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Conditioned Preference in Humans: A Novel Experimental Approach

Ingrid S. Johnsrude

Wellcome Department of Cognitive Neurology, Institute of Neurology, Queen Square, London, United Kingdom

Adrian M. Owen

MRC Cognition and Brain Sciences Unit, Cambridge, United Kingdom

W. Vivienne Zhao

School of Human Communication Sciences and Disorders, McGill University, Montreal, Quebec, Canada

and

Norman M. White

Department of Psychology, McGill University, Montreal, Quebec, Canada

Conditioned pattern preferences were induced in 20 human participants using a computerized touch screen procedure. Three abstract monochrome patterns, presented incidentally to the subject over 180 trials in the context of a counting task, were randomly assigned to one of three reinforcement contingencies. One pattern was paired with positive visual and auditory feedback together with food reward on 90% of the trials in which it was presented and with negative visual and auditory feedback together with no food reward on the other 10% of trials. The other patterns were similarly reinforced, but at ratios of 50%:50% and 10%:90% with reward and negative feedback, respectively. Subsequently, the participants preferred the ''positive'' pattern (that paired most often with reward) to the ''negative'' pattern

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Address correspondence and reprint requests to Ingrid S. Johnsrude at The Wellcome Department of Cognitive Neurology, Institute of Neurology, 12 Queen Square, London, WC1N 3BG UK. Fax: +44 (0)171 813 1420. E-mail: ingrid@fil.ion.ucl.ac.uk.

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(that paired least often with reward). Furthermore, participants did not explicitly relate their preferences to the conditioning procedure, but instead attributed them to the characteristics of the patterns themselves, indicating that subjects were not completely aware of the effects of the conditioning procedure on their subsequent behavior.

Conditioned preference and aversion tasks have been widely used in studies of nonhuman species to elucidate the neural substrates that mediate reward and aversion, as well as the cognitive processes that are involved in their expression. Since the seminal work of Beach (1957), and Garcia and his colleagues (Garcia, Kimeldorf, & Hunt, 1957), several hundred studies of conditioned avoidance and conditioned preference have been conducted in rats (see Carr, Fibiger, & Phillips, 1989; Schechter & Calcagnetti, 1993, for reviews). Although conditioned place preference is the most extensively employed procedure, it can be considered a special case of a more general conditioning paradigm in which neutral stimuli are associated with biologically relevant events that have affective significance and subsequently elicit approach or avoidance (McDonald & White, 1993). Other related phenomena, investigated in rats and monkeys, include conditioned taste preference and aversion (Messier & White, 1984; Nachman & Ashe, 1974), fear-potentiated startle (Davis, Falls, Campeau, & Kim, 1993), avoidance tasks (Cahill & McGaugh, 1990; Dunn & Everitt, 1988), conditioned emotional responding (Selden, Everitt, Jarrard, & Robbins, 1991), and conditioned cue preference (McDonald & White, 1993).

In human subjects, similar phenomena have been explored in the context of implicit learning research. Beginning with the work of Razran (1954) and Staats and Staats (1957, 1958), researchers have used a great variety of techniques to produce changes in affective responding that are, to some degree, independent of the subjects' knowledge of the experimental manipulation. The most common procedures include subliminal mere exposure (Bornstein, Leone, & Galley, 1987; Bornstein, 1989; Kunst-Wilson & Zajonc, 1980; Mandler, Nakamura, & Van Zandt, 1987; Seamon, Brody, & Kauff, 1983) and classical conditioning (Baeyens, Crombez, Hendrickx, & Eelen, 1995; Baeyens, Eelen, Crombez, & van den Bergh, 1992; Baeyens, Eelen, van den Bergh, & Crombez, 1989; Bierley, McSweeney, & Vannieuwkerk, 1985; Fulcher & Cocks, 1997; Kirk-Smith, Van Toller,& Dodd, 1983; Levey & Martin, 1975, 1983; Martin & Levey, 1978; Niedenthal, 1990; Rozin & Zellner, 1985; Staats & Staats, 1957, 1958; Todrank, Byrnes, Wrzesniewski, & Rozin, 1995).

Insofar as the human studies employ neutral stimuli that are associated with events having affective significance and come to elicit affective reactions, they can be considered similar to the work in animals on conditioned preference and aversion. There are, however, some methodological differences between these two streams of research. In conditioned preference studies of animals, for example, the magnitude of the induced preference is inferred from a change in behavior toward the CS, which is assumed to reflect a change in the affective significance of the CS. In contrast, studies of evaluative conditioning in humans generally require subjects to evaluate the magnitude of their preferences explicitly, using rating scales, for example (Baeyens *et al.*, 1995, 1989; Bierley *et al.*, 1985; Eifert *et al.*, 1988; Levey & Martin, 1975; Todrank *et al.*, 1995). Requiring subjects to introspect and estimate the magnitude of their preferences for a particular stimulus may contaminate the data with explicit cognitive factors such as the subject's understanding of the purpose of the experiment and may not be as sensitive to preference differences as a two-alternative forced-choice procedure (Lewicki, 1985). Furthermore, the unconditioned stimuli used in the human literature generally have affective significance, but do not necessarily possess primary, biological, reward value. Since biological rewards produce conditioned preferences in animals, it seems likely that they would also do so in humans. Moreover, preferences produced by biologically rewarding stimuli may have a different basis from those produced by pleasant music or pictures of attractive scenery (Hall, Gonder-Frederick, Chewning, Silveira, & Gold, 1989).

The results of many studies in nonhuman subjects indicate that, unless a conditioned preference study is carefully designed, with due consideration given to such possible confounds as mere exposure effects, latent inhibition produced by preexposure, and initial biased assignment of the stimuli to be conditioned, it is difficult to demonstrate unambiguous conditioned preference or aversion phenomena (for discussion, see Carr *et al.*, 1989). Conditioning studies in humans are further complicated by the need to keep subjects unaware of the aims of the study, so that their behavior cannot be considered to be simple compliance with the experimenter's hypothesis. In order to reduce such ''demand awareness'' (Allen & Janiszewski, 1989; Stuart, Shimp, & Engle, 1987) and make the purpose of the study more difficult to discern, it is often necessary to disguise the experimental manipulation.

In this study, three abstract monochrome patterns were presented incidentally to each subject in the context of a cognitively demanding counting task. Each of the patterns was paired with positive visual and auditory feedback together with food reward on a defined proportion of trials (which was different for each pattern) and with negative visual and auditory feedback and no food reward on all other trials. Subsequently, a pattern-preference choice procedure and a test ascertaining knowledge of the relationship between the conditioning procedure and pattern preference (to eliminate demand artifacts) were used to determine whether a conditioned preference had been induced.

Carr *et al.* (1989) suggest that the stimuli to be conditioned should be randomly assigned to positive or negative feedback contingencies and conditioned stimuli that elicit strong unconditioned preferences or aversions should be avoided, since such biases may interact with the experimental manipulation. The amount of exposure to a stimulus may also play an important role in determining preferences, and effects of both novelty and familiarity have been described (Berlyne, 1970; Bornstein, 1989; Carr *et al.*, 1989; Stang, 1974; Zajonc, 1968). Thus, it is important to ensure that the subject receives equal exposure to all stimuli during the experimental procedure. In addition, preexposure to the stimuli to be conditioned can weaken a conditioned preference (Carr, Phillips, & Fibiger, 1988; Hammerl, Bloch, & Silverthorne, 1997), according to the principles of latent inhibition. Finally, it has been argued that the strength of a conditioned preference is proportional to the number of conditioned stimulus (CS)–unconditioned stimulus (UCS) pairings and may not occur if temporal contiguity between exposure to the conditioned stimulus and reward is absent (Allen & Janiszewski, 1989; Carr *et al.*, 1989; Fudala & Iwamoto, 1987). In accord with these considerations, the patterns to be conditioned in this study were chosen on the basis of their affective neutrality, as demonstrated in the pilot study, and each was randomly assigned to one of three reinforcement contingencies, for each subject. In addition, each of the three patterns was presented an equal number of times during the conditioning procedure, regardless of the number of times that it was paired with positive or negative feedback, and the subjects were not exposed to these stimuli prior to conditioning. Finally, in order to increase the possibility of obtaining a significant conditioning effect, 60 CS–UCS pairings were used for each stimulus and the stimulus pattern remained on the screen during reward or negative feedback.

Several features of the experimental design were included in order to minimize subjects' awareness of the experimental contingencies and of the goal of the study (demand awareness). First, the subject's attention was not explicitly drawn to the stimuli to be conditioned before or during conditioning, and these stimuli were irrelevant to performance of the experimental (masking) task. Second, the masking task (counting the incidence of reward) was deliberately made quite demanding, in order to minimize the subject's opportunity to attend to anything but the task and the occurrence of reward or negative feedback. Third, the three patterns were paired with reward on 90, 50, and 10% of the trials in which they occurred. In this way, by avoiding the absolutes of 100 and 0%, and by including a ''bivalent'' pattern (paired on an equal number of trials with reward and negative feedback), the experimental contingencies were made more difficult to discern. Pattern preferences were assessed from behavior directed at the conditioned stimuli using a binary choice procedure. Unlike in other studies of evaluative learning, subjects were required neither to estimate the magnitude of their preference for each stimulus, nor to rank the stimuli in order of preference. Finally, subjects were asked at the end of the study why they showed the preferences they did, in order to determine whether any change in preference would be attributed to previous experience with the patterns. If they attributed their preference to their previous experience, that would indicate that they were aware of the effect of the conditioning procedure. If, on the other hand, they attributed their preferences to the characteristics of the preferred pattern itself, we assumed that this was a confabulated response and that they were unaware of the effect of their previous experience.

METHOD

Subjects

Twenty right-handed McGill University undergraduate students, 10 men and 10 women, participated in the study. The average age of the participants was 21.5 years (range 19–28), and they had an average of 15 years of education (range 14–16, with 1 individual having 20 years). The experimental protocol was approved by the ethical review committees of the McGill University Psychology Department and the Montreal Neurological Institute and Hospital.

Apparatus

Computerized tests permit a greater precision and reliability in administration than other testing procedures, and thus a computerized touch screen format was used. We employed custom software written in Visual Basic and running on a Dell 486 PC DX2-50 computer with a SoundBlaster-16 sound card and a 40 × 30 cm MicroTouch touch screen. The sound was fed through a Harman-Kardon TD392 tape recorder/amplifier to Sennheiser HD520II earphones. The sound level was adjusted to be between 68 and 75 dB SPL(A).

The experimental stimuli were 6 black and white abstract patterns chosen from a larger set used previously in an unrelated study by Petrides and Milner (1982). In a pilot experiment, 19 McGill graduate students or Montreal Neurological Institute employees ranked all 12 patterns used by Petrides and Milner (1982) in order of preference (from 1 as their most preferred, to 12 as their least preferred). The 6 patterns with average ratings closest to 6.5 (5.6 to 7.3) were selected for use in the present experiment; 3 were chosen at random to be conditioned patterns (presented in the Formation and Judgment conditions), while the remaining 3 served as novel patterns in the Judgment condition (Fig. 1).

Procedure

Subjects were tested in three separate conditions, which were presented in a fixed order. The first condition, which we refer to as *Formation*, lasted about 35 min. The second and third conditions, which we refer to as *Judgment* and *Questions*, respectively, lasted about 5 min each. The participants were asked not to eat for at least 2 h before the study. Participants were required to choose either fruit-flavored pellets (Willy Wonka's Dweeb can-

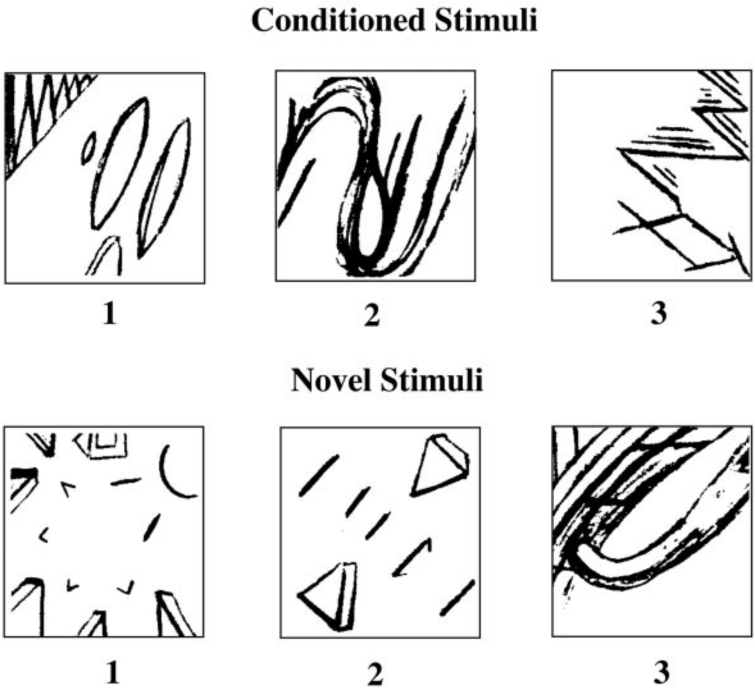

FIG. 1. The six patterns used in the experiment. The patterns in the top row were presented in the Formation, Judgment and Questions conditions. The patterns in the bottom row were only presented in the Judgment and Questions conditions.

dies) or raisins as their food reward at the outset, and they were given only the chosen type of food reinforcement during the procedure.

Formation. The subjects were presented with three black squares on the screen and were given the following instructions:

> ''You will see three boxes on the screen. At any time, one of the boxes is hiding a red ball, and the other two are hiding black balls. What you have to do is guess where the red ball is. I would like you to find as many red balls as you can. You can choose a box by lightly touching the screen. Once you have touched a box, it will open up and show you which ball was hidden underneath. Every so often, you will be asked how many times you have found the red ball in a particular box. Thus, while you are choosing boxes you have also to try and remember how many times you have found a red ball in each of the three boxes. I would like you to eat one candy/raisin every time you find a red ball.''

The subjects then proceeded to guess where the red ''ball'' was hidden by touching one of the three black ''boxes.'' Following each guess, the selected box would ''open up,'' revealing one of the three stimulus patterns and either a red or a black circle (or ''ball'') superimposed on the center of

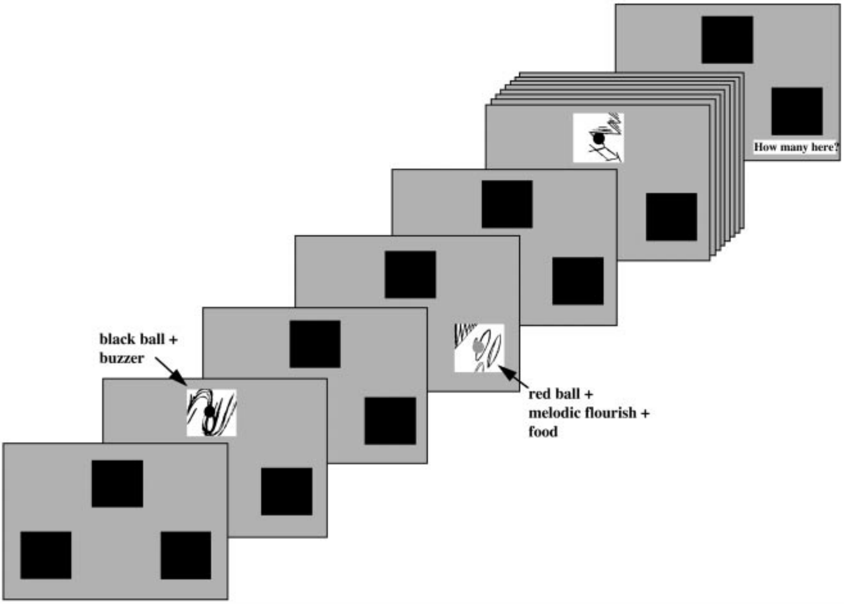

FIG. 2. Schematic drawing of a block of trials in the Formation condition. In the first trial, the subject picked the top box and heard a buzzer at the same time as the pattern and black ball appeared. In the second and third trials of the block, the subject picked the rightmost and top boxes, respectively. At the end of the block, the subject was asked to report how many times he or she found red balls in each of the three boxes, over the entire block.

that pattern (see Fig. 2). If the circle was red, the participants heard a melodic flourish and picked the chosen type of food reward (one candy or one raisin) from a bowl placed beside the computer screen. If the circle was black, they heard a buzzer and were not permitted to take a food reward. After 3 s, the selected ‘‘box’’ returned to black and the subject was required to make the next guess. This interval ensured that participants had enough time to eat the food on rewarded trials. Unknown to the subjects, the stimulus pattern and circle color seen were predetermined for each trial, regardless of the location chosen.

A total of 180 trials were presented over six blocks comprising 20, 30, 40, 40, 30, and 20 trials, respectively. In total, each of the stimulus patterns was presented 60 times, together with either a red ball or a black ball according to the contingency relationship for that pattern (see below). At the end of each block, the participants were asked how many times they had found the red circle in each of the three boxes during the previous block of trials.

Three versions of this task were prepared. In each version, a different set of pattern–reinforcement contingency pairings was used. Thus, in one version, pattern A was accompanied by reward (red circle, melodic flourish, and food) on 90% of trials in which it appeared (i.e., 54 trials) and by negative feedback (black circle, buzzer sound, and no food) on 10% of those trials (i.e., 6 trials). Pattern B was accompanied by reward on 50% of trials in which it appeared and by negative feedback on the other 50%. Pattern C was accompanied by reward on 10% of trials and by negative feedback on the other 90%. In the second version of the task the ratios were Pattern A, 10:90; Pattern B, 90:10; Pattern C, 50:50, while in the third version, the corresponding ratios were: 50:50; 10:90, and 90:10. Each subject was tested using one of the three different versions, chosen pseudorandomly, in such a way that the distribution of the versions across the sexes and across the reward types (candy or raisins) was approximately equal.

The trial order was also pseudorandom and fixed. The rarest combinations were always presented just before or just after the more frequent combinations (e.g., for the first version described above, Pattern A paired with a black circle was presented just after Pattern A paired with a red circle). In addition, an identical pattern/reinforcement pair could not occur more than twice in a row. These provisions served to break up runs of similar trials which might otherwise have alerted the subjects to the different reinforcement contingencies. In addition, each block of trials contained an equal number of red and black circles and at least one occurrence of each of the six possible combinations of circles and patterns.

Judgment. Six different patterns were used in this part of the experiment. Three of the patterns were those used in the Formation condition above, while three others were novel (see Fig. 1). On each trial, a pair of patterns was presented, one on each side of the screen. The subjects were given the following instructions:

> ''You will see two patterns on the screen. I would like you to choose the one that you prefer by touching it. Don't think too hard; just go with your first impression.''

There were a total of 30 trials, and each pattern was presented 10 times; 5 times on the left and 5 times on the right, in combination with each of the other five patterns.

Questions. All six patterns that were seen in the Judgment condition were presented simultaneously on the screen, and a number presented on top of each pattern indicated how many times the subject had chosen that particular pattern during the Judgment condition (of a possible 10). The question, ''Why did you prefer this pattern?'' was posed to the subject for the three most preferred patterns, in order to assess the subjects' perceptions of their preferences. At the end of this condition, each participant was informed of the nature of the study.

RESULTS

Ten participants (6 men and 4 women) chose raisins as the reward, and the remaining 10 chose candy. The incidental counting task was performed well, with participants scoring 97.6% (*SEM* = .79) correct across blocks. In the Formation stage, 18 participants searched all three boxes regularly, but with no fixed pattern. Only 2 subjects appeared to use any particular strategy (such as choosing the same box repeatedly until it contained a red circle or searching each of the boxes in a fixed order) consistently. Thus, participants were clearly concentrating on the counting task and following the instructions they had been given.

It was decided, *a priori*, to exclude those subjects from the analysis who demonstrated any spontaneous knowledge of the relationship between their experience with the patterns and their demonstrated preferences. This proved to be unnecessary, however, since none of the subjects related their preferences to the previous stage of the task in the Questions stage. In fact, all 20 subjects stated that their preferences were attributable to the physical characteristics of the patterns themselves (for example, for the second pattern in the Conditioned Stimuli in Fig. 1, responses included, ‘‘looks like a nerve cell’’ and ‘‘reminds me of the ocean in Florida’’).

Figure 3 shows the mean preference scores (maximum = 10) and standard errors for the ‘‘positive’’ pattern (the pattern paired at 90% with reward), the ‘‘negative’’ pattern (the pattern paired at 90% with negative feedback), and the ‘‘bivalent’’ pattern (the pattern paired equally often with positive and negative feedback), as well as those for the three ‘‘novel’’ patterns that were only presented during the Judgment and Questions conditions. There was a significant main effect of pattern when these six preference scores were compared directly, using one-way repeated measures ANOVA [$F(5, 95) = 2.98$, $p = .015$]. Planned comparisons among the patterns demonstrated that subjects preferred the positive pattern to the negative pattern [$F(1, 95) = 14.0$, $p = .0003$]. In addition, the positive pattern tended to be preferred to the bivalent pattern [$F(1, 95) = 3.40$, $p = .07$], which in turn tended to be preferred to the negative pattern [$F(1, 95) = 3.61$, $p = .06$]. There were no differences in preference scores among the novel patterns, $ps > .60$. Weighted contrasts comparing the novel patterns to each of the three conditioned patterns revealed that the novel patterns were preferred to the negative pattern [$F(1, 95) = 8.26$, $p = .005$], and they were slightly, but nonsignificantly, less preferred than the positive pattern [$F(1, 95) = 2.93$, $p = .10$]. There was no significant difference in preference scores between the novel patterns and the bivalent pattern [$F(1, 95) = .30$, $p = .59$].

Supplementary two-way analyses of variance were conducted to examine the effects of both Sex and Reward Type (candy or raisins) on pattern preference. No significant interaction effects or main effects of Sex or Reward Type were observed [Interactions, $F(5, 90) < 1.07$, $p > .38$; Main effects, $F(1, 90) < 1.00$, $p > .33$].

One-group *t* tests, comparing preference scores for the six patterns to the value 5 (which would be the expected mean preference if subjects were truly

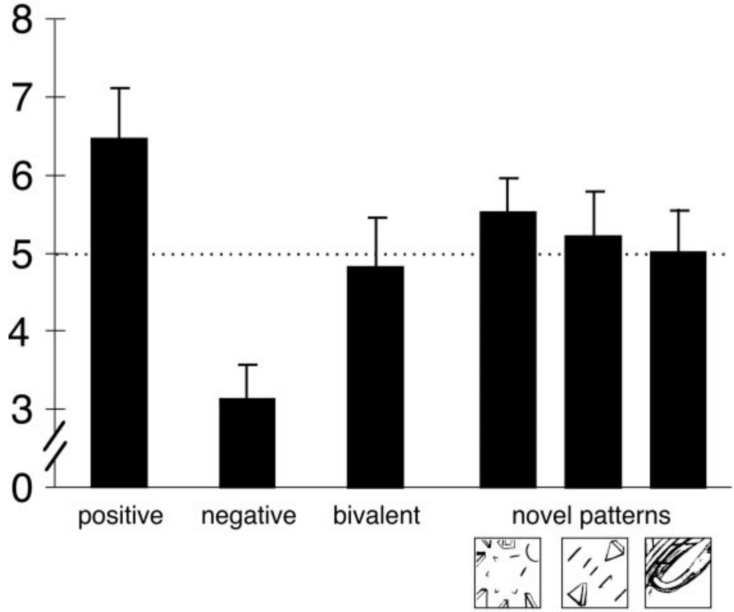

FIG. 3. The mean preference scores (maximum = 10) and standard errors for the ''positive'' pattern (the pattern paired at 90% with reward), the ''negative'' pattern (the pattern paired at 90% with negative feedback), and the ''bivalent'' pattern (the pattern paired equally often with reward and negative feedback), as well as those for the three ''novel'' patterns that were presented only during the Judgment and Questions conditions. Note that, since the reinforcement contingencies were randomly assigned to the different patterns within subjects, the preference scores for the positive, negative, and bivalent patterns, are not for any single stimulus pattern, whereas the preference scores for the novel patterns are for a single pattern.

indifferent to a particular pattern) revealed that the positive pattern was indeed significantly preferred [$t(19) = 2.21$, $p < .05$], and the negative pattern was significantly aversive [$t(19) = 4.71$, $p < .0005$]. Preference scores for the other patterns (novel and bivalent) were not significantly different from 5.

When the patterns were ranked within subjects in order of preference, we found that the positive pattern obtained the highest ranking in 7 of 20 subjects, and the negative pattern obtained the lowest ranking in 7 of 20 subjects. In only 3 subjects was the ''ideal'' pattern of positive ranked highest and negative ranked lowest observed. The average ranking for the positive pattern was 2.6 of a possible 6, while for the negative pattern it was 3.9.

Finally, we performed a power analysis (Keppel, 1982) in order to determine the minimum number of subjects that are required to demonstrate the preference effect. With only 15 subjects, power = .82, which is sufficient according to the criteria of Cohen (1977).

DISCUSSION

The task used in this study assesses an individual's preference for different discriminable visual patterns, after experience with these patterns in the presence of reward or negative feedback. Following the Formation condition, subjects exhibited a significant tendency to prefer a previously neutral pattern that had been paired with reward and a tendency to avoid a previously neutral pattern that had been paired with negative feedback. Since the conditioned patterns were all presented an equal number of times during the formation condition, any putative effects of novelty or familiarity can be ruled out. Furthermore, subjects did not explicitly and spontaneously ascribe their preferences to their experience during the Formation condition: during the Questions stage, no subject invoked the reward contingency associated with a particular pattern in the Formation condition as a reason for their preference. In fact, they attributed their preferences to the physical characteristics of the patterns themselves. This is a clear demonstration of demand unawareness and indicates that the subjects' change in behavior cannot be owing to their explicit knowledge about the experimental goals (Allen & Janiszewski, 1989; Stuart *et al.,* 1987; Reber, 1993). Furthermore, a majority of subjects actually preferred at least one other pattern to the positive one and chose at least one other pattern even less than they chose the negative one. The conditioned effect appears therefore to be a relatively subtle one: other factors (such as *a priori* aesthetic sensibility) must also have been at play in determining a subject's preferences. These other factors were perhaps more subjectively salient, given that all participants attributed their preferences for their three most preferred patterns to the physical characteristics of the patterns themselves. In sum, although the conditioned preference effect was evident in the group data, it appears to have been masked by other factors within subjects. Thus it seems likely that subjects were to some degree unaware of the conditioned effect, although our test of explicit knowledge was not strong enough to draw any firm conclusions about this. Supplementary questions would have been helpful for assessing the degree to which subjects were aware of the experimental contingencies. Questions like ''Do you remember seeing any of these patterns when you were hunting for red balls and counting? If so, which ones? Did you notice any association between the red ball and any of these patterns? If so, which ones?'' would have been useful in this regard.

Preference scores for the novel patterns, as well as for the bivalent pattern, were not different from 5, the value predicted if subjects were choosing at random. The positive pattern tended to be preferred to both the novel and bivalent patterns, which tended in turn to be preferred to the negative pattern, although these differences were not significant. They may have become significant if more subjects had been tested.

The results of the present study are consistent with other studies demonstrating affective response conditioning in normal human subjects (Allen & Janiszewski, 1989; Baeyens *et al.*, 1989, 1992, 1995; Bierley *et al.*, 1985; Fulcher & Cocks, 1997; Hammerl *et al.*, 1997; Kirk-Smith *et al.*, 1983; Levey & Martin, 1975, 1983; Martin & Levey, 1978; Niedenthal, 1990; Staats & Staats, 1957, 1958; Stuart *et al.*, 1987; Todrank *et al.*, 1995), using a variety of conditioned and unconditioned stimuli. However, unlike as in many of these investigations, the procedure used in the current study was based directly on conditioned preference and aversion tasks that have been used extensively in studies of animal learning and reward. We attempted to preserve the critical components of these conditioned emotional response procedures while extending the experimental approach to human subjects.

Although the results of the present study clearly indicate that pattern preferences may be conditioned in humans, they give no information about the likely neural substrates underlying conditioned preference. Studies in other species have attempted to elucidate the neural basis of conditioned reward and aversion, and it is now clear that the amygdala plays a prominent role in conditioned emotional behavior (see Aggleton, 1993; Davis, 1992; Gallagher & Chiba, 1996; Ledoux, 1995; McDonald & White, 1993; Sarter & Markowitsch, 1985, for reviews). We hope that this study, by drawing directly on the animal conditioned preference literature, will provide a springboard for future studies aimed at elucidating brain–reward relationships in humans. Thus far, studies of preference formation in brain-damaged subjects have been inconclusive. Patients with Korsakoff's disease (in which the amygdala is largely spared), when exposed to initially unfamiliar Korean melodies, showed a subsequent preference for these melodies over novel ones, despite impaired recognition of the exposed items (Johnson, Kim, & Risse, 1985). Amnesic patients (with a wide variety of etiologies) did not show an exposure effect for initially unfamiliar faces, unlike a matched group of normal control subjects (Redington, Volpe, & Gazzaniga,1984). There have, as yet, been few substantial studies of conditional emotional responding in humans with amygdaloid lesions, although a number of single or small-sample studies, concentrating largely on conditioned fear and aversion, have produced promising results (Bechara, Tranel, Damasio, Adolphs, Rockland, & Damasio, 1995; LaBar, Ledoux, Spencer, & Phelps, 1995). The results of these small-sample studies, using a variety of experimental protocols, are not entirely straightforward: at least one study appears to demonstrate preserved learning of affective associations in a patient with bilateral amygdalar damage (Tranel & Damasio, 1993). The relative paucity of data in human subjects may, in part, reflect the logistic difficulties associated with research of this sort: patients with circumscribed lesions are rare. Since the task developed for the current study requires relatively few subjects to demonstrate an effect, it would appear to provide a promising method for investigating the neural underpinnings of conditioned reward and aversion phenomena in humans, in both patient and functional imaging studies. Future work will seek to confirm that what is known about conditioned emotional behavior in animals is equally relevant to the human experience.

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