CLASSICAL CONDITIONING AND ATTENTIONAL BIAS

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Summary — The present study was designed to test whether an attentional bias can arise from aversive classical conditioning. Using a differential conditioning paradigm in which slides of angry faces served as conditioned stimuli (CS+ / CS−) and electric shock served as unconditioned stimulus (UCS), skin conductance responses (SCRs) of normal subjects (N = 20) were recorded. The effectiveness of the conditioning procedure was proved by differential SCRs to CS+ and CS− slides during the later acquisition trials. During a subsequent extinction phase, sets of three numbers were superimposed on CS+ and CS− slides. Subjects were asked to add up these numbers as quickly as possible and to vocalize the results. Vocalization latencies as indexed by chin EMG activity were significantly longer with CS+ than with CS− trials. This result is explained in terms of the attention attracting properties that the CS+ acquires as a result of its pairing with the UCS. It is argued that these properties compete with the attentional resources that are needed for an ongoing task (i.e., addition task). The data suggest that a learning approach to the origins of attentional biases in anxious subjects might be fruitful.

There is evidence that anxious subjects tend to shift attention towards stimuli they fear. A number of recent studies convincingly demonstrated that anxiety is accompanied by hyper-attention (i.e., attentional bias) to threatening or fear-relevant verbal stimuli (see review by Eysenck & Mathews, 1987). The attentional bias phenomenon has been observed in simple phobias (Watts, McKenna, Sharrock & Trezise, 1986), obsessive-compulsives (Foa & McNally, 1986), social phobics (Hope, Rapee & Heimberg, 1989), patients with generalized anxiety disorder (Mathews & Macleod, 1985), and subjects with high trait-anxiety scores (Macleod & Mathews, 1988). Several experimental techniques have been successfully employed for documenting attentional biases in anxious subjects. Some researchers used the Stroop-color task (Mathews & Macleod, 1985), others used a dichotic listening paradigm (Burgess, Jones, Robertson, Radcliffe & Emerson, 1981), and still others made use of advanced visual reaction-time set-ups (Macleod, Mathews & Tata, 1986). In sum, the attentional bias phenomenon occurs in many types of anxiety and can be demonstrated by various experimental techniques. Therefore, it is no wonder that this phenomenon has become the cornerstone of recent cognitive-experimental approaches to anxiety (Mathews & Eysenck, 1987; Eysenck, 1988).

It has been suggested that attentional bias is a cognitive strategy which characterizes persons with high trait-anxiety (e.g., Eysenck & Mathews, 1987). According to this view, persons with low trait-anxiety shift their attention away from threatening stimuli, whereas persons with high trait-anxiety focus attention on these stimuli. Preferential encoding of threatening stimuli would occur as a result of this attentional bias in high trait-anxiety. This would, in turn, give rise to elevated state-anxiety levels and, eventually, to anxiety disorders. Yet, direct evidence of a causal role of attentional biases in the etiology or maintenance of anxiety disorders is lacking. In their
recent review, Mathews and Eysenck (1987) admit that:

none of the research discussed so far conclusively demonstrates that biased cognitive processing either causes or contributes to the maintenance of pathological anxiety. It remains possible that clinical anxiety states arise in quite different ways, and the cognitive effects documented here are secondary consequences of the emotional disorders rather than being one of its causes (p. 228).

The present study was undertaken in order to shed some light on this causality issue, i.e., on the functional relationship between fear and attentional bias. More specifically, the hypothesis tested was that an attentional bias phenomenon may occur as a result of aversive conditioning.

A number of researchers have used Pavlovian conditioning of autonomic responses as a model for the etiology of phobic fears (e.g., Deitz, 1982; White & Davey, 1989). To examine whether it is possible to establish an attentional bias in normal subjects by means of Pavlovian “fear” conditioning, a differential paradigm was employed in the present study. That is to say, subjects were confronted with two stimuli (slides of angry faces), one of which (CS+) was followed by an electric shock (UCS) during acquisition, while the other stimulus (CS−) was never followed by a UCS. During a subsequent extinction phase, the stimuli were combined with sets of three numbers. The subject was instructed to add up these numbers as quickly as possible and to verbalize the result. If conditioning elicits an attentional bias (i.e., hyperattention to CS+), verbalization would be expected to be slower during CS+ than during CS− slides.

Method

Subjects

Subjects were 20 volunteering undergraduates (15 females). Their mean age was 22.7 yr. (range: 19–33). Their mean Total Phobia score on the Fear Questionnaire (FQ; Marks & Mathews, 1979) was 23.8 (SD = 11.5) which is more than one standard deviation below the mean score of phobic out-patients reported by van Zuuren (1988). Their mean score on the Depression Symptom Inventory (DSI; Bouman, 1987) was 41.4 (SD = 8.8), which is more than one standard deviation below that of depressive patients (Bouman, 1987). Thus, it can be concluded that, as a group, the present subject sample was free of phobic and depressive complaints.

Apparatus and Stimulus Materials

For obtaining an independent measure of the degree to which the conditioning procedure was successful, skin conductance responses (SCRs) were recorded. Skin conductance responses were measured with Beckman Ag-AgCl electrodes (8 mm diameter) filled with the Unibase electrode paste described by Fowles, Christie, Edelberg, Grings, Lykken, and Venables (1981). The electrodes were attached to the medial phalanges of the second and third fingers of the subjects right hand and connected to a Beckman Skin Conductance Coupler (type 9844). To control for SCR artifacts due to irregular breathing, respiration rate (RR) was recorded with a respiration belt connected to a Beckman Voltage/Pulse/Pressure Coupler.

The latency of verbalization was measured by means of bipolar electromyographic (EMG) recordings from the chin region. Whereas chin EMG is relatively insensitive to covert oral responses (McGuigan, 1979), it can be used for detecting activity bursts due to verbalization. These EMG bursts were recorded with Beckman miniature surface Ag-AgCl electrodes filled with Hewlett Packard Redux paste. The electrodes were connected to a Beckman EMG Coupler (type 9852 A), with low- and high-pass filters set at 1000 and 50 Hz, respectively. The raw EMG signal was fed to a contour-following
integrator of the type recommended by Fridlund (1979). Integration period was 25 msec. Subjects' verbalizations were also monitored by an intercom-system. An event marker was used by one of the experimenters to signal the onset of verbalization. These marks were later used for ascertaining that large EMG bursts were, indeed, related to vocalization. The intercom was also used for checking whether verbalized results were correct.

SCR, RR, integrated EMG, and event marks were recorded on paper (10 mm/sec) by a Beckman Polygraph (type R711).

Electric shocks (UCSs; dc; 0.5 sec.) were produced by a shock generator and delivered through two electrodes attached to the first finger of the subject's left hand.

Since previous research has shown that angry faces are salient cues (Merckelbach, van Hout, van den Hout & Mersch, 1989) that elicit strong SCRs in a conditioning paradigm (Dimberg, 1986), slides depicting angry facial expressions were used as CSs. The facial stimuli were taken from Ekman and Friesen (1975). The gaze from each facial cue was directed at the subject. During the extinction phase, a set of three numbers (ranging from 1 to 9) was superimposed on each facial expression. The numbers were placed at the top or at the bottom of the stimulus in such a way that identification of the face was not complicated. Since there are reasons to assume that short stimulus presentation facilitates conditioning (Sandin & Cherot, 1989), slide duration was set at 3 sec throughout the experiment. The slides were projected onto a white screen by a Kodak Carousel, 2 m in front of the subject. The size of the projected image was approx 75 × 110 cm.

CS and UCS presentations and physiological recordings were controlled by a PDP Minc 11 computer.

Design

The experiment was conducted according to a 2 (conditioning: CS+ vs CS−) × trials (3; 4; 5; see below) within-subject design. That is, subjects were repeatedly confronted with two angry faces. During acquisition, one face (CS+) was followed by a shock UCS, whereas the other face (CS−) was never followed by a UCS.

Procedure

Subjects sat in an armchair that was placed in a dimly lit, electrically shielded chamber. The apparatus was located in an adjacent room. Slides were projected through a hole in the wall. Subjects were instructed to watch the slides and to avoid unnecessary movement. Subjects were also told that when slides were accompanied by digits their task was to add up these digits silently and to verbalize the result as quickly as possible. Subjects were shown an example of an angry face stimulus with digits superimposed on it. Subjects were informed that mild electric shocks would occur now and then during the experiment. After subjects had given their consent, electrophysiological recording sites were cleaned with distilled water and EMG recording sites were cleaned with 70% alcohol. Electrodes were then attached with adhesive collars. This was followed by a shock work-up procedure, during which subjects were asked to choose a UCS level that was "mildly annoying". No information was given concerning the CS-UCS contingency.

The experiment proper consisted of three phases. During habituation (3 CS+ and 3 CS− trials), slides were presented without UCS. An acquisition phase followed (4 CS+ and 4 CS− trials) during which the CS+ was followed by a shock UCS, but the CS− was not. The UCS was delivered exactly upon CS+. The third and final phase consisted of unreinforced presentations of the slides (5 CS+ and 5 CS− trials). It was during this extinction phase that three numbers were superimposed on the slides.

Inter-trial intervals varied between 8 and 12 sec, with a mean of 10 sec. The slides were
randomly presented with the restriction that a particular slide was not presented more than twice in succession. To facilitate differential responding to CS+ and CS− slides, one slide depicted an angry male face and the other slide depicted an angry female face. Sex of CS+ and CS− was counterbalanced across subjects. The numbers that accompanied CS+ and CS− slides during extinction were matched in terms of place (below or above the face). Furthermore, in order to control for irrelevant variations in task difficulty, the same series of numbers were superimposed on CS+ slides for half of the subjects and on CS− slides for the other half of the subjects and vice versa. At the end of the experiment a debriefing interview was held.

Response measurement and analysis

SCRs were defined as maximal deflections occurring 1–3 sec after stimulus onset. SCRs were measured in microvolts and subjected to square root transformation. SCRs due to respiratory irregularities occurred on less than 1% of the trials. These SCR values were excluded from analysis and replaced by estimates based on SCRs to adjacent trials.

The time that subjects needed to add up the three numbers and to verbalize the result was defined as the seconds that elapsed between slide onset and EMG bursts due to vocalization. An inspection of the polygraph records (i.e., correlation between event marks and bursts) showed that it was relatively easy to differentiate between these EMG bursts and irrelevant EMG activity. In most cases, the former type of activity reached an amplitude that was approx. five times as large as that of irrelevant activity. The time for accomplishing the addition task was included in the analysis irrespective of correctness or incorrectness of the verbalized result. On 6% of the total number of trials, subjects failed to verbalize. These missing values were randomly distributed over subjects and over CS+ and CS− trials. Therefore, the missing values were replaced by group means.

SCRs were analyzed by means of 2 (CS+ vs CS−) × trials analyses of variance (ANOVAs) in which both factors were treated as repeated measures. Separate ANOVAs were carried out for SCRs during habituation, acquisition, and extinction.

Subjects’ reactions to the addition tasks during extinction were analyzed in two ways. First, a 2 (conditioning: CS+ vs CS−) × trials repeated measurement ANOVA was performed on the verbalization latencies. Second, using a t-test, the number of incorrect verbalizations during CS+ trials was compared to the number of incorrect verbalizations during CS− trials. Greenhouse–Geisser corrections were applied to comparisons involving a trial factor.

Results

Electrodermal reactions

During habituation, there was no differential responding to CS+ and CS− slides \( [F(1,19) < 1] \). The only effect reaching significance was a trial effect \( [F(2,38) = 9.8, p < 0.01] \) due to a general decline in SCRs over habituation trials.

The mean SCRs on acquisition trials are shown in the left panel of Figure 1. During acquisition, CS+ slides were followed by a shock UCS. The mean amplitude of this UCS was 0.61 mA \( (SD = 0.39) \), which is low compared to the standards given by, for example, Husselt (1978). A significant conditioning × trials effect \( [F(3,57) = 4.1, p < 0.05] \) implied that differential responding to CS+ and CS− occurred on the last acquisition trials. Mean values for the last two CS+ and CS− acquisition trials were 0.24 \( (SD = 0.27) \) and 0.11 \( (SD = 0.18) \), respectively \( [t(19) = 3.5, p < 0.01, \text{one-tailed}] \). No further significant effects were found during acquisition.

SCRs during extinction are shown in the right panel Figure 1. It should be noted that SCRs during extinction trials were generally
larger than those during acquisition trials. A 2 (conditioning: CS+ vs CS−) × 2 (phase: acquisition vs extinction) ANOVA on the last acquisition and first extinction SCRs did indeed show a main effect of phase \([F (1,19) = 23.1, p < 0.01]\).

The ANOVA performed on the SCR extinction data failed to show differential SCRs to CS+ and CS− slides \([F (1,19) < 1]\). The only effect reaching significance was the overall decline in responding over trials \([F (4,76) = 9.3, p < 0.01]\).

**Vocalization latencies**

Vocalization latencies during CS+ and CS− extinction trials are shown in Figure 2. As can be seen, latencies were generally longer with CS+ than with CS− slides. This was confirmed by the ANOVA which revealed a main effect of conditioning \([F (1,19) = 5.0, p < 0.05]\).

Mean values (sec) for CS+ and CS− trials were 3.44 and 3.30, respectively. Due to the initial decrease and consequent increase of vocalization latencies over trials, the trial effect reached only borderline significance \([F (1,76) = 2.6, p < 0.07]\).

The mean numbers of incorrect verbalisation for CS+ and CS− slides were 0.9 \((SD = 0.8)\) and 0.6 \((SD = 0.7)\), respectively. A \(t\)-test showed that this difference was marginally significant \([t (19) = 1.5, p < 0.09, \text{ one-tailed}]\).

**Discussion**

The present study was based on a small number of acquisition trials and a mild UCS intensity. Nevertheless, the conditioning procedure was successful in that differential electrodermal responding to CS+ and CS− slides was obtained during the last acquisition trials. The fact that the vocalization latencies were...
significantly longer on CS+ than on CS− extinction trials can best be interpreted as a consequence of this successful aversive conditioning. According to this view, the CS+ acquired attention attracting properties as a result of its pairing with the UCS. The attention attracting properties of the CS+ interfered with the addition task during extinction and this, in turn, led to a delay in vocalization latencies. In other (cognitive) words, the conditioning procedure resulted in an attentional bias towards the CS+. Thus, the present findings demonstrate that classical conditioning is a sufficient condition for eliciting an attentional bias which competes with attentional resources that are needed for an ongoing task. In a sense, the data presented above can be regarded as a Pavlovian parallel to the Stroop-color interferences that occur when anxious subjects are required to color-name words they fear (e.g., Watts et al., 1986). The idea that the CS+ attracts attention is, of course, in keeping with modern learning theories. In a recent review of research on SCR conditioning, Maltzman (1987), for example, concludes that if and when the subject “discovers the significance of the CS as a signal for the UCS, an OR (i.e., orientation reaction), a form of attention, is induced to the discovered significant stimulus” (p. 233).

During extinction, a general increase in SCRs was found as well as absence of differential electrodermal responding to CS+ and CS−. Both phenomena can probably be explained by the following two factors. First, it must be remembered that subjects were confronted with compound stimuli consisting of faces and numbers during extinction. The facial component was also presented during habituation and acquisition. However, the numbers were new and may have caused an orienting SCR that obscured remaining effects of conditioning in the electrodermal mode. Second, the question can be raised whether the vocalization that was required during extinction facilitated SCRs. If so, shorter vocalization latencies with CS− than with CS+ trials will have counteracted differential responding due to conditioning.

The V-wave that characterized vocalization latencies during extinction possibly reflects practice effects on early trials and fatigue effects on later trials. Further research in this field should concentrate on a detailed analysis of the interrelationships between attentional biases as indexed by latencies and autonomic responding.

A second point that warrants further investigation along the lines specified above is the alleged pre-attentive nature of attentional biases in anxiety (Mathews & Maucleod, 1985; but see also Trandel & McNally, 1987). During debriefing interviews, 18 out of 20 subjects reported that the addition task distracted attention from the face stimulus to such a degree that elaborate processing of the stimulus was impossible. If the unreliability of post-hoc verbal reports is kept in mind, these interview data only suggest that the attention attracting properties of the CS+ operate in a relatively early phase of the attentional process. Nevertheless, this suggestion would be in line with recent research by Öhman (1986), which showed that pre-attentive conditioning effects can be obtained with fear-relevant (i.e., angry faces) but not with fear-irrelevant (i.e., happy faces) stimuli.

An important issue in the discussion about the attentional bias of anxious subjects is whether this bias arises as a consequence of anxiety (fear) or vice versa. On the assumption that aversively conditioned SCRs and fear form a continuum, our findings show that the former possibility might play a role. If attentional biases originate from (classically conditioned) fear, a successful behavioral treatment of this fear is expected to result in an elimination of such biases. This was, in fact, documented by two studies, one dealing with dichotic listening bias in obsessive-compulsives (Foa & McNally, 1986) and the other dealing with Stroop-color interferences in simple phobics (Watts et al., 1986).

In sum, both the present findings and the
studies which reported a disappearance of attentional bias following treatment, suggest that a learning approach to the origins of attentional biases might be fruitful.

References


