance. In order to range-correct amplitude scores each response was expressed as a proportion of the subject's maximal response during the experiment according to the formula: $\phi_{ix} = SPR_{ix}/SPR_{i\,max}$.

Various analyses were also carried out for minor hypotheses pertaining to the relation between affective experience of the stimuli and autonomic responses to them. For these, T-tests and correlations were performed. All analyses in this experiment were done by computer using the SPSS (Release 9) statistical package.

TABLE 2

Sources of Variation, Degrees of Freedom and Type of F-statistic used in the MANOVA

Source of Variation	df	Type of F-statistic
Between-groups		
Hemisphere-of-presentation (H)	1,36	identical to univariate F
CSword (W)	1,36	
H x W	1,36	
Repeated factors		
Conditioning (C)	1,36	
H x C	1,36	
W x C	1,36	
H x W x C	1,36	
Trial blocks (T)[a]	4,33	F variate based on Pillai's criterion
H x T	4,33	
W x T	4,33	
H x W x T	4,33	
C x T	4,33	
H x C x T	4,33	
W x C x T	4,33	
H x W x C x T	4,33	

[a] The degrees of freedom are for the acquisition phase. For the extinction phase df = 2,35 (since there are only 3 trial blocks).

RESULTS

Range-correction

Since some subjects produced maximum deflections which were 20 times larger than that of other subjects, this wide range in reactivity suggested that a range-correction procedure (Lykken, 1972) might be useful in reducing error variance. To justify the use of this procedure the experimental groups must not differ in maximal responses (Lykken, 1972). Separate ANOVAs were carried out for maximal positive and negative m-amplitude deflections and no significant differences were found (see Tables E-1, E-2 and E-3 in Appendix E) hence, the range-correction procedure was justified. Table E-3 presents the group means for maximal positive and negative m-amplitude deflections. Generally, it was found that the use of range-corrected scores in analyses resulted in reduced error variance. Unless otherwise indicated, findings are based on range-corrected data.

Experimental Findings for the Acquisition Phase of Conditioning

Positive SPR component in the first latency interval. A MANOVA performed on m-amplitude scores for the positive component of the SPR in the first latency interval (.5-5.5 sec. following CS onset) during the acquisition phase yielded a number of significant findings (see Table E-4 in Appendix E for a summary). Table E-5 in Appendix E presents cell means and standard deviations. Two main effects were significant: a Conditioning effect (C), $F(1,36) = 23.91$, $p < .001$, with larger mean responses to the CS+ ($M = .16$) than to the CS- ($M = .07$); and a Trials effect (T), $F(4,33) = 9.80$, $p < .001$, with declining responses in later trials (see Table E-6 in Appendix E for means). The Conditioning and Trials factors were also involved in significant interaction effects. One of these was a Hemisphere-of-presentation (H) x Conditioning interaction, $F(1,36) = 3.86$, $p < .05$. Figure 3 illustrates this effect. T-tests were calculated to determine if there were significant differences in responses to the CS+ and CS- for each of the right and left hemisphere conditions. Results indicated that m-amplitude responses to the CS+ ($M = .12$) were significantly greater than those to the CS- ($M = .07$) for the right hemisphere condition, $t(19) = 2.69$, $p < .05$, as well as for the left hemisphere condition, $t(19) = 3.78$, $p < .05$ ($M = .20$ for the CS+; $M = .07$ for the CS-). The H x C interaction effects shows a pattern of greater differential conditioning for stimuli directly presented to the left hemisphere as opposed to the right hemisphere.

A significant C x T effect was obtained, $F(4,33) = 2.74$, $p < .05$. Figure 4 illustrates the course of differential responding across trials for both the first and second latency intervals. (Responses in the second latency interval are discussed at a later point.) Referring to the first interval responses in Figure 4, it can be seen that responses to the CS+ were greater than those to the CS- and that the greatest differential responding occurred in the second and third trial blocks.

A significant CSword x Conditioning interaction effect was obtained, $F(1,36) = 6.46$, $p < .02$. As shown in Figure 5, differential responding to the CS+ and CS- was greater for the condition in which CROWD was the CS+ word. A significant W x C x T interaction effect, $F(4,33) = 4.27$, $p < .01$, provides a clearer view of the way in which differential conditioning is infuenced by the CSword serving as the CS+ (see Figure 6). Notable is the larger response to the CS- as compared to the CS+ in the first trial block for the CSword CLOTH. It is also evident that greater responding to CROWD+ as compared to CLOTH+ is limited to the first two trial blocks after which relative response sizes of the CS+s reverses.

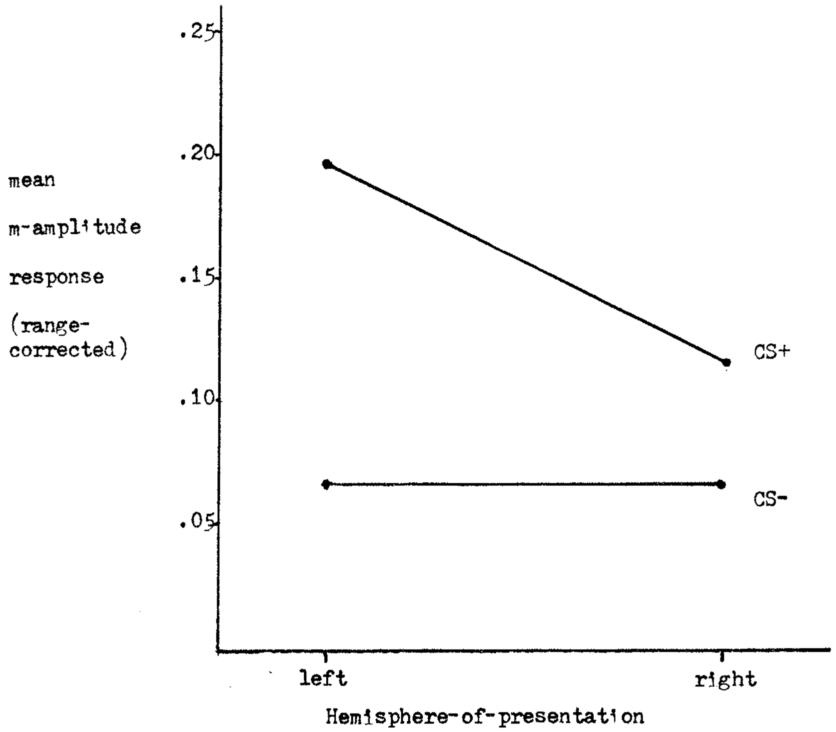


Figure 3. Hemisphere-of-presentation by conditioning interaction based on m-amplitude scores for the positive component of the SPR in the first latency interval during acquisition.

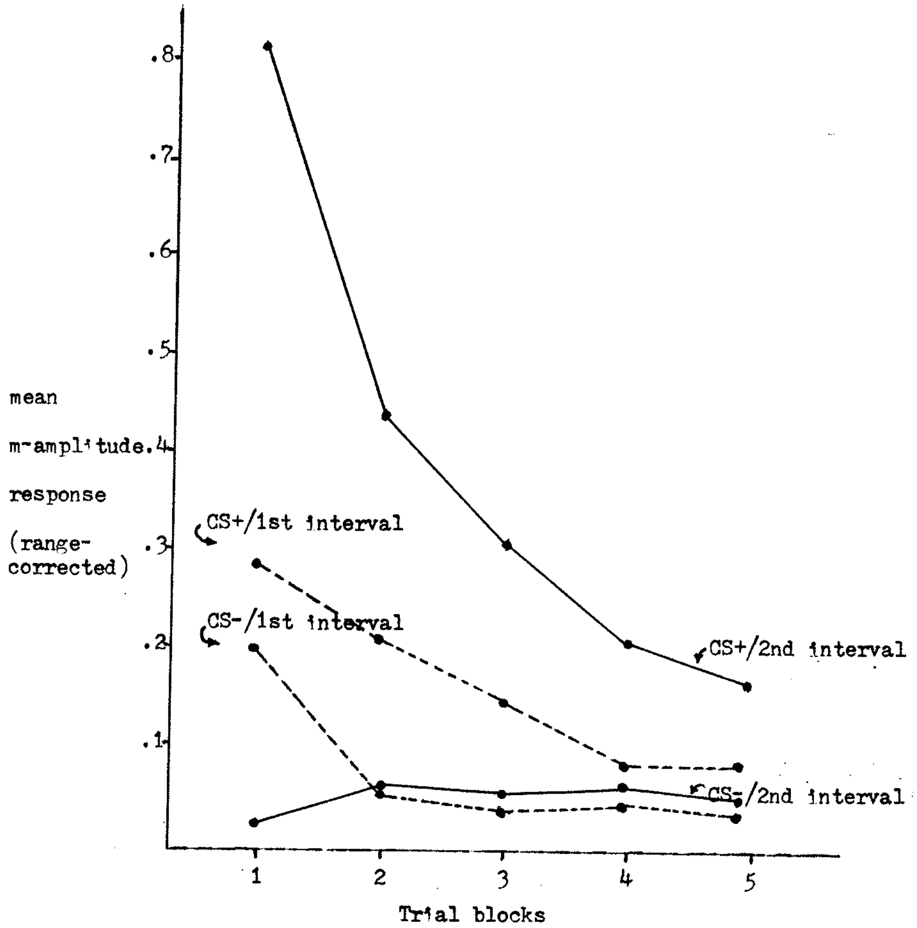


Figure 4. Conditioning by trials interactions based on m-amplitude scores for the positive component of the SPR in the first and second latency intervals during acquisition.

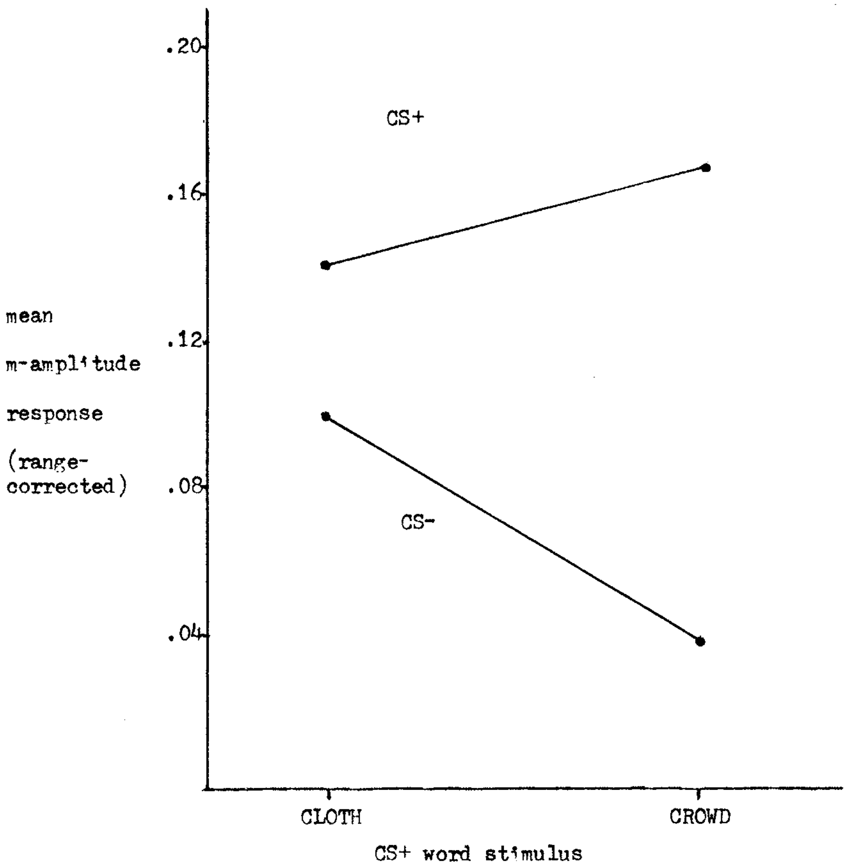


Figure 5. CSword by conditioning interaction based on m-amplitude scores for the positive component of the SPR in the first latency interval during acquisition.

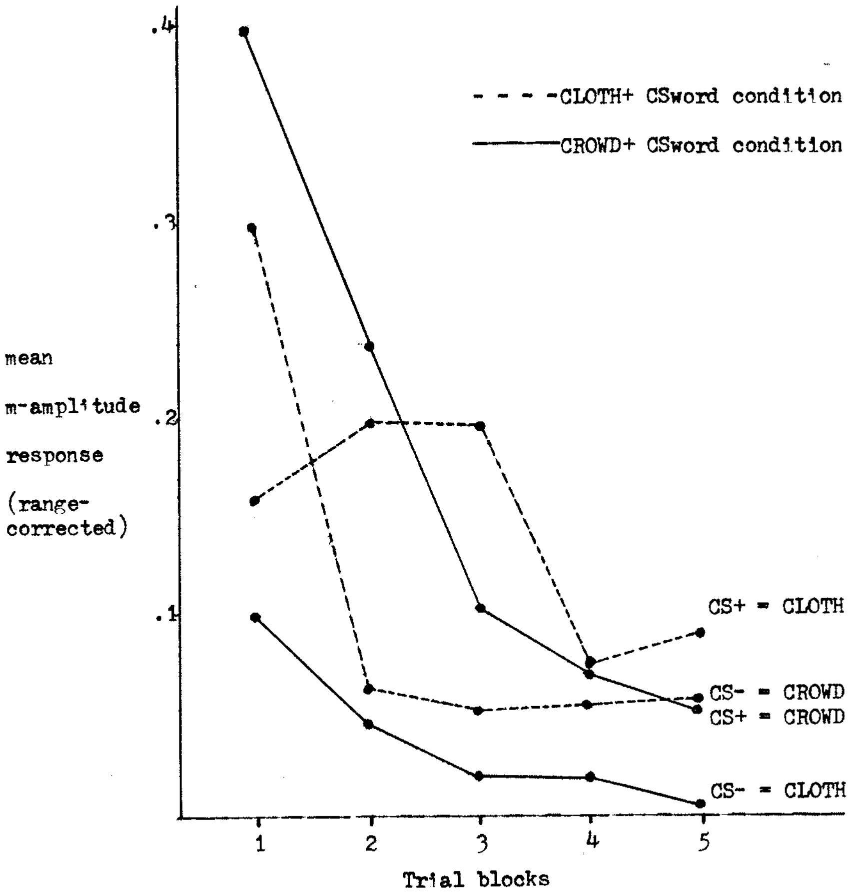


Figure 6. CSword (CLOTH = CS+/CROWD = CS- or CROWD = CS+/CLOTH = CS-) by conditioning by trials interaction based on m-amplitude scores for the positive component of the SPR in the first latency interval during acquisition.

In order to determine if sensitization effects may have differed across conditions, and so have confounded the above results, a MANOVA was performed on only CS- responses. Two significant effects were found. One was a Trials main effect, $F(4,33) = 5.59$, $p < .002$, and the other was a CSword effect, $F(1,36) = 5.39$, $p < .03$. Mean CS- responses across trial blocks 1 to 5 were .20, .05, .03, .04 and .03 respectively. The mean m-amplitude response to CROWD- (i.e., CROWD serving as the CS-) was greater (M = .10) than the mean response to CLOTH- (M = .04). There was, however, no significant Hemisphere-of-presentation effect, $F(1,36) = .10$, $p = .75$, and no significant interaction effects (p = .14 or greater).

Positive component responses in the first interval during acquisition were also analysed using unmodified amplitude, magnitude, probability and frequency scores (see Appendix F for definitions). For the unmodified amplitude scores, MANOVA results revealed the following significant effects: a Conditioning effect, $F(1,36) = 22.16$, $p < .001$; a Trials effect, $F(4,33) = 10.97$, $p < .001$; a CSword by Conditioning interaction, $F(1,36) = 4.92$, $p < .03$; and a CSword by Conditioning by Trials interaction, $F(4,33) = 2.59$, $p < .05$. The H x C interaction effect, $F(1,36) = 3.19$, $p < .08$, and the C x T interaction effect, $F(4,33) = 2.33$, $p < .08$, were <u>not</u> significant, although the trend was in the same direction as with m-amplitude scores.

For the magnitude scores, the following significant effects were obtained: a Conditioning effect, $\underline{F}(1,36) = 20.82$, $\underline{p} < .001$; a Trials effect, $\underline{F}(4,33) = 10.19$, $\underline{p} < .001$; a CSword by Conditioning interaction, $\underline{F}(1,36) = 5.78$, $\underline{p} < .02$; a W x C x T interaction, $\underline{F}(4,33) = 4.17$, $\underline{p} < .01$; and a C x T interaction, $\underline{F}(4,33) = 3.74$, $\underline{p} < .01$. The H x C effect, $\underline{F}(1,36) = 3.32$, $\underline{p} < .08$ was not significant, although the trend was in the same direction as with m-amplitude scores.

For the probability scores, a MANOVA yielded the following significant effects: a Conditioning effect, $\underline{F}(1,36) = 18.82$, $\underline{p} < .001$; a Trials effect, $\underline{F}(4,33) = 9.27$, $\underline{p} < .001$; and a C x T interaction, $\underline{F}(4,33) = 2.86$, $\underline{p} < .05$. When probability scores based on the IRD index of conditioning were entered into a MANOVA (rather than separate CS+/CS- probability scores) no significant results were obtained.

A MANOVA applied to frequency scores for the positive component of the SPR in the first latency interval during acquisition resulted in three significant effects: a Conditioning effect, $\underline{F}(1,36) = 19.87$, $\underline{p} < .001$; a Trials effect, $\underline{F}(4,33) = 6.97$, $\underline{p} < .001$; and a C x T interaction, $\underline{F}(4,33) = 3.35$, $\underline{p} < .02$. Table 3 compares the significant findings obtained for MANOVAs on unmodified amplitude, m-amplitude, magnitude, probability and frequency scores of the positive component of the SPR in the first latency interval during acquisition.

TABLE 3

A Comparison of Significant MANOVA Results obtained for unmodified Amplitude, m-amplitude, Magnitude, Probability, and Frequency scores of the Positive Component of the SPR in the First Latency Interval during Acquisition

Effect	Type of Score				
	Amp	m-amp	Mag	Prob	Freq
Conditioning (C)	*	*	*	*	*
Hemisphere-of-presentation (H) x C	NS	*	NS	NS	NS
CSword (W) x C	*	*	*	NS	NS
Trials (T)	*	*	*	*	*
C x T	NS	*	*	*	*
W x C x T	*	*	*	NS	NS

Note. NS = not significant. The asterisk (*) signifies that the result is significant at a level of $p < .05$ or better.

Positive SPR component in the second latency interval. A MANOVA of m-amplitude scores for the positive component of the SPR in the second latency interval during acquisition also yielded several significant effects. Table E-7 in Appendix E provides a summary of the results. Again, a Trials main effect, F(4,33) = 13.19, $p < .001$, and a Conditioning main effect, F(1,36) = 195.14, $p < .001$ were obtained. Successive trial blocks showed declining mean responses (M = .42, .24, .18, .13, and .11 respectively), and the mean response on the CS+ trials (M = .39) was greater than the mean response on the CS- trials (M = .04). Note that in this second latency interval which follows the UCS, the differential responding may reflect both CRs with long latency and URs (on CS+ trials).

Two significant interactions were also found. One was a C x T effect, F(4,33) = 17.76, $p < .001$, and the second was a H x C x T effect F(4,33) = 3.55, $p < .02$ (see Figure 4 for the 2-way interaction and Figure 7 for the 3-way interaction). The 3-way interaction involves greater responding to the CS+ in the right as compared to the left hemisphere condition for the first two trial blocks, and a subsequent reversal with greater responding to the CS+ in the left hemisphere condition.

In order to test for sensitization effects that may have confounded the above results, a MANOVA was performed on only CS- responses. No significant effects were obtained ($p = .18$ or greater).

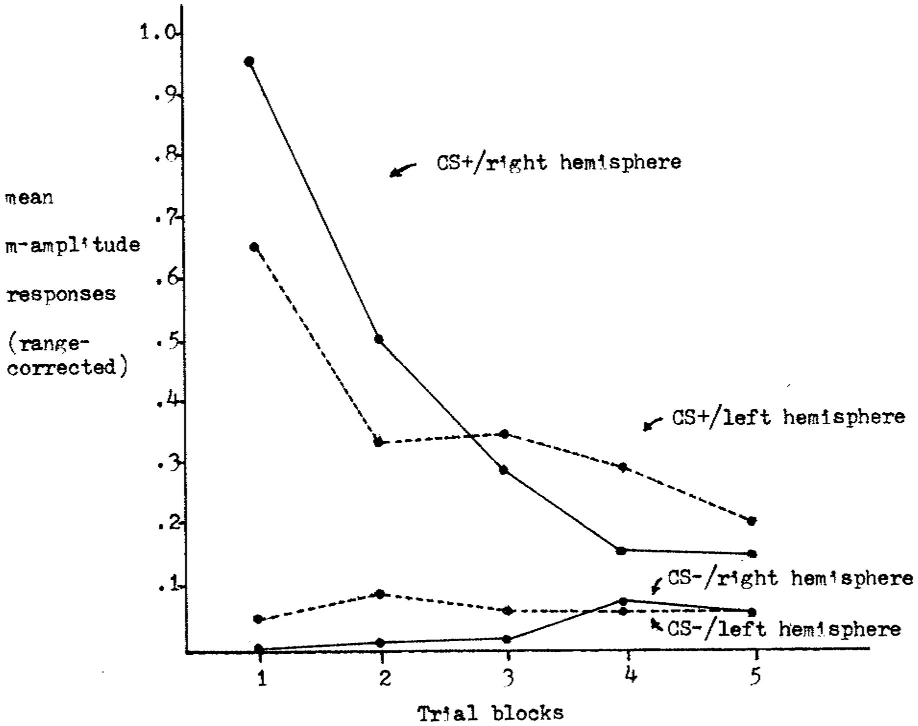


Figure 7. Hemisphere-of-presentation by conditioning by trials interaction based on m-amplitude scores for the positive component of the SPR in the second latency interval during acquisition.

Negative SPR component in the first latency interval. M-amplitude scores of the negative component of the SPR were also examined. The following significant effects were found for the negative component in the first latency interval during acquisition; a Conditioning effect, $F(1,36) = 18.25$, $p < .001$; and a Trials effect, $F(4,33) = 5.01$, $p < .001$.

Negative SPR component in the second latency interval. For the second latency interval during acquisition, the following negative component effects were significant: a Conditioning effect, $F(1,36) = 344.75$, $p < .001$; a Trials effect, $F(4,33) = 6.20$, $p < .001$; and a W x C interaction, $F(1,36) = 4.08$, $p < .05$. The W x C interaction is illustrated in Figure 8. This interaction involves greater differential responding to the CS+/CS- when the word CROWD is the CS+ as opposed to when the word CLOTH is the CS+. As Figure 8 shows, m-amplitude responses to CLOTH- and CROWD- are about the same. It is the responses to the CS+ which largely accounts for the W x C interaction; when CROWD served as the CS+, mean m-amplitude responses were significantly greater ($M = .63$) than when CLOTH served as the CS+ ($M = .55$), $t(38) = 1.81$, $p < .05$.

Unlike in the case of the positive component m-amplitude responses during acquisition, the negative component responses showed no significant C x T interaction effects. However, for comparison with the C x T effects for the positive component of the m-amplitude responses, these

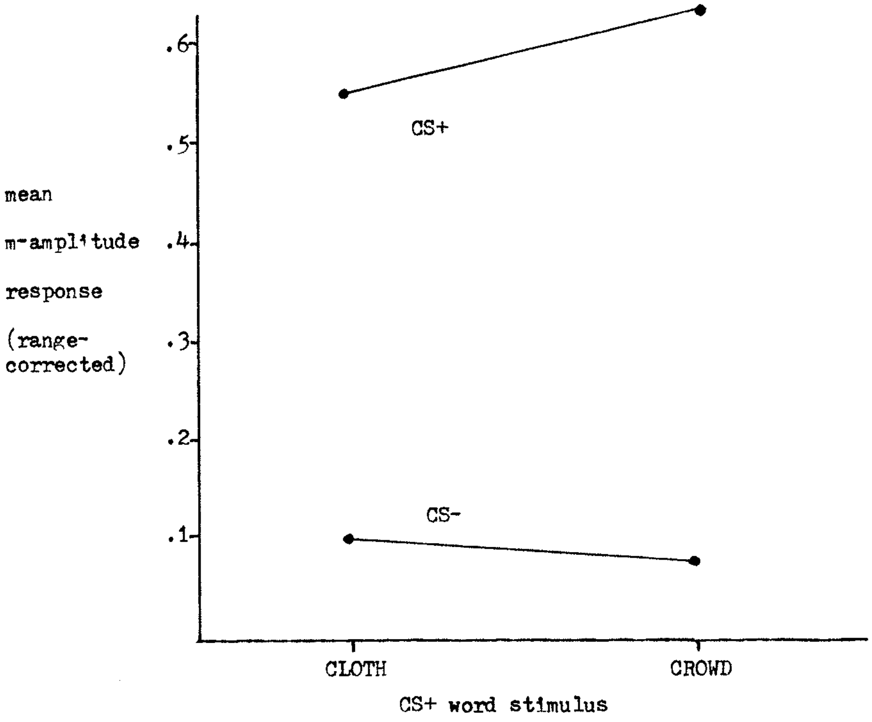


Figure 8. CSword (CLOTH = CS+ or CROWD = CS+) by conditioning interaction based on m-amplitude scores for the negative component of the SPR in the second latency interval during acquisition.

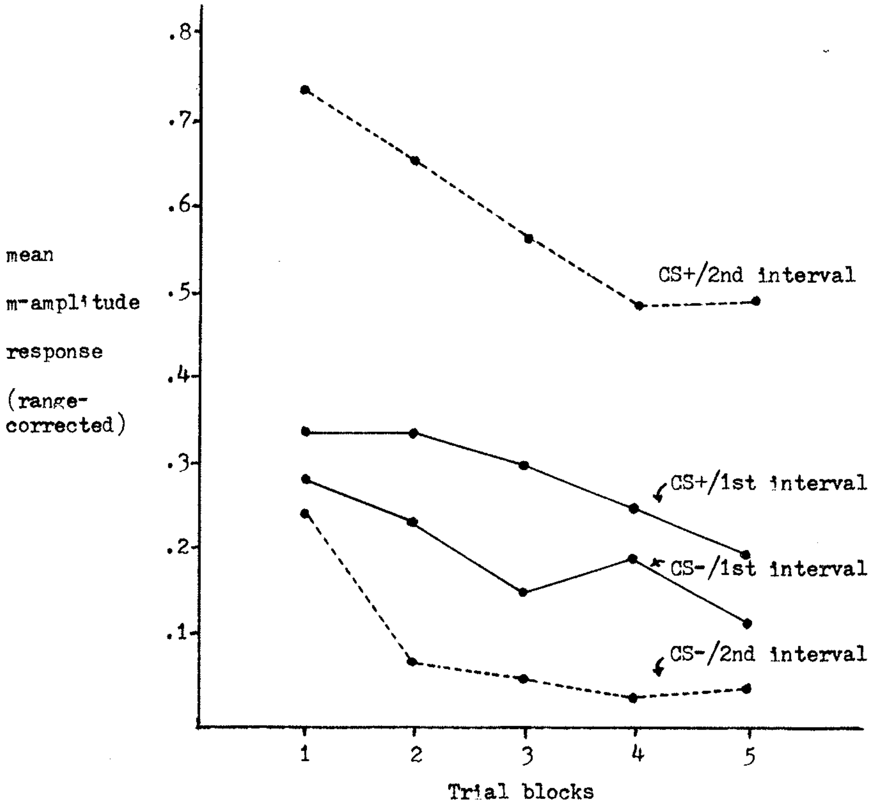


Figure 9. M-amplitude responses for the negative SPR component in the first and second latency intervals during acquisition plotted as a function of conditioning and trials.

negative component responses to the CS+/CS- across trials have been plotted in Figure 9. Two features are particularly prominent in the responses for the negative SPR component. One, differential responding to the CS+/CS- is much greater in the second latency interval as compared to the first latency interval. Two, this greater differential responding in the second latency interval is due to both heightened responding on CS+ trials in the second as compared to the first latency interval , and diminished responding on CS- trials in the second as compared to the first latency interval. Mean m-amplitude responses to the CS- in the first latency interval ($\underline{M}$ = .20) are significantly greater, $\underline{F}(1,39) = 17.63$, $\underline{p} < .001$, than in the second latency interval ($\underline{M}$ = .09).

Experimental Findings for the Extinction Phase of Conditioning

For the extinction phase, few responses were made by subjects and these tended to show much variability. Analysis of this data yielded mainly nonsignificant effects. M-amplitude scores of the positive component of the SPR in the first latency interval when entered into a MANOVA yielded only one significant effect, a W x C x T interaction, $\underline{F}(4,35) = 3.21$, $\underline{p} < .05$. As illustrated in Figure 10, there is evidence of greater responding to the CS+ as compared to the CS- across trials; however, responses fluctuate widely across trial blocks. Given that many subjects

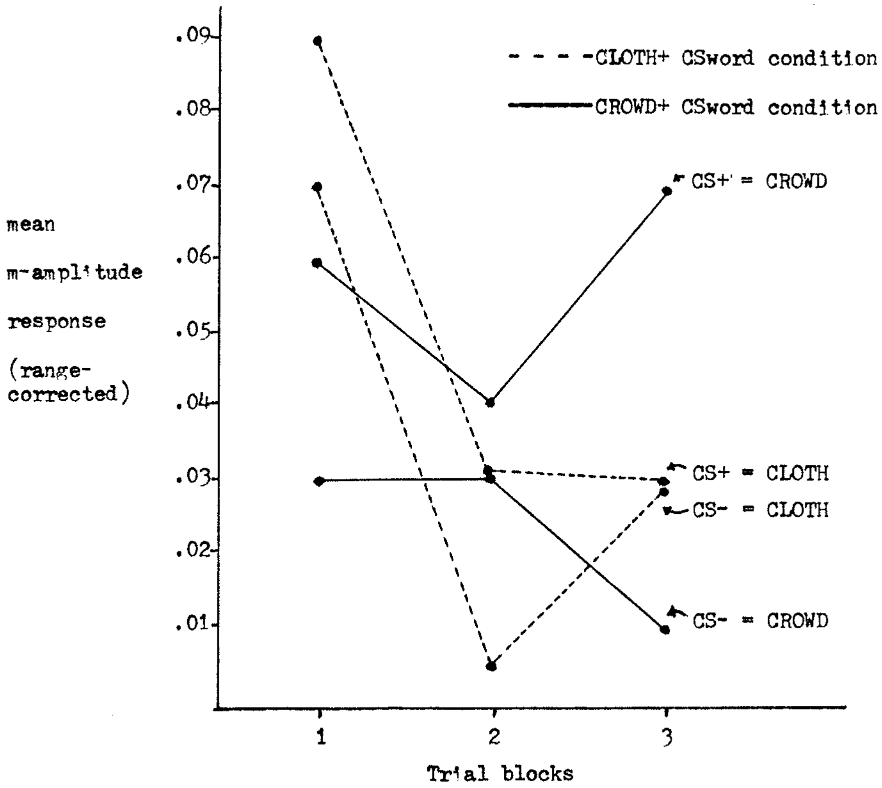


Figure 10. CSword (CLOTH = CS+/CROWD = CS- or CROWD = CS+/CLOTH = CS-) by conditioning by trials interaction based on m-amplitude scores for the positive component of the SPR in the first latency interval during extinction.

did not respond during extinction, the reliability of this effect must be questioned.

A MANOVA of m-amplitude scores of the positive component of the SPR in the second interval produced no significant results. For both the first and second latency interval, m-amplitude responses for the positive SPR component showed a trend of larger deflections in the left hemisphere condition as compared to the right hemisphere condition for CS+ stimulus presentations. No significant effects were found for m-amplitude responses of the negative component; however, again, there was a trend of greater responding in the left hemisphere condition.

Response Patterns on the First Three Acquisition Trials

As is evident from Figures 4, 7 and 9, m-amplitude responses to the CS+ and CS- show decrements from the first trial block onwards during acquisition. One exception, as shown in Figure 6, are response patterns to the CS+ CLOTH for the positive component of the SPR in the first latency interval. Here, m-amplitude responses showed an increment across the first few trial blocks before habituation set in. In those instances where no increment in responses to the CS+ occurred across initial trial blocks, responding may have rapidly reached asymptote in the first few individual trials, hence blocking the first three trials would fail to reveal this effect. The first three individual trials for the CS+ and CS- were examined to determine if any increments in acquisition responding occurred.

Figures 11 and 12 illustrate the differential response patterns to the CS+ and CS- across the first three acquisition trials. Here data has been collapsed across right and left Hemisphere-of-presentation conditions since response patterns for these two conditions were essentially similar. Response curves in Figures 11 and 12 are based on range-corrected magnitude scores, whereas response curves for trial blocks (Figures 4, 7 and 9) are based on range-corrected m-amplitude scores, and so response levels for the CS+ and CS- in Figures 11 and 12 (if averaged across the three individual trials) are not numerically equivalent to those respective response levels graphed for the first trial block in Figures 4, 7 and 9. Nonetheless, this does not affect interpretation of the response patterns obtained for the individual trials.

The pattern of SPRs across the first three trials in the first latency interval reveals several interesting features. Most striking are the dissimilar response curves obtained when CLOTH served as the CS+ as opposed to when CROWD served as the CS+ (Figure 11). When CLOTH was the CS+, response magnitudes to that stimulus were smaller than those to the CS- CROWD on the first acquisition trial. However, by the third trial a reversal occurred with greater responding to the CS+. When CROWD was the CS+, response

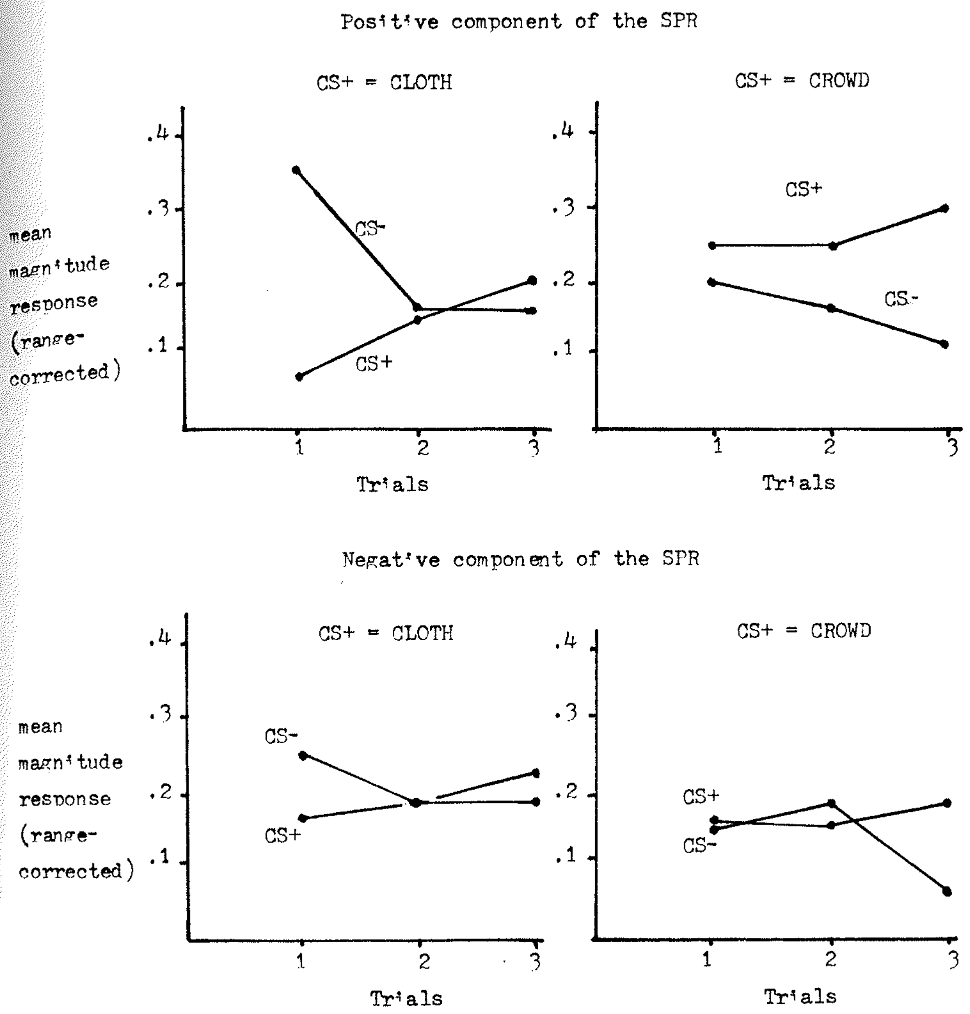


Figure 11. Mean SPR magnitudes for the first latency interval across the first three trials during acquisition (N = 20).

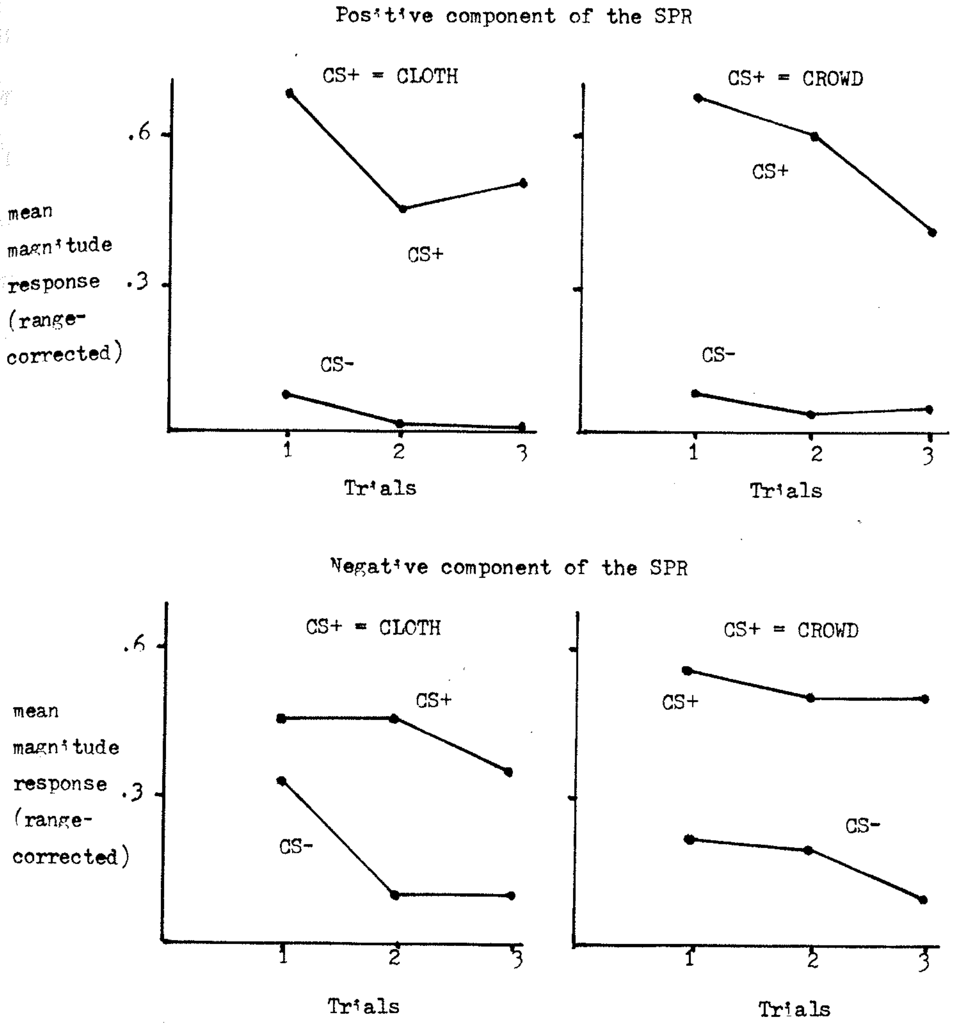


Figure 12. Mean SPR magnitudes for the second latency interval across the first three trials during acquisition (N = 20).

magnitudes to that stimulus were <u>larger</u> than or essentially equal to those to the CS- CLOTH on the first acquisition trial. By the third trial, responding to the CS+ CROWD had increased and responding to the CS- CLOTH had decreased. Even though initial responding to the CS- was greater than to the CS+ in the condition in which CLOTH served as the CS+, it is of note that the CS- showed a decline in response magnitudes across trials, whereas the CS+ showed an increase. The surprising reversal in the pattern of responding to the CS+/CS- may be largely due to greater sensitization effects associated with the stimulus CROWD compared to the stimulus CLOTH; only after several trials does the conditioning contingency surmount these effects. In order to further characterize sensitization effects to CLOTH and CROWD, subjects' responses to the very first presentation of a CS in the stimulus series were examined. Half the subjects received CLOTH as the first CS and half CROWD. The mean magnitude (range-corrected) of responses for the positive component of the SPR was .42 when CROWD was the first CS presented and .13 when CLOTH was the first CS presented (with no distinction made between CS+ and CS- stimuli).

Turning to Figure 12, it is clear that response patterns in the second latency interval are unlike those in the first latency interval. Generally, mean response magnitudes to the CS+ and the CS- show a decline across the first three trials. In comparing responses in the second latency interval with those in the first latency interval, two differences stand out. First, mean response magnitudes to the CS+ are greater in the second latency interval than in the first latency interval; second, mean response magnitudes to the CS- are smaller in the second latency interval compared to those in the first latency interval.

Additional Analyses of SPR Data

A variety of other manipulations were performed on the SPR data; but, this proved to be unproductive--only an occasional trials or conditioning effect was obtained. One such manipulation was a multivariate analysis of probability and frequency scores in linear combinations with m-amplitude scores. Another approach that yielded no results was the use of covariate analyses with "pleasantness" ratings of the CS+ stimuli serving as the covariate measure. M-amplitude scores of the complex-positive SPR response (i.e., the trough to peak difference) were also entered into a MANOVA; however, this approach generally yielded fewer significant effects than MANOVAs based on the simple positive response scores (i.e., those scores based on the difference in deflection between baseline and peak). Analysis of latency scores produced no significant effects; this measure showed much fluctuation across trials with no discernable trend of shortened latencies.

Semantic Differential Ratings of the Conditioned Stimuli and UCS

Various analyses were also carried out to test the minor hypotheses. In order to determine if the "pleasant/ unpleasant" ratings of the CS+ and CS- were affected by the conditioning process, separate 2-way ANCOVAs were performed for each of the two stimulus words, CLOTH and CROWD, with ratings of the stimuli prior to conditioning serving as the covariate, and post-conditioning ratings serving as the independent variable. The two independent variables are Hemisphere-of-presentation and CSword. For the stimulus word CLOTH, no significant effects were found. Regardless whether the word CLOTH served as the CS+ or the CS-, mean ratings of this word on a 7-point scale ("pleasant/unpleasant") were not significantly different, $\underline{F}(1,35) = 2.98$, $\underline{p} < .09$. There was, however, a trend to more negative ratings of CLOTH if it served as the CS+ as opposed to the CS- (see Table 4). For the stimulus word CROWD, an ANCOVA revealed a significant CSword effect, $\underline{F}(1,35) = 21.34$, $\underline{p} < .001$. As shown in Table 4, when the word CROWD served as the CS+ rather than as the CS-, it was rated more negatively.

An additional ANCOVA was performed on pre- and post-conditioning ratings of the CS+ entered as covariate and dependent variable respectively; in half the cases the CS+ was the word CROWD, and in half the cases it was CLOTH. A significant CSword effect was obtained, $\underline{F}(1,35) = 6.02$, $\underline{p}$

$<.02$, with a more negative mean rating given for the CS+ word CROWD than for the CS+ word CLOTH (see Table 4).

A t-test for correlated samples was also performed to determine if the mean ratings for the two stimulus words CLOTH and CROWD differed prior to conditioning. A significant finding was obtained, $t(39) = 2.58$, $p < .02$, with the mean rating for CLOTH ($M = 4.3$; $SD = 1.0$) being more positive than the mean rating for CROWD ($M = 3.7$; $SD = 1.2$). These means are similar to those obtained in the pilot study ($M = 4.5$ for CLOTH; $M = 3.6$ for CROWD). The fact that the means for CLOTH and CROWD were not found to be significantly different in the pilot study seems to be due to the reduced power of a smaller sample size.

The mean ratings of the loud noise (UCS) along a dimension of "painfulness" showed no significant differences across the four groups; for the left hemisphere/CS+ = CROWD condition, $M = 3.7$; for the left hemisphere/CS+ = CLOTH condition, $M = 3.3$; for the two right hemisphere conditions, the mean in each case was also 3.3. The results of a Pearson correlation showed no relationship between "painfulness" ratings of the UCS ($M = 3.4$; $SD = 1.6$) and "unpleasantness" ratings of the CS+ ($M = 3.0$; $SD = 1.4$), $r(40) = .03$, $p < .43$.

A number of Pearson correlations were carried out to test for relationships between SPR responses and each of "painfulness" ratings of the UCS, and "unpleasantness"

TABLE 4

Mean Pre- and Post-conditioning Ratings on a 7-point Scale
Along a dimension of "pleasantness" (7 = pleasant)
for the stimulus words CLOTH and CROWD as
a Function of CS+/CS- Counterbalancing

	CSword condition			
	CLOTH+/CROWD-		CROWD+/CLOTH-	
	pre-conditioning	post-conditioning	pre-conditioning	post-conditioning
mean ratings for CLOTH	4.3	3.6	4.3	4.3
mean ratings for CROWD	3.8	4.4	3.5	2.4

ratings of the CS words. Table 5 displays the results of these various correlations. Generally, there was a significant negative correlation between ratings of "pleasantness/unpleasantness" of the CS+ (unpleasant = 1; pleasant = 7) and the absolute m-amplitudes of the skin potential response during conditioning. That is, the larger the size of the absolute response of the SPR, the more negatively the word CSs were rated. Only one significant correlation occurred between "painfulness" ratings of the UCS and the size of m-amplitude responses, and this was in a direction opposite to predictions, $\underline{r}(40) = -.34$, $\underline{p} < .02$. Note that in Table 5, the SPR variables "pone" and "ptwo" are based on a differential conditioning index (I.D.) for the positive component. This index is computed by averaging the differences in m-amplitude responses (range-corrected) to the CS+ and CS- across the 5 acquisition trial blocks for each subject. That is: $\text{I.D.} = \sum_{t=1}^{5} (\text{CS+} - \text{CS-})/5$. As shown in Table 5, the greater the amount of differential conditioning, the more "unpleasant" the CS+ was rated post-conditioning.

TABLE 5

Correlations between SPR Responses and "Painfulness" Ratings of the UCS and "unpleasantness" Ratings of the CS Stimuli (*N* = 40)

Stimulus Ratings		pmax[d]	nmax[e]	pmean[f]	nmean[g]	tmean[h]	pone[i]	ptwo[j]
UCS[a]	*r*	.17	.01	.18	-.34**	.23*	.13	.19
	p	.15	.48	.13	.02	.08	.21	.12
postCS+[b]	*r*	-.25*	.37**	-.30**	.01	-.38**	-.44**	-.31**
	p	.06	.01	.03	.47	.01	.01	.03
preCS+[c]	*r*	.15	-.14					
	p	.19	.19					

Note. For each pair of numbers, the top is the Pearson correlation and the bottom is the respective probability level. For stimulus ratings of the UCS, postCS+ and preCS+, the smaller the rating value (with 7 being the largest, and 1 the smallest) the more negative (unpleasant or painful) the stimulus (CS+ or UCS) was experienced. For the response variables nmax and nmean, larger deflections in m-amplitude take on more *negative* values.

[a] This is the rating of the loud noise post-conditioning by each S.

[b] This is the rating of the CS+ post-conditioning by each S.

[c] This is the rating of the CS+ pre-conditioning by each S.

[d] This is the maximum positive m-amplitude response (nonrange-corrected) of each S during conditioning.

[e] This is the maximum negative m-amplitude response (nonrange-corrected) of each S during conditioning.

[f] This is the mean positive m-amplitude response of each S for the first and second latency intervals during acquisition.

[g] This is the mean negative m-amplitude response of each S.

[h] This is the mean complex-positive response (nonrange-corrected) of each S.

[i] This is a differential conditioning index (I.D.) for the positive component of the SPR in the first latency interval during acquisition for each S.

[j] Similar to pone, but based on the second latency interval.

[*] *p* < .10

[**] *p* < .05

DISCUSSION

Generally, the results only partially supported the predictions of the major and the minor hypotheses. In addition, some interesting, unpredicted hemispheric effects were obtained. The first major hypothesis of greater differential conditioning for right as compared to left hemisphere stimulus presentations was not supported. The significant effect, was, in fact, in the opposite direction; that is, greater differential conditioning of the positive component of the SPR (in the first latency interval) occurred in the left hemisphere condition during acquisition. No hemispheric effects were found during extinction.

The second major hypothesis predicted greater differential conditioning on earlier trials in the right as compared to the left hemisphere condition. Results did show a significant 3-way interaction for the positive m-amplitude responses in the second latency interval during acquisition. This effect involved greater differential responding to the CS+/CS- for right as compared to left hemisphere presentations for the first two trial blocks, and a subsequent reversal in later trials. In this interaction effect, CS- curves were similar for the left and right hemisphere conditions and remained close to a zero m-amplitude level of responding. It is the pattern of declining responses to the CS+ in the left and right hemisphere condition which accounts for the interaction effect. Whereas this three way interaction effect (H x C x T) appears to support the second hypothesis, there is some question as to whether or not differential responding to the CS+/CS- reflects conditioning. That is, differential responding in this second latency interval may reflect URs on CS+ trials and their absence on CS- trials rather than contingency learning. Alternatively, differential responding to the CS+/CS- may reflect the combined influence of contingency learning and the presence or absence of URs. This problem is addressed in greater detail at a later point.

The minor hypotheses were only partially supported. For hypothesis 3 results were in line with predictions. Verbal stimuli that had been paired with the UCS during conditioning were affectively experienced as more "unpleasant" following conditioning compared to the same stimuli if they had served as CS-s instead.

Hypotheses 4 and 5 were not supported. No relation was found between the extent of aversiveness (i.e., "painfulness") of the loud noise (UCS) and the amount of differential conditioning (as measured by an index of differential conditioning, I.D.) in the one case, and the size of the maximal SPR of each subject in the other.

Hypotheses 6 and 7 both found support. A relation was obtained between the extent to which the CS+ was experienced as "unpleasant" and the amount of differential conditioning (I.D.) on the one hand, and the size of the maximal SPR of each subject on the other. That is, the more unpleasant the CS+ was experienced (based on post-conditioning ratings) the greater was the average amount of differential conditioning, and the larger was the maximal response deflection.

The study also yielded several significant effects which were not predicted. These involve interactions of the CSword factor (CS+ = CLOTH or CS+ = CROWD) with other factors, and generally show a heightened influence of the word stimulus CROWD on skin potential responding.

Conditioning Versus Habituation

Differential responding to the CS+/CS- was found in both the first and second latency interval during acquisition. Response curves, except in one instance (positive SPR m-amplitudes to the CS+ CLOTH in the first latency interval), showed a decline across trial blocks. This pattern of declining responses brings into question whether in fact conditioning had occurred. On the face of it, an argument could be made that only evidence for habituation exists and that no contingency learning took place. Groves and Thompson (1970), for example, have proposed a dual-process theory of habituation in which habituation and sensitization are postulated to develop independently and interact to yield the final response. This kind of model would emphasize the importance of sensitization effects in accounting for differential rates of habituation to the CSs. Among researchers who use electrodermal measures, there is some debate regarding the distinction, both in theory and in practice, between ORs and CRs (e.g., Grings, 1977; Gale & Ax, 1968; Maltzman, Raskin & Wolff, 1979; Prokasy, 1977; Stern, 1977). Stern (1977), for example, contends that much of what is called simple classical conditioning is in fact no more than habituation of ORs. The fact that such habituation occurs at a slower rate when the CS is followed by the UCS (as opposed to when it is not followed) may be due to arousal or sensitization. The same explanation might be applied to differential classical conditioning; however, in this case, one could object that differential sensitization to the CS+ and CS- is less likely since the same subject receives both types of CSs. Prokasy (1977) maintains that differential conditioning data provides for the "reasonably safe" conclusion that first interval responses reflect stimulus pairing. Maltzman, Weissbluth and Wolff (1978) are inclined to the view that, in humans, ORs in habituation and conditioning may reflect similar underlying processes. In light of the disagreements that exist regarding what constitutes convincing evidence of conditioning, the present findings of rapidly habituating responses to the CS+/CS- bring into question whether or not conditioning occurred. Evidence of a growth in the CS+ response curve, however brief, would strengthen a conditioning interpretation of differential response patterns to the CS+/CS-. For this reason, <u>individual</u> trials in the first trial block were examined. The patterns of responding to the CS+/CS- across the first three acquisition trials indicate that contingency learning did occur--albeit at a rapid rate.

One set of prominent features of the CS+/CS- response curves in the first latency interval for the first three acquisition trials (see Figure 11) are a rise in CS+ responding and a decline in CS- responding across trials. By the third trial the CS+ responses have reached asymptote and thereafter decline. This pattern of differential responding appears to favor a contingency learning point of view.

Since subjects were given some information regarding the conditioning contingency prior to presentation of stimuli (i.e., they were informed that a relation existed between the loud noise and words which would make it possible to predict the former), it is not surprising that acquisition occurred within the first trial block. Rapid acquisition in EDR conditioning in humans has been commonly observed. Grings (1977) points out that learning curves for EDR seldom follow popularized forms (i.e., negatively accelerated growth functions) and that instruction-induced effects are often quite immediate. Prokasy (1977) makes a similar comment that EDR performance to a CS rises rapidly in the first one to five trials and then declines. And again, Maltzman, Weissbluth and Wolff (1978) point out that asymptote responding occurs almost at the outset of conditioning with a subsequent decline in the magnitude of the GSR-CR if the conditioning situation remains predictable. Pendery and Maltzman (1977) reported a differential conditioning study in which one group of human subjects were required to discover the word-tone contingency; the other group was given information about the contingency. For the uninformed group, responding increased to the CS+ across the first few trials reaching a peak on the fifth CS+ presentation. In contrast, the instructed group reached asymptote on the first trial and thereafter showed declining responses to the CS+. It was also found that the maximum CS+/CS- difference for the informed group occurred on the first trial. Responses to the CS- also showed a decrement across trials from the fifth CS- presentation onwards. This pattern of responding for the informed group closely parallels that found in the present study. Maltzman's findings strongly suggest that negatively sloped CS+/CS- curves in which habituation occurs from the first trial onwards can reflect contingency learning since a negatively accelerated curve was obtained for the uninformed group, and this group only differed from the informed group in information about the contingency. The differing response patterns of the two groups may reflect similar associative processes involving cognitive systems, but having characteristic patterns of development based on expectancies directed by contingency information available.

There is evidence to indicate that the absence of an adaptation phase prior to conditioning also affects the rate of asymptotic responding. Maltzman, Raskin and Wolff (1879) reported a differential conditioning study in which three groups of human subjects received different preconditioning exposures to words prior to conditioning. One group received 40 different words, a second received 20, and a third received zero words. Subjects were subsequently conditioned to the CS+ word PLANT (which was not present among the preconditioning stimuli) which was paired with white noise (UCS). Neutral filler words were interspersed among conditioning trials. It was found that the group receiving no preconditioning trials produced the largest GSR magnitudes on the first trial, with declining responses thereafter to the CS+. The other two groups showed close to zero magnitude responding to the CS+ on the first trial but quickly rose to asymptote in the first four to seven trials. Once reaching peak responding, these two groups also showed rapid habituation. Response magnitudes to the filler control words were greater for the no preconditioning group than for the two groups which received preconditioning trials.

The above findings reported by Maltzman are important in that they suggest that a momotonically deccelerating response curve can reflect conditioning. It appears that contingency information and preconditioning exposure are two variables which can lead to asymptotic responding on the first trial. The fact that no adaptation phase was used in the present study, and that partial contingency information was supplied, probably accounts for the initial elevated level of responding and rapid rise to asymptote. The finding of brief, although not dramatic, rises in CS+ responding with rapid habituation thereafter, in light of the above considerations, does appear to reflect conditioning.

It should be pointed out that rapid habituation rates may be an intrinsic characteristic of the EDR system. In the case of eyelid conditioning, for example, CS+ responding seems to be sustained across a greater number of trials (e.g., Hellige, 1975).

Turning to response patterns in the second latency interval across the first three acquisition trials (see Figure 12), evidence for conditioning effects in terms of a growth in CS+ responding is lacking. Instead, responses to the CS+ and the CS- show declines from the first trial onwards. Also evident is a large difference in SPR magnitudes for CS+ and CS- trials. Attributing differential CS+/CS- responding to stimulus pairing is made additionally problematic by the fact that the second latency interval follows the point in time when the UCS appeared (CS+ trials) or would have appeared (CS- trials). As a consequence, responses may largely reflect URs on CS+ trials and hence the large magnitudes. Following completion of the main experiment a couple of additional subjects were presented the UCS in isolation (i.e., no CSs were presented) and latencies of the UR were recorded. It was found that latencies were about 1.5 sec. on average. This suggests that in the main experiment URs had sufficient time to develop in the second latency interval. Although second latency interval responses probably partly reflect URs on CS+ trials, it is not unreasonable to assume that these responses also reflect a CR contribution. Inspection of raw SPR data revealed that on some trials the second interval response occurred early in the latency interval and on other trials later in the latency interval. Those second interval responses showing a latency of 1 sec. or less (following UCS presentation) may well reflect CRs, whereas longer latency responses may reflect URs or a combination.

Perhaps second interval responses may reflect CRs to a greater extent than at first suspected. A comparison of SPR response characteristics on CS- trials, across the five acquisition trial <u>blocks</u> in the first and second latency intervals leads to this suggestion. Figure 9 shows a sizable (and in fact significant) difference between m-amplitude responses of the negative SPR component to the CS- in comparing the first with the second latency interval. Only in the first trial block are the responses to the CS- comparable between the two latency intervals. The lower level of responding to the CS- in the second as compared to the first latency interval seems to reflect conditioned responding; the higher level of responding in the first latency interval may be due to greater orienting activity. That is, in the first latency interval following the CS- presentation, the subject may have some lingering expectations of receiving a blast of loud noise, since the 5 sec. point at which a UCS sometimes occurs (on CS+ trials) has not yet lapsed; after the passage of this critical 5 sec. point, it would seem that the subject is then able to predict "no shock". Apparently, then, the subject has learned something about the CS-UCS timing as well as the safety signal of the CS-, and both factors are perhaps reflected in the lowered responding to the CS- in the second latency interval. The findings of Gale and Ax (1968) are relevant here. They reported a discrimination conditioning study in which the CSs were tones and the UCS was shock delivered 9.5 sec. after onset of the CS+. These researchers examined both first and second latency interval responses (1-4.5 sec. and 4.5-10.5 sec. respectively). They interpreted first interval responses as ORs and second interval responses as CRs. Results revealed basically similar patterns of differential responding to the CS+/CS- for the OR and CR based on SCR amplitude measures. However, for CS- presentations, they did observe that CR amplitudes across trials were appreciably smaller than OR amplitudes--not unlike the findings in the present study. With respect to the present study, it must be pointed out, however, that taking the response patterns to the CS- as evidence of conditioning does not preclude the contribution that URs may make to responses on CS+ trials. As for the _positive_ component of the SPR, there is no difference in level of responding to the CS- in comparing the first and second latency intervals (see Figure 4) except in the first trial block. An explanation for this lack of difference might be that "floor effects" in second latency interval responses prevented a separation from first interval responses to the CS- for trial blocks beyond the first.

Sensitization Effects

In taking the position that differential responding to the CS+/CS- in the present study reflects contingency learning rather than merely differential rates of habituation, it is nonetheless recognized that sensitization effects influenced responding. Sensitization, here, refers to a response that resembles a CR which is elicited by a CS without any pairing with the UCS, or without any prior presentation of the UCS (Terrace, 1973). These sensitized responses usually habituate, but in some instances presentation of a UCS can restore or augment them. In the present study, evidence indicates that sensitization effects had their greatest impact on the first trial but diminished thereafter. It appears that the CS word CROWD as compared to the word CLOTH was particularly susceptible to sensitization effects. It was found that when CROWD was the very first CS presented to subjects, response magnitudes were larger than when CLOTH was the first CS presented. Subjects also showed larger m-amplitude responding (positive component of the SPR) to CROWD- than to CLOTH- across trial blocks in the first latency interval. This may be due to unique arousal-related properties of the word CROWD. Unpleasant negative connotations might account for the heightened sensitization effects related to this word.

The heightened sensitization effects for the CS- CROWD are clearly apparent on the first acquisition trial (see Figure 11). This sensitization effect is more pronounced for the positive component than the negative component of the SPR. Sensitization effects appear to have diminished greatly by the second trial; in all cases, by the third trial responding to the CS- is at lower magnitudes than to the CS+. It is particularly interesting to note that in the cases where the word CROWD was the CS+, response levels to the CS+/CS- were essentially the same on the first acquisition trial. In contrast, in the cases where CLOTH was the

CS+ (the upper and lower graphs on the left of Figure 11) sensitization effects for CROWD- resulted in a large difference in response magnitudes to the CS+/CS- on the first trial. The fact that for the condition in which CROWD was the CS+ (the upper and lower graphs on the right side of Figure 11) response magnitudes to the CS+/CS- were quite similar on the first trial and showed increasing separation across subsequent trials strongly suggests that conditioning took place. In the condition in which CLOTH was the CS+, differential responding to the CS+/CS- was also apparent by the third trial; however, the difference in response magnitudes to the CS+/CS- was not as great as in the condition in which CROWD was the CS+. It appears, then, that sensitization effects diminished less rapidly in the CLOTH+ as compared to the CROWD+ condition.

There is one aspect of the response curves in Figure 11 that requires further explanation. If the word CROWD has heightened arousal-related properties compared to the word CLOTH, why was this manifest only when CROWD served as the CS- and not when it served as the CS+ (or at least not as dramatically)? The answer lies in the presentation sequence of the CS+ and CS-; these sequences differed for the CROWD+ and CLOTH+ conditions. Let us first take the condition in which CROWD was the CS-. One half of the subjects received the CS presentation sequence CS+,CS- (i.e., CS+ followed by CS-) at the commencement of conditioning. That is, their first CS exposure was to CLOTH+ and this was followed by CROWD-. It is posited that the loud noise (UCS) on the CLOTH+ trial sensitized the response on the following CROWD- trial. The other half of the subjects in this condition received an initial sequence of CROWD-,CLOTH+. It is posited that for this sequence a sensitized response of a sizable magnitude occurred on the CROWD- trial due to the fact that it was the first CS trial. In sum, the large average magnitude of the response on the first CROWD- trial is based on sensitization effects due to a blast of loud noise heard for the first time on a preceding CLOTH+ trial, as well as sensitization effects due to CROWD- having occurred first in the CS presentation sequence.

Turning now to the condition in which CROWD was the CS+, a somewhat different picture emerges. One half of the subjects in this condition received the CS presentation sequence CROWD+,CLOTH- at the commencement of conditioning. In this case, one would again expect a sizable sensitized response to CROWD+ since this is the first CS trial and so a novel event. The other half of the subjects in this condition received an initial presentation sequence CLOTH-,CROWD+. In this case, one would expect relatively small sensitization effects on the CROWD+ trial since neither is it the first CS nor has any blast of loud noise yet occurred at this point in the CS presentation sequence (keeping in mind that the focus here is on the first latency interval). The end result is that the average response magnitude calculated for CROWD+ on the first trial will be relatively smaller than the average magnitude calculated for CROWD- on the first trial because in the former condition the average response magnitude to CROWD+ is not augmented by sensitization effects due to the novel blast of loud noise. Only on the second acquisition trial are the CS sequencing effects more or less equalized across conditions. As for the stimulus word CLOTH, sensitization effects appear to be relatively minimal (compared to CROWD); neither the circumstance in which CLOTH occurred first in the CS presentation sequence nor the one in which it occurred just after a trial in which the UCS was presented for the first time seemed to have much impact.

Sensitization effects can sometimes be a problem if they differ across experimental conditions, since this results in confounding with independent variables. In the present study, an examination of responses not likely to be CRs (i.e., those on CS- trials) failed to reveal differential sensitization effects across hemispheric conditions in the first or second latency intervals. Assuming that sensitization effects followed a similar pattern for responses to the CS+, it does not appear likely that sensitization effects distorted hemispheric effects obtained.

Terrace (1973) has stated that in a CS+/CS- discrimination procedure, sensitization effects are essentially the same on both types of trials. This, however, only holds if the CSs share similar response-eliciting characteristics. It is apparent that in the present study, even though CSs were similar types of words having a near-neutral emotional valence, sensitization effects were unequal for CLOTH and CROWD. As discussed above, these differences in sensitization effects appeared to be most pronounced in the first trial. Although sensitization effects for the two CSs continued to differ across later trials, differential responding is attributed largely to conditioned responses.

Hemispheric Interaction Effects

It is difficult to account for the greater differential responding in the left as opposed to the right hemisphere condition in the first latency interval--particularly in light of the reverse hemispheric effect that occurred in the second latency interval. In both cases, hemispheric effects were only found for the positive component. The findings for the first latency interval appear to go against the hypothesis that right hemispheric emotional/motivational processes play a larger or more effective role than left hemispheric processes in autonomic classical conditioning. The opposing findings for the first and second latency intervals suggest that hemispheric processes mediate in complex ways dependent not just on the general paradigm used (e.g., autonomic classical conditioning) but also on various factors such as the type of stimuli used, the parameters of the contingency, and the cognitive style of the individual (e.g., Hellige, 1975). The findings in the present study are in keeping with the growing realization in laterality research that performance differences between the left and right hemispheres are highly unstable, shifting with changes in experimental design, instructions, and levels of practice (Cohen, 1979). Although it is by no means clear which factors in the present study have contributed to the hemispheric effects, the reversal in hemispheric advantage from the first to the second latency interval indicates that differing characteristics of the CSs and UCS may at least in part account for the findings. The use of verbal stimuli as CSs may have given the left hemisphere a subtle advantage in conditioning, since it is specialized in processing verbal information. Cognitive factors, then, may have played a role in conditioning. That is, rather than simply attending to the physical features of the CSs in order to distinguish the CS+ from the CS-, subjects may have brought into play the semantic processing capabilities of the left hemisphere when exposed to the verbal material. This explanation seems all the more plausible, given the interaction effects obtained with the counterbalancing of the two verbal stimuli CLOTH and CROWD. As described in greater detail below, the different connotative values of these two words appears to have had an unequal influence on electrodermal responses during conditioning. Semantic processing, then, appears to be an important component in this conditioning experiment. The notion that cognitive factors play a prominent role in human classical conditioning is not new (e.g., Razran, 1955) and has been the focus of much research (e.g., Biferno & Dawson, 1977; Maltzman, 1979).

In the second latency interval, on earlier trials, greater differential responding occurred to stimuli presented to the right as opposed to the left hemisphere. This hemispheric effect is opposite to that found for the first latency interval. What accounts for this reversal? A distinctive feature of the second latency interval is the occurrence of the UCS on CS+ trials just prior to this latency interval. It may be that the aversive nature of the blast of noise contributed to the right hemispheric effect. As discussed earlier, second interval responses appear to be a product of both a UR and a CR. Consistent with other laterality research (e.g., Carmon & Nachshon, 1973; Cohen et al., 1976; Dimond & Farrington, 1977; Suberi & McKeever, 1977) it may be that the right hemisphere is relatively more activated than the left in the emotional processing of high intensity stimuli, and this manifests itself in the electrodermal response.

It is suggested, then, that the left hemispheric effect found in the first latency interval reflects essentially verbal/cognitive processing of contingency information, whereas the right hemispheric effect in the early trials of the second latency interval reflects input from relatively more activated emotional systems of the right side of the brain along with left hemispheric activity involved in processing contingency information. The shift, in the second latency interval, from a right to a left hemispheric effect in the midpoint in the acquisition phase may be the result of a gradual deactivation of right hemispheric emotional processes through habituation, which occurs at a greater rate than habituation to the CSs.

The contribution of left and right hemispheric processes during conditioning may be compared to the distinction between "voluntary" and "involuntary" responses which Maltzman (1979) has made. Maltzman and coworkers have found that task instructions have a strong influence on the course of habituation of the SCR induced by a series of stimuli; but these instructions do not affect the magnitude of the response to the first stimulus in the series (Maltzman, 1979). The interpretation they offer is that the initial response to a relatively unpredictable stimulus is less affected by idiosyncratic processes such as cognitive sets as compared to later responses. They view the initial response as relatively involuntary, relating to a sudden change in the environment. Later responses are regarded as relatively voluntary in the sense that they appear to be influenced by speech and thinking. In short, one type of OR appears to reflect cognitive factors more than the other. From the point of view of the present findings, the so-called voluntary OR may be relatively more under the influence of left hemispheric processes and the so-called involuntary ORS may be relatively more under the influence of right hemispheric emotional processes. Maltzman's observation that task instructions did not affect the magnitude of the response to the first stimulus in the series, then, may reflect the relative dominance of right hemispheric emotional processes over the cognitive/verbal ones of the left hemisphere. However, this notion of relatively greater activation of right hemispheric processes by an initial CS is only partly supported by findings in the present study. An inspection of response magnitudes to the first CS in the series revealed larger magnitudes for the right hemisphere condition, but only for the negative--not the positive---component of the SPR. It remains unclear precisely what the nature of hemispheric influences is in determining responses to initial stimuli; however, when intense, aversive stimuli occur during the course of conditioning, the findings of the present study do suggest an increased role of right hemispheric emotional processes.

The reversal in hemispheric effects from the first to the second latency interval in the present study suggests that the electrodermal response in aversive classical conditioning reflects complex hemispheric interactions. Such factors as stimulus intensity and semantic attributes may influence the relative activation of different brain systems. Furthermore, this balance of activation may shift as a function of time elapsed since CS onset, and as a function of repeated stimulus presentations. The fact that a left hemispheric conditioning effect was obtained in the first latency interval in which word CSs were presented, and a right hemispheric effect in the second latency interval in which an aversive, intense UCS was presented, suggests that semantic systems were ascendant in the first latency interval and emotional systems increasingly activated in the second latency interval.

Although a conception of conditioning as strengthening of associations cannot be excluded on the basis of the obtained hemispheric effects, it seems that a view of classical conditioning, in humans, which takes into account cognitive influences is more consistent with other similar research (e.g., Biferno & Dawson, 1977; Dawson, 1973; Dawson & Furedy, 1976; Maltzman, 1977). It is also of interest to note that cognitive factors have been found to influence the conditioned eyeblink response (Grant, 1973).

Maltzman and his coworkers have reported a number of lines of evidence indicating that cognitive processes at some level of informational analysis play a crucial role in classical conditioning. Their research has found that subjects who were unable to verbalize the CS-UCS contingency did not condition; that increases in GSR magnitudes, for individual subjects, occurred on those trials on which contingency awareness developed; and that instructions were effective in altering the growth and the course of the conditioned response (Maltzman, Langdon, Pendery & Wolff, 1977; Pendery & Maltzman, 1977).

Maltzman also considers response habituation to reflect cognitive processes. Pendery and Maltzman (1977) reported that prior exposure to a stimulus list can alter the course of habituation during adaptation. In the first half of the adaptation phase, the group that was shown the stimulus list produced lower magnitude GSRs than the group not shown the list. In the last half of the adaptation phase, the group that had been shown the stimulus list showed a reversal in habituating responses compared to the other group, apparently anticipating the UCS. Pendery and Maltzman (1977) ruled out differential arousal affects on the basis of an absence of significant differences in skin conductance levels between the groups. Another group of researchers have also found instructional effects in electrodermal habituation (Iacono & Lykken, 1983). Different groups of subjects were told to ignore or attend to tone stimuli while they were exposed to a radio play at the same time. It was found that the ignore groups were less responsive and habituated faster than the attend groups. These kind of results appear to suggest that habituation is not solely a function of the immediate stimulus and past similar stimuli.

Maltzman (Maltzman, 1977, 1979; Pendery & Maltzman, 1977) has argued that the conditioning and habituation process in humans is more complex than that posited to operate in spinal cats (e.g., see Thompson & Spencer, 1966); Maltzman maintains that the conditioned response is a GSR-OR (Maltzman, Weissbluth & Wolff, 1978) which reflects both stimulus novelty and stimulus significance. According to this view, ORs reflect higher attentional processes directed toward the anticipation of future events. The evidence for conditioning as a cognitive process is compelling; however, the nature of these "higher" processes and those aspects of informational analysis necessary for the conditioned response still needs to be further explored.

The interpretation of the present findings in terms of shifts in balance of activation of the cognitive and emotional systems at different points during the CS-UCS interval receives some support from a recent study which has specifically investigated shifts in allocation of cognitive processing capacity (Dawson, Schell, Beers and Kelly, 1982). These researchers required subjects to perform a secondary reaction time (RT) task at various points in the CS-UCS interval during the course of electrodermal classical conditioning. Results showed that RT changed systematically during the CS-UCS interval, exhibiting a peak in slowing at

300 msec. following CS+ onset, and decreasing at 1000 msec. following an expected UCS. It was also found that RT was significantly slower following an improperly cued UCS (i.e., one presented on a CS- trial) than following a properly cued UCS. Dawson et al. (1982) rejected an arousal interpretation in favor of one based on the notion of allocation of cognitive processing capacity, arguing that the latter explanation best fits the data. In the context of the present study, it may be that the reversal in hemispheric conditioning effects between the first and second latency intervals reflects, in part, similar underlying shifts in processing as those suggested by the findings of Dawson et al. (1982).

Various lines of evidence of the kind considered above appear to indicate that higher attentional processes pertaining to the discovery and anticipation of stimulus relations may play an important role in conditioning as reflected in the electrodermal response. Research with brain-damaged patients also implicates these higher attentional processes pertaining to informational analysis and problem solving. In particular, Luria (1973) has found that both patients with lesions in posterior parts of the hemispheres and lesions in the frontal lobes show rapid habituation of the GSR-OR to stimulus presentations. However, they differ in an important way. Patients with lesions in the posterior hemispheres showed a restabilization and slow extinction of the orienting response when meaning was imparted to stimuli by verbal instructions, but frontal patients did not show this effect. Apparently, the electrodermal response reflects both elemental informational processing systems responsive to stimulus change and more sophisticated systems (in the frontal region) involved in the generation of anticipatory schema responsive to instructions.

What is needed to make a more convincing case for the posited critical role of cognitive or problem-solving processes in classical aversive conditioning is an experimental bridge between phenomenological and behavioral approaches to the question on the one hand, and electrophysiological approaches focussing on patterns of neural activity in the brain on the other. This kind of strategy has been suggested by Maltzman (1979). He has proposed that research of the kind reported by Livanov (1977) might be useful in further developing a cognitive theory of classical conditioning. Livanov (1977) has demonstrated that when a normal adult engages in problem solving, recordings from the cerebral cortex show an increase in synchronous biopotential activity and appear to reflect the transmission of information. Maltzman has suggested combining the use of such recordings of brain activity with electrodermal measures. He has hypothesized that an increase in synchronous biopotential activity between spatially distant centres in the brain may be correlated with the appearance of an OR in conditioning and the ability to verbalize the conditioning contingency.

Electrodermal Lateralization versus Hemispheric Effects

A possible confounding factor in interpreting the hemispheric effects in the present study is lateralization of the electrodermal response system. Evidence indicates that electrodermal activity may sometimes be differently affected in different limbs by the same experimental treatment. LaCroix and Comper (1979) found that bilateral (left/right hand) differences in skin conductance were a function of the type of cognitive task assigned to subjects. Verbal (left-hemispheric) and spatial (right-hemispheric) tasks produced smaller response amplitudes in the hand contralateral to the more activated hemisphere than in the ipsilateral hand. They concluded that lateralized cortical influences play an inhibitory role in electrodermal activity. Myslobodsky and Rattok (1977), however, reported greater electrodermal activity in the left hand with spatial tasks, and in the right hand with verbal tasks. Then again, O'Gorman and Siddle (1981), in a study using stimuli similar to those used by LaCroix and Comper (1979) found that the SCR was larger in the right hand than in the left regardless of the nature of the task (verbal versus spatial). Right-handed subjects were used in these studies.

There are no clear implications from these findings as to the choice of hand in recording responses. Moreover, these studies were not concerned with conditioning effects and so raise doubts on the generalizability of the findings to the kind of experimental paradigm used in the present study.

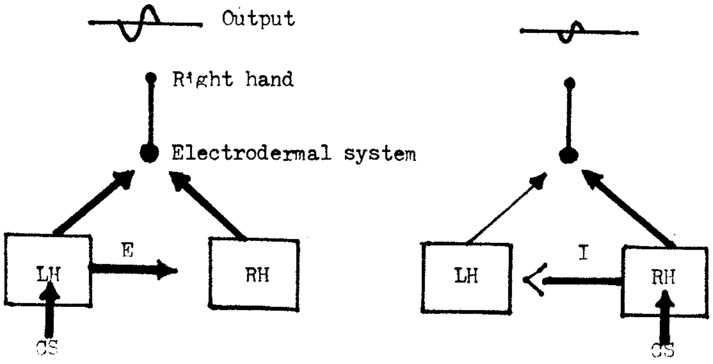
In the present study, the right hand was used to record electrodermal activity. Unilateral, as opposed to bilateral electrode placement, has the disadvantage that one cannot be sure that both hands produce similar patterns of electrodermal activity, yet some evidence does indicate that in electrodermal habituation and conditioning the choice of hand placement may not be crucial. Some researchers using the SPR and SCR in electrodermal habituation and conditioning have found that recordings taken simultaneously from both limbs produce similar results (Iacono & Lykken, 1983; Martin, Stambrook, Tataryn & Beihl, 1980).

Assuming that both hands yield similar response patterns, it seems probable that the laterality effects obtained in the present study are attributable to differences in activated processes of the left and right hemispheres rather than to lateralized excitatory or inhibitory control of electrodermal response systems by cortical processes. The fact that both a left (in the first latency interval) and right (in the second latency interval) hemisphere-of-presentation effect were obtained speaks against a model of either contralateral excitatory or inhibitory control mechanisms of the electrodermal response system. Models of contralateral electrodermal control would attribute the differing electrodermal conditioning effects obtained in the left and right hemisphere-of-presentation conditions to asymmetrical placement of the SPR electrodes. Thus, the findings in the present study of greater CS+ responding in the left hemisphere-of-presentation condition might be attributed to contralateral excitatory control mechanisms governing the response system to the right hand. In other words, according to this model, electrodermal laterality effects for the left and right hemisphere-of-presentation conditions are not necessarily due to differing levels of activation of the two hemispheres, but rather to the control mechanism of the response system. If one, however, attempts to fit a model of contralateral excitatory control to the present findings of a left hemisphere-of-presentation effect (in the first latency interval), this would fail to explain the right hemisphere-of-presentation effect found in the second latency interval. For the right hemisphere-of-presentation effect, proponents of lateralized electrodermal control mechanisms would have to argue for a contralateral control mechanism having inhibitory characteristics. That is, activation of the right hemisphere leads to greater electrodermal responding in the right hand than does activation of the left hemisphere due to inhibitory contralateral controls exerted by the left hemisphere on the response system. The findings in the present study of both a left and right hemisphere-of-presentation effect (in the first and second latency intervals respectively) indicate, then, neither the excitatory nor the inhibitory model of contralateral control of the electrodermal response system, in itself, is sufficient. The nature of electrodermal control mechanisms is still poorly understood, but likely operate in a more complex fashion than simply through contralateral inhibition or excitation. Both the present findings as well as the conflicting results reported by others mentioned above speak against such a simple view.

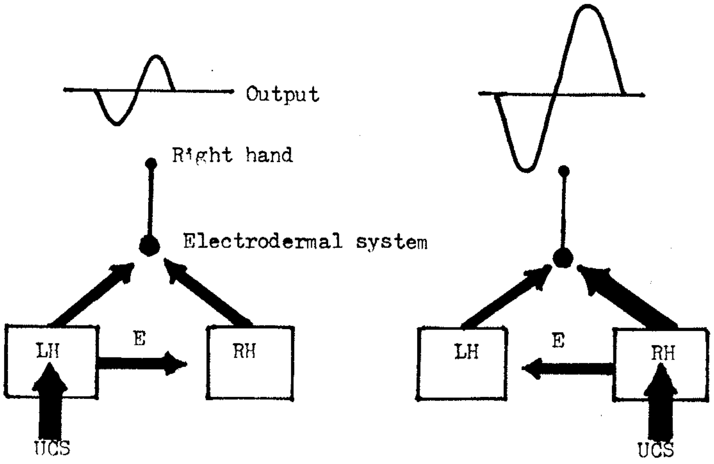
A point that should not be overlooked is that proponents of models of contralateral electrodermal control mechanisms base the interpretation of their research data on the assumption that the left and right hemispheres in the two experimental conditions in their studies are equivalently activated. For example, LaCroix and Comper (1979) in one condition used verbal tasks to activate the left hemisphere and in the other condition used spatial tasks to activate the right hemisphere; electrodermal recordings were taken from both hands. One of their findings was that activation of the left hemisphere produced larger responses in the left hand than did activation of the right hemisphere. Rather than appealing to contralateral inhibitory controls to account for these findings, an explanation based on differing levels of activation of the two hemispheres by the verbal and spatial tasks may be more accurate. LaCroix and Comper (1979) discount this alternative for various reasons (including the findings of equal tonic levels of skin conductance across conditions); however, heart rate differences found across conditions give some reason to suspect that activation levels for the two hemispheres were not equivalent. In the case of the present findings, the view is taken than no simple model of contralateral control mechanisms of the electrodermal response system is appropriate; whatever excitatory or inhibitory influences operate in the determination of the electrodermal response are probably complex. The position taken in the present study is that the left and right hemisphere-of-presentation effects are due to differing levels of activation in the hemispheres. The sum of the relative activation of the two hemispheres for left or right visual field stimulus presentations is posited to be the essential determinant of the hemisphere-of-presentation effects observed in the conditioned electrodermal response.

In view of the complexity of the brain, and evidence indicating that the electrodermal response is a function of widespread activities in the limbic system (Isamat, 1961), the hypothalamus, the basal ganglia, the premotor corticospinal system (Edelberg, 1972, 1973), and higher cortical centres (LaCroix & Comper, 1979; Wang, 1964), one can only speculate on the nature of hemispheric excitatory and inhibitory influences that contribute to the final conditioned response. The left hemisphere-of-presentation effect found for the first latency interval conditioned responses appears to suggest, as discussed earlier, that semantic processes of the left hemisphere play an important role in conditioning--at least when CSs are words. In this first latency interval, when CSs are presented to the left hemisphere, the left hemisphere may have an excitatory influence on the right hemisphere, and the summative activity leads to the response. In this proposed model, right hemispheric processes are thought to contribute through the activation of memories of unpleasant experiences, including that of the UCS. When CSs are presented to the right hemisphere, activation of unpleasant memories may lead to an inhibition of left hemispheric processes, with the result that a relatively smaller conditioned response occurred. Figure 13 (top half) illustrates these posited hemispheric interactions which might account for the finding of greater conditioned responses for CSs presented to the left as opposed to the right hemisphere.

In the case of the second latency interval the UCS has a more immediate effect, since it occurs just prior to this response interval. The lower half of Figure 13 illustrates the kind of hemispheric interactions which might contribute to the greater conditioned responses for CSs presented to



First latency interval



Second latency interval

Figure 13. A schematic of possible hemispheric influences contributing to the final electrodermal response in conditioning. The thicknesses of arrows represent levels of activation; they are only intended to be suggestive of relative levels of activation (E = excitatory; I = inhibitory).

the right hemisphere as opposed to the left. The intensity of the UCS may account for the right hemisphere-of-presentation effect obtained on early trials in the second latency interval. Here, emotional processes of the right hemisphere may have been strongly mobilized. When the UCS is presented directly to the right hemisphere (LVF), the intense activation of this hemisphere may release previous inhibitory influences directed to the left hemisphere which operated in the first latency interval, such that some indirect activation of semantic processes in the left hemisphere can occur. When the UCS is presented to the left hemisphere, indirect activation of right hemispheric emotional processes is posited to occur through left hemispheric excitatory influences. It is plausible that the emotional processes of the right hemisphere contributing to the conditioned response may be more intensely activated by direct presentations of the UCS (LVF) than by indirect presentations (RVF). It is posited that the summative influence of indirect left hemispheric activation and intense right hemispheric activation leads to the larger responding to the CS+ (in the second latency interval) for stimulus presentations to the right hemisphere (LVF) as compared to the left hemisphere (RVF).

This proposed model can also accommodate the fact that a reversal in the hemisphere-of-presentation effect occurred in later trial blocks in the second latency interval. The reversal to greater responding to CS presentations to the *left* hemisphere in later trials may be explained in terms of similar hemispheric interactions proposed to account for the left hemisphere-of-presentation effect obtained in the first latency interval. That is, as responses to the UCS habituated in the second latency interval, the hemispheric interactions that were in effect in the first latency interval may have continued over to the second latency interval with little modification in balance of activation. In later trials, then, direct activation of the right hemisphere in the second latency interval may not have been sufficient to release inhibitory effects on the left hemisphere--as posited to have occurred on earlier trials. In effect, then, the greater conditioned responses for stimulus presentations to the left hemisphere on later trials in the second latency interval may be due to similar hemispheric interactions posited to account for greater responding to CS presentations to the left hemisphere in the first latency interval. This proposed model is highly tentative, but it provides a basis for further investigation. By changing latency intervals, UCS intensities, or the time frame of the CS-UCS interval, it may be possible to test aspects of the model of hemispheric interactions.

Hemispheric Effects in Other Conditioning Studies

Only a few studies in the literature have reported hemispheric differences in conditioning. These studies differ from each other and from the present study in terms of the conditioning procedure used and the research question being investigated.

Hellige (1975), in a classical eyelid conditioning study, found that the relative activation of the left and right hemispheres as reflected in the conditioned eyeblink response is influenced by individual differences in cognitive processing strategies.

Von Wright et al. (1975) reported a dichotic listening study aimed at testing notions relating to selective attention. Unexpectedly they found that subjects who shadowed with the left ear conditioned more reliably to a word associated with shock, than subjects who shadowed the right ear. For the left ear condition, 21/24 subjects showed a criterion conditioned response; for the right ear condition, only 9/20 produced a criterion response. This finding suggests that conditioning may be facilitated by right hemispheric emotional processes. In terms of the present study, these findings reported by Von Wright et al. are consistent with the right hemispheric effect obtained for earlier trials in the second latency interval. On the other hand, they are contrary to the findings in the present study of a left hemispheric effect in the first latency interval.

The latency interval used by Von Wright et al. (1975) to measure the skin resistance response has characteristics which parallel those of the second latency interval used in the present study. Von Wright et al. used a conditioning contingency in which the CS had a duration of .75 sec. and was followed .5 sec. after onset by the UCS. The latency interval used to measure responses was .5-5.0 sec. after the occurrence of the CS. Conditioning to the CS was measured on trials in which the UCS was withheld. It is plausible that the responses on the test trials may, in part, be anticipatory CRs, given that the latency interval closely followed the point at which the UCS would have occurred. In the present study, the second latency interval followed the point at which the UCS occurred, and to this extent there is some degree of similarity between the latency intervals of the two studies. If one accepts this parallel, then the findings of the two studies do show some consistency; that is, a right hemispheric effect is suggested in both instances. Although this interpretation is plausible, it must not be overlooked that the two studies differ in many key aspects. Von Wright et al. (1975) used a shadowing procedure in which both hemispheres were activated by simultaneous messages to both ears; in which the UCS, shock, was applied unilaterally; in which a partial reinforcement schedule was used; and in which response measures were taken on test trials. Their use of a partial reinforcement schedule may well account for the fact that the majority of subjects showed sustained responding after an average of 33 CS presentations.

Finally, a more recent dichotic listening study has also reported hemispheric differences in conditioned responses (Dawson & Schell, 1982). As in the Von Wright et al. (1975) study, a word-shock contingency was used, but with a CS-UCS interval of .4 sec. The latency interval used to record GSR magnitudes spanned the 1 to 3 sec. time period following the CS. Results are based on test trials in which the UCS was withheld. Subjects received 8 CS+/CS- conditioning trials prior to the test phase. Findings showed larger GSR magnitudes for CSs presented to the left ear than for those presented to the right ear. This lateralized effect differs from that found by Von Wright et al. in that the CSs in the Dawson and Schell (1982) study were presented to the <u>nonattended</u> channel. In the Von Wright et al. (1975) study, the lateralized effect is based on CSs presented to the attended channel. In neither case did the researchers give any evidence to indicate that the other channel showed lateralized effects. What contribution attending makes to the effect is unclear, but it appears to be a subtle one.

Unlike the dichotic listening studies, the present study obtained both left and right hemispheric conditioning effects. Again, given the many differences between the present study and the others, any number of factors could account for the apparent contradiction. As Cohen (1979) has pointed out, a variety of factors can lead to shifts in performance between the left and right hemispheres including experimental design, levels of practice, task difficulty and subject population. In the present context, the use of simultaneous stimulus presentations to both ears in the dichotic studies may have resulted in a different left/right balance of activation in the hemispheres as compared to the present study. It is interesting to note that Hellige (1975) did find a left hemispheric effect in eyelid conditioning (i.e., greater differential eyeblink responding for right visual field stimulus presentations), but this effect was limited to a group of subjects characterized as C-form eyeblink responders, and was attributed to their cognitive processing style.

Stimulus Characteristics

Skin potential responding. Some significant interaction effects in conditioning involving the counterbalancing factor (CS+ = CROWD or CS+ = CLOTH) were obtained that were not predicted. For positive component responses in the first latency interval during acquisition, the CS+ word CROWD produced larger wave deflections than the CS+ word CLOTH in the first two trial blocks (with little differentiation on later trials). Responses to the CS- word CLOTH were consistently lower than responses to the CS- word

CROWD. For negative component responses in the second latency interval a similar pattern of greater responding to the CS word CROWD was observed. For positive component, first interval responses, it is also of note that responses to CROWD- were greater than those to CLOTH+ in the first trial block and approached the deflection m-amplitudes of CROWD+. As well, in the first two trial blocks, differential responding to CROWD+/CLOTH- was greater than differential responding to CLOTH+/CROWD-. It is not clear why the positive component in the second interval did not show any interaction effects involving the CS counterbalancing factor, but an inspection of <u>frequency</u> data did show a trend toward higher frequency responding to the CS+ CROWD as compared to the CS+ CLOTH in the second interval.

The general pattern of greater responding to the CS+ word CROWD than to CLOTH may be interpreted on the basis of its more negative or "unpleasant" connotative value as compared to the word CLOTH. In both the pilot study and main experiment (prior to conditioning) CROWD was rated more negatively (less than the neutral point of 4 on the 7-point scale) than CLOTH (somewhat greater than 4); in the pilot study the scale distance between the two words was .9 and in the main experiment the separation was .7 points. Frequent associations given by subjects to the word CROWD included "shopping centre", "hockey game", and "rock concert". On the other hand, CLOTH was associated with the words "clothes", "shirt", "blanket", and "socks". The semantic associations to CROWD exemplify places which typically have large groups of people and tend to be noisy. It may well be that in the context of the present study where loud noises were presented, associative links were made between the UCS, crowds and the unpleasant events that might have been experienced in that kind of situation (e.g., noise, pushing, violence). During conditioning, then, the loud noise may have enhanced processing of the word CROWD in terms of negative associated meanings and this in turn may have led to greater electrodermal responsiveness. What is suggested here is that semantic processes came into play in the conditioning process. To the extent that unpleasant experiences are posited to have been activated by CROWD, emotional processes related to the activation of unpleasant memories are also thought to play a role. This posited associative process would also apply to the word CLOTH; however, since this word seems unlikely to have a network of negative connotations similar in extent and degree to that of CROWD, the activation of these more neutral associations is thought to lead to relatively lower responsiveness. The finding of a left hemispheric conditioning effect in the present study provides some tentative evidence that semantic processes of the left hemisphere may be involved in stimulus processing. In order to test this notion further, hemispheric conditioning might be carried out with pairs of words having a unique semantic relationship with the conditioning contingency. An example of such words are QUIET and SOUND. In a conditioning procedure in which a loud noise UCS is used, QUIET as the CS+ would be semantically incongruent with the context of the contingency; conversely, SOUND as the CS+ would be congruent. For our purposes, these word CSs should have the same--preferably neutral--emotional valence prior to conditioning. In accord with the postulated role of semantic processes in classical conditioning of word CSs, one would predict that SOUND as the CS+ would result in greater electrodermal responsiveness than QUIET as the CS+. It would be of further interest to use shock as the UCS rather than loud noise. In this case, one would predict that SOUND and QUIET as CS+s would not result in response differences.

The extent to which semantic factors are involved in aversive classical conditioning to word CSs is still uncertain, but the finding in the present study would seem to suggest that it is not merely structural aspects of the stimuli that are attended to--although this would be sufficient for discriminations to be made between the CS+ and CS-. Luria (1981) has cited studies conducted in his laboratory which also point to the activation of semantic networks of associations in conditioning as reflected in the orienting response. In these studies subjects were conditioned to word CSs. It was found that subjects showed orienting responses to words semantically related but not to words phonetically related. In Hellige's (1975) classical eyelid conditioning study there is some indication that the meanings of the words used as CSs interact with their assignment in the conditioning contingency in determining the final response. Hellige found greater differential conditioning in the left hemisphere as opposed to the right hemisphere condition for C-form responders when the CS+ word was BLINK and the CS- was DON'T BLINK, but no hemispheric differences when the CS+/CS- words were reversed. Apparently the context of the words in the contingency is important under some conditions. This kind of influence of semantic features in conditioning suggests that cognitive processes involved in the learning of stimulus relationships may play a crucial role. This is not to say that processes involving a strenghtening of associations cannot contribute to conditioned responses; however, it appears that in humans these more elemental processes are frequently overridden. It seems that in both eyelid conditioning (e.g., Grant, 1973) and electrodermal conditioning (e.g., Maltzman, 1977) that consideration should be given to the role of cognitive functions. Although it is important to take the response system into consideration in understanding the conditioning process, it is proposed that in human conditioning cognitive processes may often have a prepotent influence in determining the course of conditioning. As discussed earlier, electrophysiological data pertaining to patterns of cortical activity in conditioning might be useful in further examining this question.

Semantic differential ratings. Post-conditioning ratings of the two CS words CROWD and CLOTH suggest that the conditioning experience altered the significance attached to them. When CLOTH or CROWD served as the CS+ their respective ratings became more negative post-conditioning as compared to pre-conditioning. That is, they were experienced as more "unpleasant" after conditioning. The two words, however, still stood in the same relationship to each other. That is, post-conditioning ratings still showed CROWD to be experienced more negatively than CLOTH. When the two words served as CS-s, post-conditioning ratings were equivalent. What happened was that post-conditioning ratings of CROWD- increased in the positive direction with the result that they matched ratings of the CLOTH- stimulus. Ratings of CLOTH- did not show a change from pre-conditioning ratings.

It seems clear that conditioning influenced the affective significance of the CS words, but one can only speculate on the extent to which cognitive processes contributed to the pattern of changes in CS ratings from pre- to post-conditioning. The post-conditioning shift toward a more positive rating for CROWD-, but not for CLOTH-, may reflect relational learning in which "congruency" between the meaning of the CS and its context in the conditioning contingency (as CS+ or CS-) was assessed at some covert level of processing. Appropriately, CROWD+ and CLOTH+ acquired an increased negative affective significance based on their relationship with the loud noise. Since CLOTH- was a signal for no loud noise, its valence remained near the neutral point. For CROWD+/CLOTH- arrangement there is congruency between the relative "pleasantness" of the two words (based on pre-conditioning ratings) and their context in the conditioning contingency. This is not the case, however, for the CLOTH+/CROWD- arrangement. Here, the context of the two words in the conditioning contingency is opposite to the relative pre-conditioning negativity of the words. This notion of congruency may account for the fact that CROWD-, unlike CLOTH-, received a more positive rating post-conditioning. It is suggested that the incongruency of the CLOTH+/CROWD- arrangement may have resulted in a "reevaluation" at some covert level of the affective significance of CROWD when it served as the CS-. That is, the inconsistency between an initial relatively negative evaluation of CROWD and its relatively positive context in the conditioning arrangement perhaps required a cognitive adjustment. The kind of study proposed earlier using the CS words SOUND and QUIET in congruent and incongruent contingency relationships might provide evidence in support of this notion.

Other interpretations of the shift in ratings for CLOTH- and CROWD- are also plausible. Findings reported by Maltzman, Weissbluth and Wolff (1978) of a negative shift of CS- ratings from pre- to post-conditioning (5.13 to 4.79) suggest that perhaps CS-s simply gravitate toward the mean due to regression effects. In the final analysis, interpretations of the pattern of word ratings remain unsettled, since any number of alternative explanations can fit the results. For example, the lack of change in pre- to post-conditioning ratings of CLOTH- may be due to generalized arousal effects from the highly unpleasant CROWD+ stimulus with the result that increases in post-conditioning ratings of CLOTH- were attenuated. One must also recognize the fact that semantic differential ratings and electrodermal activity are very different kinds of responses and may be controlled by different brain systems which do not have a one-to-one correspondence. Others have observed discrepancies in response systems. Schneiderman (1972) has observed divergencies between autonomic and somatic responses in the rate of CR acquisition, discriminative responding and reactions to stress in aversive classical conditioning. Maltzman, Gould, Barnett, Raskin and Wolff (1977) have found that vascular responses do not always reflect stimulus changes in the same way as the GSR. They have suggested that these discrepancies may be due to different brain centres controlling response systems or characteristics of the response systems themselves. In the present study, the discrepancy between electrodermal responses to the CS-s and post-conditioning ratings of these stimuli is particularly evident. Here, responses to CROWD- were larger than those to CLOTH- during conditioning. In contrast, post-conditioning ratings of these two simuli were the same. Although the two response types (SPR and semantic differential ratings) do not correspond for the CS-s, they do for the CS+s. Perhaps in the case of the CS-s the discriminations are too fine to be made by the semantic differential response processes. In view of the fact that an extinction phase was used in the present study (during which subjects showed virtually no electrodermal responding) and yet significant differences were obtained in semantic differential ratings post-conditioning, seems to give further indication that different processes may contribute to the final SPR and semantic differential rating responses.

Although evaluative ratings of the stimuli do not always have close correspondence with electrodermal responding, results of the present study make it clear that conditioning did have some effect in changing the affective significance of the words (with CROWD+ showing the maximum change of .9 points). Maltzman and coworkers in their semantic conditioning studies have also used semantic differential ratings of stimuli and have found similar effects. Maltzman, Weissbluth and Wolff (1978) reported a small pre- to post-conditioning shift of CS-s ratings toward the neutral point (from 5.13 to 4.79) on 7-point semantic differential scales. The CS+ ratings, however, showed a greater shift in the negative direction from 5.25 to 3.56. Maltzman, Langdon, Pendery and Wolff (1977) also found that post-conditioning ratings of CS-s were close to the neutral point (means ranging from 4.33 to 4.47) and were not different for groups which had received differing intensities of the UCS. However, the CS+ and UCSs were rated as highly unpleasant, and more extreme unpleasantness ratings were given for high intensity UCS conditions. These researchers also reported that those subjects who were able to verbalize the conditioning contingency were more likely to rate the CS+ more negatively than subjects who were unable to to verbalize. Maltzman's findings are consistent with those of the present study in that in both cases CS+ ratings became more negative and CS- ratings approached the neutral point post-conditioning. It is worth noting that post-conditioning ratings of the CS-s in the present study are about the same as those reported by Maltzman and his team; in both cases ratings are just above the neutral point.

In the present study, correlations were obtained between ratings of the CS+ and m-amplitude responses; the more unpleasant the word stimulus was experienced, the larger the skin potential response. No significant relation was found between ratings of the UCS and skin potential responses, or between ratings of the UCS and ratings of the CS+. The reason for this is not evident. Consistent with the present findings, Maltzman, Raskin and Wolff (1979) reported that subjects who rated the CS+ more negatively showed greater overall responsivity (GSR) and greater differential semantic conditioning than neutral raters. These types of relationships suggest a gross empirical relationship between systems involved in the affective evaluation of word stimuli and systems activated in the electrodermal response to these stimuli. However, as indicated above, discrepancies were also found.

Extinction

No important effects were obtained for the extinction phase. At the end of the acquisition phase, most subjects showed almost complete habituation of responses. During extinction, most subjects on most trials gave no responses. Those electrodermal responses that were elicited were highly variable, hence any interpretation of the response patterns graphed in Figure 10 is highly tentative. What is evident from the graph is that CS+ responding was greater than CS- responding. The higher responding to CROWD as CS+ as compared to CLOTH as CS+ on the third extinction trial block is consistent with the evaluative ratings of these words. On the other hand, response m-amplitudes to the CS-s are not commensurate with evaluative ratings. There is a slight indication of a drop in response levels from the first to the second extinction trial block; this may reflect a development of expectations that the UCS would no longer appear. It may have been helpful to have used a partial rather than full reinforcement schedule in the present study to sustain responding during extinction.

Interpretations of the Positive and Negative Wave Components of the SPR

An ongoing point of disagreement among researchers investigating the SPR has centred around the interpretation of the positive and negative components of the electrodermal response. Edelberg (1973) has proposed a theory of electrodermal activity in which positive and negative SPR components are posited to arise out of different effector systems; namely, epidermal and sweat gland activity. This theory holds that the hydration level is controlled by two opposing systems. Sweat production by sweat glands is thought to lead to increased hydration; whereas, the activity of the absorbing membranes in the epidermis is viewed as resulting in decreased hydration. In this model, the sweat gland mechanism produces long time-constant changes in skin conductance through alterations in the level of sweat in the ducts. In contrast, the absorbing membrane is implicated in short time-constant conductance changes through variations in membrane permeability. Edelberg

(1970) has reported that positive SPRs are associated with faster SCR recovery rates than are negative SPRs. In view of the evidence that recovery rate is slowed down by aversive stimulation such as emotionally charged words and the threat of shock, and hastened by goal directed tasks such as counting backward by sevens (Edelberg, 1972), it would seem that the positive component of the SPR is more closely linked to orienting responses, and the negative to defensive responding. Edelberg (1973) has proposed that the level of skin hydration varies as a function of situational demands. Goal orienting is thought to be associated with a medium hydration level for optimal tactile sensitivity, and threatening or aversive situations are thought to result in inhibition of the epidermal readsorption process and higher hydration levels. This is viewed as an adaptive response in preparation for defensive behavior in that hydration serves to protect the skin from abrasions. Edelberg has suggested that a phobic situation might provide the prototype for sweat responding (see Ohman, Fredrikson & Hugdahl, 1978). Some support for the posited relationship between situational demands and effector activity in the skin is provided by Ohman et al. (1978). They observed differing dorsal/palmer SCR patterns in the hand for phobic, but not for neutral, stimulus presentations, and attributed this to the unequal distribution of sweat glands in the two skin surfaces. The interpretation was made that phobic stimuli, unlike neutral stimuli, activated the sweat gland mechanism. Since there are more sweat glands on the palm, this according to the researchers, resulted in palmer/dorsal differences in response patterns for the phobic stimuli. Ohman et al. (1978) have suggested that the sweat producing responses to the phobic stimuli may reflect defensive responding (DR).

Whereas some researchers have argued for a relation between the negative SPR component and defensive responding (e.g., Edelberg, 1973), others have suggested that the positive component reflects defensive responding (e.g., Raskin et al., 1969). More recently, Raskin (1973) has expressed doubts regarding his earlier interpretation of the positive component as a DR. Glaus and Kotses (1974) have suggested that the OR may be manifested in either component. The response patterns of the positive and negative components in the present study appear to favor this last view.

In the present study, comparisons of negative and positive component responses in the first latency interval revealed that negative m-amplitude responses to the CS+ are larger than positive m-amplitude responses to the CS+, and slower to decline across trials. A similar patterns applies to CS- responses. SPRs based on the frequency measure showed higher frequency responses to the CS+ and CS- for the negative component as compared to the positive component in the first interval. A similar pattern was reported by Glaus and Kotses (1974) in their differential conditioning study using the SPR. In the second latency interval of the present study, again, negative m-amplitude responses to the CS+ showed a slower decline than positive responses.

As for conditioning effects in the present study, both the positive and negative components showed differential responding to the CS+ and CS-. It is of interest that a Conditioning x Trials interaction was found for the positive component, but not for the negative component. The significant interaction effect for the positive component is based on a rapid decline of CS+ responses across trials. Glaus and Kotses (1974) also reported differential conditioning for both components of the SPR. Unlike in the present study, they obtained a Conditioning x Trials interaction for the negative as well as the positive component. Other researchers have failed to obtain simultaneous conditioning in both components of the SPR. Shmavonian, Miller and Cohen (1968) reported differential conditioning only for the positive component, using amplitude measures. Yamazaki, Watanabe and Niimi (1969) concluded from their findings that conditioning occurs primarily in the negative component. Researchers have suggested that the positive and negative components may be differentially influenced by a variety of perceptual and cognitive factors (Burnstein et al., 1965; Raskin et al., 1969). In view of the differing response patterns of the positive and negative components in the present study, and the fact that interaction effects involving either the hemisphere-of-presentation factor or the CSword factor were essentially limited to the positive component, it would appear that the two wave components do not measure the same thing.

In attempting to demonstrate that one component of the SPR reflects an OR and the other a DR researchers have focussed on habituation rates. This follows from the defining characteristics of the OR and DR. Sokolov (1963) has developed an influential theory of stimulus information processing based on the occurrence of ORs and DRs (Raskin, 1973). Sokolov, like others (e.g., Maltzman, 1979), views the OR as critical in conditioning. He (Sokolov, 1963) has described the function of the OR as being that of producing heightened sensitivity to environmental stimulation in order to increase information intake and facilitate learning. Whereas Sokolov considers the OR to be elicited by moderate levels of stimulus intensity, the DR is thought to be produced by intense or aversive stimulation. In contrast to the OR, the DR is highly resistant to habituation. The function of the DR is described as attenuating the effects of strong stimulation to protect the organism (Raskin, 1973). To date, <u>electrodermal</u> measures have failed to successfully differentiate the OR and DR. Although differing habituation rates for the positive and negative component of the SPR have been observed by various researchers (e.g., Glaus & Kotses, 1974; Loveless & Thetford, 1966; Raskin et al., 1969), the patterns have not always been consistent and it is far from established whether or not these habituation patterns represent different response systems. The findings of the present study, though by no means conclusive, do indicate that the positive component is not necessarily a DR, and may well reflect an OR which is sensitive to different stimulus features or cognitive processes.

The basis for rejecting the notion that the positive component primarily or exclusively reflects a DR is the finding in the present study of faster habituation rates for that component. This is the case both in the first interval and second latency interval. Glaus and Kotses (1974) similarly observed greater habituation rates of the positive component as compared to the negative component. Loveless and Thetford (1966) reported a conditioning study that used adaptation and extinction trials in addition to acquisition trials. SPR responses during adaptation showed quick habituation to the positive component relative to the negative. Responses during acquisition revealed an initial rise in wave deflection of the positive response, and then quick habituation; negative component deflections remained about the same. In the extinction phase, the positive component completely extinguished, but the negative did not. The researchers interpreted the positive component as an OR, and suggested that it originates in the epidermal cells of the skin, whereas the negative component originates in the sweat glands. Raskin et al. (1969) reported a study in which subjects received a series of brief presentations of white noise at different stimulus intensities (ranging from 40 to 120 dB.). They found that for initial stimulus presentations, the negative component of the SPR produced no differentiation as a function of stimulus intensities; however, with repeated presentations of the loud noise stable response magnitudes developed in the first few trial blocks; these were relatively large for the two highest stimulus intensities, and small for the three lowest stimulus intensities. The positive component showed large initial differences in response magnitude as a function of stimulus intensity, but repeated stimulation resulted in the habituation to zero of response magnitudes at all intensities except 120 dB. The researchers interpreted these findings as indicating that the negative component represents an OR and the positive a DR. However, their conclusion is not particularly convincing. First, in comparing positive and negative component responses, negative responses showed relatively little habituation. Granted, initial negative responses were smaller in absolute magnitude than positive responses, but they declined relatively little across trials (which is similar to findings in the present study). In contrast, the positive component responses <u>all</u> showed a dramatic fall-off in magnitude from initial stimulus presentations. Figure 14 demonstrates the kind of relative response patterns Raskin et al. (1969) obtained for positive and negative components at high, medium and low stimulus intensities. Second, in late trials, there is practically no difference between positive and negative components in terms of either the absolute response magnitude to 120 dB. stimulus intensities, or the relative difference in response magnitudes to the highest and the lowest stimulus intensities. In short, their demonstration of relatively rapid declines in magnitudes of responses for the positive component appears to suggest an OR, not a DR.

The finding by Raskin et al. (1969) of marked initial differences in response magnitudes of the positive component (but not the negative component) to differing stimulus intensities may reflect a sensitivity of the positive component to stimulus features that have emotionally arousing properties. The fact that the positive component may have such special characteristics does not, however, suggest that it necessarily reflects a unique response system; it may simply be an OR having those response attributes.

Uno and Grings (1965) have reported that high intensity stimulation more readily evokes the positive wave than does low intensity stimulation. Burstein et al. (1965) found that emotionally charged words are more likely to evoke positive as opposed to negative responses. In the present study, the differential effects of the two stimulus words

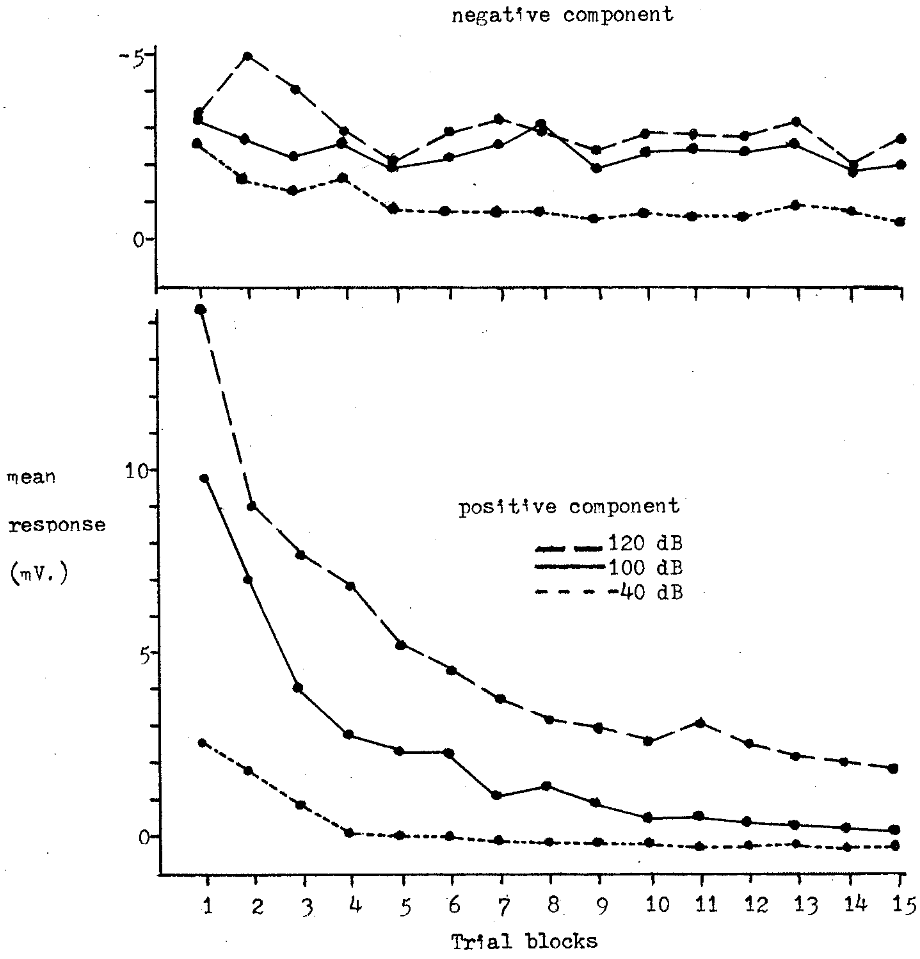


Figure 14. Mean negative and positive components of the SPRs to the different stimulus intensities as a function of successive stimulations. (Adapted from Raskin, Kotses & Bever, 1969.)

CLOTH and CROWD on SPR responding were more apparent for the positive than for the negative component. All this does seem to suggest that the positive component may be more influenced than the negative by unpleasant or highly emotionally arousing stimulus features. It does not suggest a separate effector system. The interpretation of the positive component of the SPR as a DR by Raskin et al. is particularly suspect in light of recent findings by Turpin and Siddle (1979); they reported negative evidence in the distinction of ORs and DRs in their investigation of the effects of various auditory stimulus intensities on SPR and SCR.

As discussed above, habituation rates for the positive and negative components suggest that the former does not reflect a DR. Some other characteristics of the response patterns of the positive and negative components in the present study also indicate that the distinction between ORs and DRs is tenuous. An inspection of negative component responses to the CS- (Figure 9) shows a marked sustained elevation of m-amplitudes for the first latency interval as compared to the second interval. However, positive component responses to the CS- in the first latency interval and second latency interval both quickly habituate (Figure 4). Glaus and Kotses (1974) have similarly noted sustained elevated responding for the negative component to the CS- in the first latency interval. This attenuation on differential conditioning by the large negative component responses to the CS- seems to reflect an OR. This appears to cast doubt on the notion proposed by some that the negative component principally is involved in defensive responding, since the CS- is a signal for safty from noise blasts. The view is shared with Glaus and Kotses (1974) that likely the OR is manifested in both components.

The factors influencing positive component responding are complex, and not merely tied to stimulus intensity. For example, subjects can show wide individual variations in responding, with some giving few or no positive responses and others giving many. Interactions between individual responsiveness and situational factors will likely have to be taken into account to better understand the component waves of the SPR. Based on the present findings, and taking into consideration the pattern of higher m-amplitude and frequency responses for the negative component, one line of thinking to pursue is that of viewing the negative component as a generalized, attentional orienting response, and the positive component as a more specific response to emotional features of the stimulus situation.

A Comparison of Electrodermal Response Measures

Researchers have differed in their recommendations and practices regarding the choice of SPR measures. In the present study, positive component SPRs in the first latency interval were analyzed using each of amplitude (unmodified), m-amplitude, magnitude, probability and frequency measures. As Table 3 demonstrates, m-amplitudes yielded the most significant effects, followed by magnitude measures. Probability and frequency measures gave comparable results. Amplitude measures, except for the lack of a C x T interaction effect, produced similar results as the magnitude measure. The most striking aspect of the m-amplitude measure is that it alone yielded a significant interaction involving the hemisphere-of-presentation factor. Prokasy and Kumpfer (1973) have suggested that a large part of the variance in conditioning is due to the presence or absence of a response, and that magnitude measures confound this aspect of the response with deflection size information. The significant effects obtained for the probability measure (C, T, and C x T) indicate that conditioning effects based on m-amplitude and magnitude measures are essentially due to variance related to the presence or absence of a response. The lack of a C x T interaction for the amplitude (unmodified) measure indicates that this measure "partials out" variance due to the presence or absence of a response. On the other hand, the presence of a significant C x T interaction when magnitude or m-amplitude responses were entered into analysis suggests that both these measures involve some confounding of probability with amplitude aspects of the response data. In further comparing the m-amplitude and probability measures, the H x C, W x C, and W x C x T interaction effects obtained for the m-amplitude responses, but not for the probability response measure, indicate that they are likely based on deflection size rather than that aspect of the response data pertaining to the presence or absence of a deflection. Frequency and probability measures appear to tap the same aspect of the response data; namely, the presence or absence of a deflection.

On the basis of the differing findings obtained for the various response measures, the m-amplitude measure seems to be most responsive to aspects of the conditioning contingency. It is not clear why, but perhaps its method of distinguishing between two different response classes for below criterion responses (see Appendix F) is most suited to the analysis of the complex wave form of the SPR. Frequency and probability measures are not particularly useful if used in isolation; however, if used in conjunction with other measures they do provide some information on the extent to which the presence or absence of a deflection accounts for significant effects. Frequency measures in the present study, as compared to the study reported by Glaus and Kotses (1974), showed a limited range of variation; they ranged, on average, from 0 to 2 responses for a given component. This small range may have attenuated effects using this measure. In the study reported by Glaus and Kotses frequencies appear to have been as high as 28 or more per trial. This difference between the two studies could be due to any number of factors, including the equipment used or response criteria. In any case, the results of the present study demonstrate again that the suitability of an SPR measure depends, in unknown ways, on the nature and design of the study. As for latency measures in the present study, they proved to be of no value; for all subjects, latencies fluctuated seemingly at random, with no decrease across trials. However, other researchers have used SPR latency measures successfully (e.g., Jeffress, 1928; Martin, Stambrook, Tataryn & Beihl, 1980). The usefulness of the latency measure may well depend, like other electrodermal measures, on the nature of the study or the contingency arrangement used. For example, Martin et al. (1980) in their first experiment used a trace conditioning procedure with an ISI of .5 sec. The present study also used a trace procedure, but with an ISI of 5 sec. Perhaps this larger interval results in greater variation in response latency. A further point to consider is that subjects were given information about the conditioning contingency at the start. This was not the case in the study reported by Martin et al. (1980). The rapid rise to asymptote in the first few trials and subsequent habituation indicates that the conditioning contingency in the present study may have had an almost immediate impact on shortening latencies so that no further decline took place in later trials. Indeed, response latencies on CS+ trials in the first latency interval tended to remain unchanged from the first trial block (_M_ = 2.0 sec.) onwards (_M_ = 2.3 sec. in later trials). This trend appears to support the idea that rapid habituation limited the usefulness of the latency measure in the present study.

A few additional items relating to the use of electrodermal measures are pertinent here. In the present study the deflection size of the positive component was measured according to both a definition based on baseline-to-peak difference and on trough-to-peak difference. As detailed in Appendix F, researchers disagree on how best to measure the deflection size of a wave component. The present findings indicated that trough-to-peak deflection measurement results in greater variability in the data. This greater variability may be due to the fact that the positive and negative components of the SPR are responsive to different aspects of the stimulus situation. In the present study, this is reflected by the fact that the positive component yielded hemispheric effects not found for the negative component. Using a composite score for the positive component may result in the loss of important information. A simple positive score (based on baseline to peak) appears to be more responsive to independent measures, hence its use is recommended.

Finally, the IRD index of conditioning (Restle & Beecroft, 1955) showed itself to be without merit in the present study. Part of the problem, as with the complex-positive SPR measure, may be that its use results in the loss of valuable information necessary for detecting differences.

Future Directions

As Cohen (1979) has pointed out, the main task confronting researchers who investigate hemispheric asymmetries is to account for their variability. It is increasingly recognized that many factors influence the performance of the two hemispheres. Among these factors is the thorny problem of individual differences. Hellige (1975) has demonstrated that the cognitive strategies of individuals can play a role in the course of conditioning. In the present study, an inspection of individual response records revealed that some subjects respond only to the negative component, while others respond at high frequencies to the positive component. Glaus and Kotses (1974) have also observed differences in individual response patterns to the SPR. There is still a good deal to be learned about the source of these differences. The problems they create in making generalizations from group data are obvious. Without controlling for important individual variations the chances of finding group differences are mimimized. Wide variations in individual electrodermal responsiveness were also observed in the present study. These differences in sensitivity add to error variance. Prokasy (1969) has suggested that it may be useful to adjust sensitivity settings on recording equipment to individual levels of responsiveness. This approach may have been useful in the present study in view of the range of variation from small deflections for some individuals to ceiling levels for others.

There are a number of methodological problems with the present study that have no easy solutions. One problem pertains to the requirement that subjects fixate on the centre of the stimulus screen to ensure that only one visual field is stimulated at a time. The conditioning session was a long one and subjects became restless. Since all they were required to do was look at the stimulus word, there is a good possibility that they did not attend to some stimulus presentations. The fact that hemispheric differences were indeed obtained suggests that subjects did by and large fixate. However, it may be prudent to modify the task in a way which would require subjects to provide some verification that they attended to the stimulus. Then again, this may influence cognitive activity differentially across hemispheres and so make it difficult to interpret results. Another approach may be to use a small series of different

CS-s to make the task more interesting. Reducing the length of the conditioning session would also likely be an improvement. Habituation was quick and extinction was transient, if present at all. Others have also noted that extinction may occur in one or two trials with human subjects (e.g., Grings & Dawson, 1973). In light of this, it would appear that there is little value in the use of extended trials. In addition, conditioning could be shortened by removing the diversionary stimuli. Hellige (1975), for example, reported differential conditioning effects without the use of such stimuli. Providing a partial reinforcemnt schedule might also help to decrease the rate of habituation.

Another problem pertains to the contingency arrangement used and the manner in which conditioning effects were measured. Conditioning effects were measured during the acquisition phase within a 9.5 sec. latency interval during which the UCS occurred on CS+ trials. The second latency interval responses were difficult to interpret, since responses in this interval may have reflected both CRs and UCRs. As for the first latency interval, the UCS followed the CS by 5 sec. Here, CRs may have been contaminated by anticipatory CRs, given the short ISI and the fact that response latencies were often 2 sec. or more. A longer ISI, say 10 sec., may have been better; then again, this ISI might well be too long to establish conditioning. Glaus and Kotses (1974) used an ISI of 10 sec. successfully; however, they used a delay conditioning procedure which has been found to yield superior performance than a trace procedure in conditioning research (Prokasy & Kumpfer, 1973). They, however, were not subject to the constraints of laterality research. Unfortunately, in laterality research involving sight, exposure of the CS for durations greater than about 150 msec. allows for eye movement and can result in both hemispheres being stimulated directly at the same time. A way around this may be to present stimuli auditorily. An alternate method of testing for conditioning that might be considered is the use of test trials interspersed among acquisition trials (i.e., trials in which the UCS is omitted). This has the advantage of allowing one to explore conditioning effects in the latency interval following the point at which the UCS would ordinarily occur.

Research suggestions. In light of the findings of the present study, there are several avenues of research that may be worth pursuing with regard to the relation between conditioning and hemispheric functioning. In this endeavor it would probably be more efficacious to use SCR measures of electrodermal activity, given the problematic nature of the SPR, and, taking into consideration the successful use of skin conductance measures in conditioning research. One avenue to pursue is the role of negatively valenced stimuli in conditioning across hemispheres. The present findings do show that the emotional valence of verbal stimuli can influence conditioning. One might, for example, use neutral versus highly emotional words such as "syphilis" and "cancer" to determine how hemispheres are influenced differentially. The present findings indicate that the left hemisphere is somewhat more involved than the right in conditioning to verbal stimuli that are only slightly negatively valenced in emotionality. Perhaps strongly emotional verbal stimuli reverse this hemispheric effect in accordance with the accumulation of evidence suggesting that the right hemisphere has an advantage in processing emotional features of stimuli. Furthermore, one might use pictorial stimuli of neutral and high emotional valence in conditioning to examine the extent to which they favor right hemispheric processes. Other avenues of research that might be worth exploring include the manipulation of instructional sets prior to conditioning, the use of different groups of subjects having different cognitive styles, or the manipulation of the emotional states of subjects. In the case of the last, for example, one might threaten subjects with shock in one condition but not in the other, and then compare the relative role of the hemispheres in conditioning. One might also consider investigating the impact of different UCS intensities on hemispheric advantages in conditioning. In the present study there is some evidence that an intense, unpleasant stimulus (the UCS) may activate the right hemisphere relatively more than the left, whereas a low intensity stimulus (the CS) may activate the left hemisphere relatively more than the right. If the right hemisphere was highly activated by the intense stimulation, this may have attenuated a left hemispheric advantage in conditioning to the CSs. By lowering UCS intensities this left hemispheric advantage might emerge. Admittedly, much of this is speculative, but then, little is known regarding hemispheric influences in conditioning. Careful charting of these unknown regions should increase our understanding of the processes involved.

There has been much research pointing in the direction that human classical conditioning is a cognitive process rather than an elemental one involving the strengthening of associations (e.g., Hammond, Baer & Fuhrer, 1980; Hellige, 1975; Maltzman, 1979). Most recently, Dawson, Schell, Beers and Kelly (1982) have reported a study which adds considerable force to the notion that acquisition of classically conditioned autonomic responses in humans is accompanied by a measurable allocation of cognitive processing capacity. They measured the allocation of processing capacity by monitering performance on a secondary reaction time task during conditioning. Patterns of reaction time changes at various points in the CS-UCS interval (e.g., 300 msec. following CS onset; 1000 msec. following UCS onset) were found to be more amenable to a cognitive processing explanation than one based on arousal. Some animal researchers have also come to recognize the importance which information processing may play in classical conditioning (e.g., Wagner, 1978). The hemispheric conditioning effects obtained in the present study have been interpreted along lines consistent with a cognitive processing viewpoint. It is proposed that in classical conditioning of the autonomic response there may be activation of cognitive as well as emotional systems--at least when word stimuli and intense auditory stimuli are used in the contingency. The cognitive systems may operate, in part, at a covert level of information processing in which memory stores are activated and information matching occurs. Right hemispheric emotional processes may play an increasing role, relative to the left, as the intensity of the stimuli increases. The findings of left and right hemispheric effects in the present study make it clear that, whatever the underlying mechanisms, classical aversive conditioning is a complex process influenced by hemispheric systems in unequal ways both during the course of the CS-UCS interval and during the course of conditioning as habituation sets in. If further research showed that hemispheric differences in conditioning in humans are commensurate with the nature of the stimulus materials and the processing task, this would serve to provide an additional body of evidence supporting the cognitive processing viewpoint of conditioning.

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APPENDIX A

Emotional Valence Questionnaire

Name__________

Age_____

Quickly read through the list of words below. Then, for each word, indicate by circling a number from 1 to 7 on the corresponding rating scale, how unpleasant/pleasant the word strikes you.

road	1	2	3	4	5	6	7
	unpleasant						pleasant
money	1	2	3	4	5	6	7
cloth	1	2	3	4	5	6	7
snake	1	2	3	4	5	6	7
star	1	2	3	4	5	6	7
roast	1	2	3	4	5	6	7
party	1	2	3	4	5	6	7
cheek	1	2	3	4	5	6	7
freeze	1	2	3	4	5	6	7
coast	1	2	3	4	5	6	7
food	1	2	3	4	5	6	7
death	1	2	3	4	5	6	7
tree	1	2	3	4	5	6	7
chain	1	2	3	4	5	6	7
perfume	1	2	3	4	5	6	7
ground	1	2	3	4	5	6	7
crowd	1	2	3	4	5	6	7
health	1	2	3	4	5	6	7
water	1	2	3	4	5	6	7
sex	1	2	3	4	5	6	7
desk	1	2	3	4	5	6	7
laughter	1	2	3	4	5	6	7
vomit	1	2	3	4	5	6	7

APPENDIX B

Most frequent associations to each of the key words "CHAIN", "CLOTH", "CROWD", and "COAST", based on N = 4 for each key word.

Key Word	Associations	Number of Subjects Giving Association
CHAIN	letter	2
	link	3
	gang	2
CLOTH	clothes	2
	shirt	2
	blanket	2
	hat	2
	socks	2
CROWD	people	3
	rock concert	2
	games	2
	hockey	2
	shopping centre	2
COAST	rollercoaster	2
	glide	2
	smooth	2

APPENDIX C

Stimulus Sequence Sets

Set 1

8 9 0 8 1 8 9 0 1 9 0 0 8 1 1 8 9 0 9 8 1 1 8 0 1
9 1 8 0 0 8 1 9 8 1 0 9 1 0 9 1 1 8 9 0 9 8 1 9 8
1 0 8 9 0 1 8 8 1 9 8 0 8 9 0 1 9 8 1 0 9 9 1 0 8
8 1 0 9 9 0 1 8 9 0 9 8 0 1 8 0 9 0 9 8 1 1 9 0 0

Set 2

1 8 9 1 0 8 8 0 1 9 1 0 9 8 1 9 8 1 0 9 8 0 1 8 9
1 0 9 1 8 1 9 0 0 9 1 8 9 1 0 8 8 0 1 9 1 0 9 8 1
9 0 1 9 8 0 9 8 0 1 9 8 0 9 9 0 8 1 9 1 0 8 0 1 9
1 0 8 8 0 1 9 8 0 0 9 9 1 8 0 8 1 0 9 8 1 8 9 0 8

Note. Stimulus sequences are to be read by rows. The word stimuli are coded as follows: CLOTH = 0; CROWD = 1; COAST = 8; CHAIN = 9. Depending on the experimental condition, CLOTH served as the CS+ and CROWD as the CS-, or the reverse.

APPENDIX D

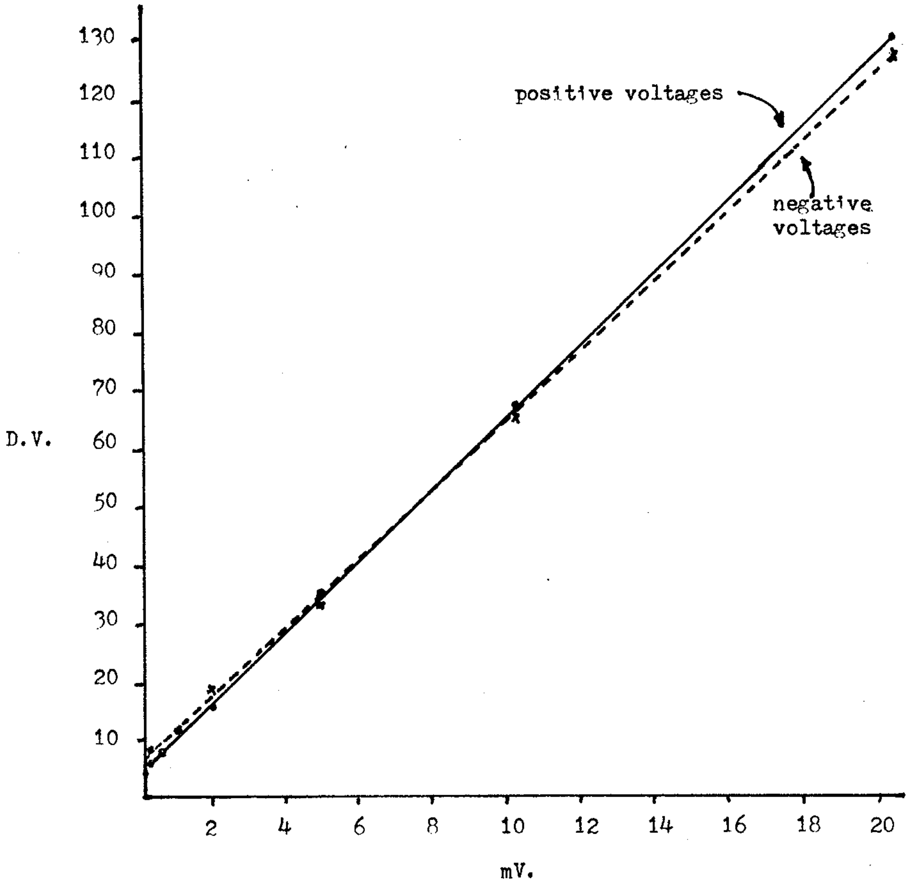

Figure D-1. Analogue to digital (A/D) conversion of SPR data originally in millivolt units. The 8 bit A/D converter transformed the data into discrete values (D.V.) with a maximal positive or negative value of 127. The absolute values of the negative voltages are plotted along with positive voltages.

Appendix E

Summary Tables of Statistical Findings

TABLE E-1

ANOVA Summary for Maximal Positive SPR m-amplitudes

Source	SS	df	MS	F	p
Hemisphere-of-presentation (H)	7.67	1	7.67	<1	.94
CSword (W)	1727.12	1	1727.12	1.45	.24
H x W	2960.81	1	2960.81	2.48	.12
Within cells	42970.15	36	1193.62		

Note. None of the effects are significant.

TABLE E-2

ANOVA Summary for Maximal Negative SPR m-amplitudes

Source	SS	df	MS	F	p
Hemisphere-of-presentation (H)	57.17	1	57.17	<1	.69
CSword (W)	841.81	1	841.81	2.36	.13
H x W	26.93	1	26.93	<1	.79
Within cells	12849.78	36	356.94		

Note. None of the effects are significant.

TABLE E-3

Cell Means and Standard Deviations for the Maximal Positive and Negative m-amplitude Deflections

Positive SPR Component

Experimental group	M	SD	N
Left hemisphere			
CS+ = CLOTH	31.30	20.60	10
CS+ = CROWD	61.65	44.10	10
Right hemisphere			
CS+ = CLOTH	47.63	39.32	10
CS+ = CROWD	43.57	29.31	10
Total	46.04	34.96	40

Negative SPR Component

Experimental group	M	SD	N
Left hemisphere			
CS+ = CLOTH	29.20	11.91	10
CS+ = CROWD	40.02	24.91	10
Right hemisphere			
CS+ = CLOTH	33.23	16.53	10
CS+ = CROWD	40.77	19.80	10
Total	35.80	18.79	40

TABLE E-4

MANOVA Summary for m-amplitude scores (range-corrected)
for the Positive SPR Wave Component in the First
Latency Interval during Acquisition

Source	df	SS	MS	F	Significance
Hemisphere-of-presentation (H)	1	0.189	0.189	1.57	0.22
CSword (W)	1	0.025	0.025	<1	-
H x W	1	0.002	0.002	<1	-
Within cells	36	4.350	0.121		
Conditioning (C)	1	0.763	0.763	23.91	0.00
H x C	1	0.123	0.123	3.86	0.05
W x C	1	0.206	0.206	6.46	0.02
H x W x C	1	0.004	0.004	<1	-
Within cells	36	1.149	0.032		

Source	df	Pillai's criterion	Approx. F	Significance
Trial blocks (T)	4	0.54293	9.80	0.00
H x T	4	0.10302	<1	-
W x T	4	0.05778	<1	-
H x W x T	4	0.07973	<1	-
C x T	4	0.24934	2.74	0.05
H x C x T	4	0.07770	<1	-
W x C x T	4	0.34130	4.27	0.01
H x W x C x T	4	0.12823	1.21	0.32

Note. Each of the four source groupings is based on a separate multivariate analysis of a specific set of contrast variables.

TABLE E-5

Cell Means and Standard Deviations of m-amplitude Scores (range-corrected) for the Positive Component of the SPR in the First Latency Interval during Acquisition

Cell	Trial Blocks				
	1	2	3	4	5
Left hemisphere CS+ = CLOTH					
CS+	0.12	0.25	0.26	0.13	0.11
	(0.15)	(0.33)	(0.29)	(0.21)	(0.19)
CS-	0.28	0.05	0.06	0.05	0.08
	(0.35)	(0.10)	(0.07)	(0.16)	(0.17)
Left hemisphere CS+ = CROWD					
CS+	0.46	0.32	0.16	0.08	0.07
	(0.36)	(0.31)	(0.19)	(0.14)	(0.15)
CS-	0.13	0.02	0.02	0.04	0.00
	(0.18)	(0.04)	(0.07)	(0.08)	(0.00)
Right hemisphere CS+ = CLOTH					
CS+	0.20	0.14	0.12	0.02	0.06
	(0.21)	(0.27)	(0.20)	(0.05)	(0.16)
CS-	0.32	0.06	0.02	0.04	0.03
	(0.26)	(0.15)	(0.05)	(0.09)	(0.09)
Right hemisphere CS+ = CROWD					
CS+	0.33	0.16	0.05	0.06	0.04
	(0.31)	(0.20)	(0.11)	(0.12)	(0.08)
CS-	0.07	0.07	0.03	0.00	0.02
	(0.16)	(0.13)	(0.08)	(0.00)	(0.05)

Note. Standard deviations are in parentheses. Cell size = 10.

TABLE E-6

Mean m-amplitude Responses across five Trial Blocks for the Positive Wave Component of the SPR in the First Latency Interval during Acquisition

Trial blocks				
1	2	3	4	5
0.24	0.13	0.09	0.05	0.05

TABLE E-7

MANOVA Summary for m-amplitude scores (range-corrected) for the Positive SPR Wave Component in the Second Latency Interval during Acquisition

Source	*df*	*SS*	*MS*	*F*	Significance
Hemisphere-of-presentation (H)	1	0.005	0.005	< 1	-
CSword (W)	1	0.026	0.026	< 1	-
H x W	1	0.001	0.001	< 1	-
Within cells	36	4.306	0.120		
Conditioning (C)	1	11.842	11.842	195.14	0.00
H x C	1	0.108	0.108	1.78	0.19
W x C	1	0.020	0.020	< 1	-
H x W x C	1	0.000	0.000	< 1	-
Within cells	36	2.185	0.061		

Source	*df*	Pillai's criterion	Approx. F	Significance
Trial blocks (T)	4	0.38474	13.19	0.00
H x T	4	0.81351	1.89	0.14
W x T	4	0.97362	< 1	-
H x W x T	4	0.92956	< 1	-
C x T	4	0.31717	17.76	0.00
H x C x T	4	0.69910	3.55	0.02
W x C x T	4	0.93248	< 1	-
H x W x C x T	4	0.91310	< 1	-

Note. Each of the four source groupings is based on a separate multivariate analysis of a specific set of contrast variables.

Appendix F

Measurement of the Skin Potential Response and Related Issues

Choosing an Appropriate Measure of the SPR

Relatively few studies reported in the literature have used the skin potential response in electrodermal conditioning studies. Most research using the SPR has been confined to investigations of the topography of the response components and their relation to sweat gland and epidermal processes involved in electrodermal activity. The absence of its use in conditioning studies is not entirely clear; however, the complex aspect of the SPR wave form may account for its lack of popularity. Little agreement exists among researchers on what the positive and negative components of the SPR signifiy, and on how best to measure these components. This aside, there are a number of advantages of the SPR including more stable baselines than SCR, the potential for additional information from the positive and negative wave components, and its more direct method of measuring sweat gland activity (as opposed to the method of passing a current through the skin) (Burnstein, Fenz, Bergeron & Epstein, 1965; Glaus & Kotses, 1974). Given these advantages, it was decided to use this measure in the present study.

There are differing opinions among researchers on how best to measure the SPR. Venables and Christie (1973) have stated that the only aspect of the SPR that can be unequivocally measured is the latency of the first response. Their rejection of wave size measures is based on the notion that the positive and negative components contaminate each other through reciprocal attenuation effect; These researchers add, however, that the negative component may be more susceptible than the positive component to this type of contamination. Venables and Christie (1973) also state that there seems to be little basis for using the difference in potential between the peaks of the negative and positive components as a measure of wave size. In contrast, Edelberg (1972) implies that such measures are useful. He suggested that the size of the positive SPR is most accurately measured as the difference between the peak of the first negative deflection and the peak of the positive deflection, without reference to the baseline. He also states that the best operational measure of the negative wave may be the sum of the initial negative deflection plus the second negative deflection. Glaus and Kotses (1974) recommend still another measure. They reported a differential conditioning study in which subjects were presented with 20 CS+ and 20 CS- trials of red and yellow lights. The exposure duration of the CSs was 10 sec. and the ITI was 40 to 80 sec. The CS+ was followed by .5 sec. of 112 dB. white noise. Glaus and

Kotses (1974) obtained significant conditioning effects using SPR frequencies of positive and negative wave components as dependent measures. The authors stated that they preferred response frequency over magnitude measures because the former may be less sensitive to artifacts introduced by interactions between subsequent positive and negative wave forms.

Little substantive evidence exists in the literature to guide in the choice of an appropriate measure. The empirical basis for the above recommendations is sparse to say the least. One genre of studies which have compared the SCR and SPR provides evidence suggesting that wave size measures may be meaningfully used. Gaviria, Coyne and Thetford (1969) reported a strong relationship between an SC "difference" measure (i.e., the difference between the final response value and the initial response value at the time of stimulus onset) and SP trough to peak (i.e., the absolute size of the trough to peak difference) and difference measures. Along similar lines, Wilcott (1958) and Jeffress (1928) found high correlations between SC and SP wave deflections. Jeffress (1928) also observed that SC and SP latencies were correlated.

Since views differ on the most appropriate measure of the SPR, several measures were used in the present study. It was hoped that a comparison of these measures might remove some of the confusion surrounding their efficacy.

SPR latency, frequency, and wave size were used as dependent measures. Separate analyses of the negative and postive wave components of the SPR were carried out for the frequency and deflection (i.e., wave size) measures.

Amplitude, Magnitude and Probability Scores

Whereas scoring of latency and frequency is relatively straightforward, wave deflection is amenable to several alternative scoring approaches, namely, magnitude, amplitude and probability. Magnitude scoring is most frequently used; it is a measure of the size of the wave deflection, with zero entered for those trials during which a response does not occur (i.e., those trials on which the deflection is not larger than a set criterion defining a response). In trial blocking, deflections that occurred above criterion are averaged with zero entries for nonresponse trials. This method of scoring in fact assumes that some size of response always occurs, independent of the response criterion; however, an arbitrary entry is made whenever whatever does occur fails to meet a set criterion (Prokasy & Kumpfer, 1973). Prokasy and Kumpfer (1973) maintain that this assumption is likely incorrect; they reject the magnitude measure on the grounds that it confounds amplitude and probability. They have found that response probability and amplitude do not always covary. Confounding of the two by way of magnitude scoring can, for example, create the erroneous impression that response size is changing when actually only the response probability is. Prokasy and Kumpfer also make the point that use of an arbitrary entry for nonresponses can increase within cell variance and so reduce the likelihood of obtaining an effect. They suggest a separate assessment of probability and amplitude. Amplitude scores are obtained by taking an average of the "response" deflections within each trial block; response deflections that are below criterion (i.e., "nonresponses") are disregarded in the averaging. Probability scores are based on the percentage of responses (above a set criterion) to the stimulus within each trial block for each subject.

The suggestions put forward by Prokasy and Kumpfer (1973) are based on their experience with the skin conductance response. How useful this approach is for SPR data is left unanswered. Unlike in the SCR, there are positive and negative wave components that complicate the picture. Magnitude scoring of the positive or negative component is relatively straightforward, since the assumption is made that a response always occurs. On the other hand, amplitude scoring makes the assumption that sometimes responses do not occur. However, disregarding "nonresponses" in the calculation of averages is problematic when positive and negative wave components are present. An example will make this clear. Suppose trials are blocked in groups of three, and a subject obtained the following responses on three trials:

-10, 13, 0 mV. Suppose, further, we are interested in scoring the positive component. The problem lies in deciding what to do with the information regarding the negative response in calculating the positive amplitude for this trial block. If .5 mV. is used as the criterion for defining a response (i.e., anything less is a "nonresponse" and disregarded), the amplitude score would be calculated as 13/1 = 13 mV. Both the first and third trial are considered nonresponses and disregarded in scoring. However, this is based on the questionable assumption that the positive and negative components are independent. Alternatively, one could view the first trial as an instance of a positive "response" of 0 mV. Since the subject did after all respond in the first trial (albeit, in the negative direction), it is debatable whether the 0 mV. positive response in the first trial is in the same response class as the 0 mV. response in the third trial. That is, while the 0 mV. deflection in the third trial might appropriately be regarded as belonging to the class of "nonresponses", the 0 mV. positive deflection in the first trial might best be regarded as belonging to the class of "responses". From this, amplitude would be calculated as 13/2 = 6.5 (i.e., the mean is based on the first two trials in which a "response" occurs). The essence of the problem, then, in calculating SPR amplitudes is deciding on the appropriate response class for below criterion deflections. Prokasy and Kumpfer (1973) restricted their discussion of amplitude scoring to SCR measures and so have not addressed this issue. In contrast to the use of amplitude measures, applying a magnitude score to the above sample data is simple: All trials are included in taking an average of the deflections (resulting in a score of 13/3 = 4.33 mV.). With this approach to response measurement no decisions have to be made regarding which trials to disregard in the calculation of scores. There is, however, the problem of confounding probability with amplitude.

The calculation of probability scores for SPR responses can also be problematic. Suppose, again, one is blocking three trials and that a set of three responses happened to be: -8, 5, 0 mV. One has the option of basing probability scores on positive and negative wave components separately, or calculating probability scores on the basis of all deflections, without distinguishing between the two wave components. So, for example, the probability for the positive component would be 1/3 = .33; for the negative, .33 as well; and for all responses, the probability would be 2/3 = .67. Since there are no clear guidelines for choice, probability scores were calculated for each of the separate components as well as the combined components in the present study.

In addition to the use of probability scores in the present study, amplitude scores were also employed. This use of both types of scoring measures has a specific advantage over magnitude measures in the interpretation of effects; it makes its possible to attribute results to either changes in response probability or changes in the size of the deflection. As discussed above, SPR amplitude can be scored in two ways, depending on how responses below criterion are classified. In the present study, the position is taken that positive and negative wave components cannot be reasonably regarded as independent. For this reason, the alternative SPR amplitude measure (i.e., the second approach discussed which takes into account that below criterion deflections may belong in separate response classes) was used. Henceforth this amplitude scoring approach will be called "m-amplitude" (modified amplitude).

Measuring Differential Conditioning Effects

In the present study, the "amount" of conditioning was determined by differential responding to the CS+ and CS-. One of the main advantages of using a discrimination or differential conditioning approach is that the subject serves as his own control. A variety of indices have been developed to measure amount or "strength" of differential conditioning (e.g., Hilgard, Jones & Kaplan, 1951; Restle & Beecroft, 1955). Probability scores (as opposed to, say, amplitude scores) of the CS+ and CS- are entered in the computation of these indices. Restle and Beecroft (1955), for example, have provided the following index of relative differentiation (IRD): IRD = (CR+ - CR-)/(CR+ + CR-). It expresses the difference in probability of response to the CS+ and CS- as a proportion of the sum of the response probabilities. This index may be a more accurate reflection of strength of conditioning than a simple index based on the difference in response probabilities to the CS+ and CS-, in that it takes into account absolute probabilities in addition to relative probabilities. The problem with the use of indices, however, is that a loss of information occurs. An alternative approach is to retain the scores associated with the CS+ and CS- and enter them as a separate "conditioning" factor with two levels in an ANOVA. This approach has been used with success in a number of studies (e.g., Glaus & Kotses, 1974; Hellige, 1975; Ohman, Fredrikson & Hugdahl, 1978). In the present study, this approach was used for all response measures. In addition, the IRD index advocated by Restle and Beecroft (1955) was also used for probability scores (in which case a conditioning factor was not used in the ANOVA).

Merits of an Adaptation Phase

Glaus and Kotses (1974) recommend not using an adaptation phase prior to conditioning for reasons that it would avoid attenuating overall responsiveness. They argued that this approach would provide for a more precise intrasubject control for sensitization, and would eliminate uncertain effects of prior habituation. Since they were successful in obtaining conditioned effects with the SPR, their suggestion of not using an adaptation phase was followed in the present study.

Choice of Latency Intervals for Response Measurement

Conditioning studies have found that with ISIs longer than 4 or 5 sec., multiple responses occur during the latency interval following the CS (Prokasy & Kumpfer, 1973). For the SCR, the first response component occurs within 3 to 4 sec. of CS onset, the second just prior to the point in time at which the UCS ordinarily would occur, and the third at the point in time when the UCR ordinarily would occur (Prokasy & Kumpfer, 1973). It has been found that responses occurring in the first latency interval (i.e., within 4 or 5 sec. of CS onset) are relatively independent of those occurring in the second latency interval (Prokasy & Ebel, 1967), and hence, may not be measuring the same thing. Studies have reported differential conditioning effects for first, second, and third interval responses (e.g., Ohman, Fredrikson & Hugdahl, 1978; Ohman, Fredrikson, Hugdahl & Rimmo, 1976). Ohman et al. (1976) have suggested that first interval responses may reflect orienting activity related to processing of the CS, and that second interval responses may involve "expectancy-type" cognitive activity. Glaus and

Kotses (1974) in their study of conditioning using the SPR, divided the latency interval into two separate scoring intervals (.4-5 sec. and 5.1-10 sec. after CS onset), and classified all skin potentials as either first or second interval responses according to their onset latencies. They found that conditioning was more pronounced in the second (5.1-10 sec. after stimulus onset) as compared to the first interval for the negative component of the SPR. There also appeared to be a generally greater pairing effect for the negative as compared to the positive component. In using SPR measures, then, it seems important to take into account both the interval of measurement and which of the two components best carries information in that interval. Glaus and Kotses (1974) have noted that individual differences must also be taken into consideration. They observed a strong tendency for some subjects to condition predominantly in terms of one component or the other. Subjects showing a conditioned effect primarily in terms of the negative component, displayed greater differential conditioning in the latter half of the ISI, whereas those conditioning primarily in the positive component, showed greater responding in the earlier ISI.

All this indicates that useful additional information may be obtained by separately scoring responses occurring in early and late latency intervals. In the present study, two latency intervals were used; the first, .5-5.5 sec.

following CS onset, and the second, 5.5-9.5 sec. after CS onset. Separate analyses were carried out on the positive and negative component SPRs in the first and second latency intervals.

Choice of Hand for Recording Electrodermal Activity

There are no clear guidelines in the literature on the choice of hand for electrode placement. Studies have shown successful conditioning using either hand for recording electrodermal activity. In the present study, the right hand was used to record SPRs. Results have been interpreted on the assumption that both hands yield similar response patterns. Other researchers who have recorded electrodermal activity simultaneously from both hands have found no left/right hand differences (e.g., Iacono & Lykken, 1983).

A procedure which might be followed in future studies to help decide which hand is most appropriate for recording electrodermal activity is the use of bilateral recordings for a few subjects. This would help to determine if significant differences between the hands exist to merit bilateral recordings for all subjects.

General Problems in Electrodermal Measurement

A few other problems with electrodermal measurement will be briefly mentioned. The type of electrolyte used can influence electrodermal recordings (Fowles & Schneider, 1978; Venables & Christie, 1973). Epidermal hydration can have a profound effect on skin potential measurements. Evidence indicates that even with test periods less than an hour, there can be a marked reduction in SPR amplitudes due to hydration (Venables & Christie, 1973). This has been attributed to the attenuation of electrical activity originating in the sweat glands. In view of the extended period of time that subjects had electrodes attached in the present study, this may have attenuated responses. Placement of electrodes may also affect recordings in unknown ways. In the present study electrodes were placed in contact with palmer and dorsal surfaces of the right hand. A more typical arrangement that others have used is the placement of the active electrode over the thenar eminence of the hand, and the reference electrode on the volar surface of the forearm of the same limb just below the elbow (e.g., Glaus & Kotses, 1974; Raskin et al., 1969). A ground electrode is also attached to the dorsal surface of the opposite hand. A host of other factors can also affect electrodermal activity, including skin temperature, room temperature, biological cycles, and previous activity of the subject (Venables & Christie, 1973). One other factor which can be particularly troublesome is the occurrence of artifactual responses. In the present study hand movement may have resulted in a number of artifactual responses; subjects tended to become restless during the course of the conditioning procedure. Since trials were blocked, it was possible to eliminate artifactual responses by averaging trials in a given block. Nonetheless, artifactual responses are not likely to always let themselves be known. They are most easily detected if they show very short response latencies following stimulus onset.