

Experiment 2

Method

Participants

Five male and five female Harvard University undergraduate students participated in this study.

Card Scheme

In order to discriminate between the somatic-marker and consciously-driven explanation of the data presented in past gambling task experiments (Bechara et al., 1994; Bechara et al., 1996; Bechara et al., 1997) and experiment 1, the following card scheme was constructed, parallel to experiment 1 and previous experiments mentioned (see Table 2 and Figure 8 and compare with Table 1 and Figure 1). The methodology of this experiment was closely matched to the previous experiments, but the magnitude of the reward and punishment of the decks was changed.

In this study, decks A and B rewarded the subject with \$225 each time a card was turned, leading to a reward of \$2250 for every 10 cards, but also punished the subject with a \$1500 loss every 10 cards. In deck A, this loss took the form of 5 small, randomly occurring punishments ranging from \$200 to \$400, whereas in deck B, a single, random punishment of \$1500 occurred within every 10 cards. In contrast, decks C and D rewarded the subject with \$25 each time a card was turned, leading to a

reward of \$250 for every 10 cards, but also punished the subject with a \$1000 loss within every 10 cards. In deck C, this loss consisted of 5 small, randomly occurring punishments ranging from \$100 to \$300, whereas deck D provided as punishment a single, random \$1000 punishment.

The amount of punishment and reward in each deck was also carefully selected to maintain a high level of similarity with experiment 1 and previous gambling task studies. Specifically, the ratio of the magnitude of punishment and reward between the good and bad decks was exactly reversed. In previous studies (see Table 1), every 10 cards from either of the bad decks were associated with a total money exchange (reward plus punishment) of \$2250, whereas the good decks were associated with \$750 of money exchange. Thus, the ratio of magnitude of reward plus magnitude of punishment for the bad decks compared to the good decks was \$2250 divided by \$750, or 3 to 1. As can be seen from Table 2, this ratio was reversed in experiment 2. In this experiment, either good deck rewards and punishes a total of \$3750 every 10 cards, compared to \$1250 of money exchange per 10 cards in either bad deck, thus leading to a 3 to 1 ratio (\$3750 divided by \$1250) which is reversed compared to previous experiments. Finally, this card scheme was selected only after significant testing with pilot subjects in which it was discovered that the difficulty of the task, as measured by the number of cards selected from the good decks compared to the bad decks, was similar to numbers found in experiment 1 and previous gambling task experiments.

In this design, the bad decks (C and D) had a *lower* magnitude of both “per card” punishment and reward than the good decks (A and B), even though ultimately choosing from the bad decks led to a loss and choosing from the good decks led to a

gain. This is the opposite of earlier studies (Bechara et al., 1994; Bechara et al., 1996; Bechara et al., 1997) in which the bad decks were higher in per card magnitude. This difference in design allows for the differentiation of the two conflicting hypotheses. According to the somatic marker hypothesis, the relative increase of anticipatory SCRs to selections of cards from the bad decks is caused by somatic markers which discriminate between the bad and good decks based on the ultimate gain and loss of these decks (Bechara et al., 1996; Bechara et al., 1997). By this reasoning, subjects' anticipatory SCR responses to the good and bad decks should be identical to those collected in previous experiments (Bechara et al., 1996; Bechara et al., 1997), regardless of the reversal of the magnitude of reward and punishment between the good and bad decks. Subjects should experience relatively increased anticipatory SCRs to bad decks because those decks ultimately lead to loss.

The consciously-driven hypothesis generates an alternative and opposite prediction concerning the amplitude of anticipatory SCRs in the gambling task. According to this hypothesis, subjects in previous studies (Bechara et al., 1996; Bechara et al., 1997) developed relatively increased anticipatory SCRs to bad decks because they consciously recognized that those decks were associated with higher sums. Thus, the anticipatory SCR differences between bad decks and good decks are independent of the ultimate gain and reward; rather, they are driven by differences in the magnitude of money used. In experiment 2, the reversal of magnitude should lead to a reversal in the anticipatory SCR difference: SCRs to card choices from the good decks should be higher than those from the bad decks.

Subjects were initially given a loan of \$6000 of play money to begin the game.

This amount, analogous to the \$2000 loan given at the beginning of experiment 1 and previous gambling task experiments, ensured that the subjects never lost more than the loaned amount, even if they only picked cards from the bad decks.

Results and Discussion

Behavioral Results

Card Choice

Patterns of card choice are displayed in Figure 9. As expected, subjects chose more cards from the good decks than the bad decks, and in proportions very similar to those seen in experiment 1 and previous gambling task studies (Bechara et al., 1994). Levene's test of equality of error variances revealed a homogeneity of variance across decks [$F(3,36) = 1.798, p = .17$], and thus an ANOVA was performed. A one-way ANOVA demonstrated a statistically significant effect of deck [$F(3,36) = 36.42, p < .001$], and post-hoc Tukey HSD tests revealed that the number of cards selected from the good decks (A and B) was significantly higher than from the bad decks (C and D). A two-tailed t-test comparing card choice between the good and bad decks also revealed a highly statistically significant effect [$t(38) = 9.67, p < .001$].

Verbal Responses

It is not clear, given the different nature of the card schemes across the two studies, that subjects' verbal responses in experiment 2 could be classed into the same

categories (pre-hunch, hunch, and conceptual) as listed for the earlier study in which verbal responses were collected (Bechara et al., 1997). That is, because the good decks were associated with a higher magnitude of reward and punishment compared to the bad decks, this may have elicited changes in strategy or knowledge across the game that shifted the temporal occurrence, or perhaps even the existence of, these defined periods. Nevertheless, an attempt was made to classify subjects' verbal responses into these categories, in order to compare these results with experiment 1.

In agreement with experiment 1, subjects' responses were found to be impossible to classify as either belonging to the pre-hunch or hunch periods. However, it was found that 2 of 10 subjects were classed into the conceptual period, a result similar to experiment 1.

Anticipatory SCRs

Anticipatory SCRs for each deck are shown in Figure 10. Values of anticipatory SCRs were higher for decks A and B than for decks C and D. Levene's test of equality of error variances demonstrated a homogeneity of variances across decks [$F(3,36) = 1.20, p = .32$], and thus an ANOVA was performed. A one-way ANOVA demonstrated a statistically significant effect of deck [$F(3, 36) = 5.21, p < .005$], and post-hoc Tukey HSD tests indicated that anticipatory SCRs associated with deck B were higher than those associated with decks C or D. Tukey HSD tests did not find any statistically significant differences between anticipatory SCRs associated with deck A compared to deck B. Additionally, a two-tailed t-test comparing anticipatory SCRs from the good decks (A and B) versus the bad decks (C and D) found a highly significant difference

[$t(38) = 3.57, p < .001$].

These results suggest that, when the card scheme is adjusted so that the good decks are associated with a higher magnitude of money exchange than the bad decks, they are also associated with larger anticipatory SCRs. This is contrary to what would be predicted by the somatic marker hypothesis.

Experiment 2 Compared to Experiment 1 and Previous Gambling Task Studies

Although the results of experiment 2 are in conflict with the predictions of the somatic marker hypothesis, it is unclear what variables caused the anticipatory SCRs to be higher for the good decks compared to the bad decks. In addition to the main change between the card schemes of experiments 1 and 2 - the higher magnitude of punishment and reward associated with the good decks relative to the bad decks - a number of other changes also had to be made to the card scheme of experiment 2, as can be seen from comparing Figure 8 to Figure 1, and Table 2 to Table 1. I discuss these differences in turn.

First, the absolute amount of play money (i.e., in dollars) exchanged in experiment 2 was greater, by a ratio of 5-to-3, than the money exchanged in experiment 1. Likewise, the initial loan of \$6000 in experiment 2 was larger than the initial loan of \$2000 in experiment 1. Also, in experiment 1, subjects won \$250 for every 10 cards in the good decks, and lost the same amount for every 10 cards in the bad decks. In experiment 2, subjects won a greater absolute amount of play money (\$750) for every 10 cards in the good decks, and lost the same amount for every 10 cards in the bad decks. Finally, the ratios of reward or punishment between the good and bad decks

differed between experiments 1 and 2. In experiment 1, each selection from the bad decks yielded twice as much reward as in the good decks (\$100 versus \$50), whereas in experiment 2, each selection from the good decks yielded 9 times as much reward as in the bad decks (\$225 versus \$25). Analogously, in experiment 1, every 10 cards chosen from the bad decks yielded 5 times as much punishment as in the good decks (\$1250 versus \$250), whereas in experiment 2, every 10 cards chosen from the good decks yielded 1.5 times as much punishment as in the bad decks (\$1500 versus \$1000).

These differences between experiments 1 and 2 were necessary adjustments in order to arrange the card scheme such that the good and bad decks were exactly reversed in terms of magnitude of reward and punishment and to ensure that the task was of similar difficulty to previous experiments. However, the existence of these discrepancies precludes the conclusion that the difference in anticipatory SCRs between the good and bad decks in experiment 2 is due solely to the reversed magnitude of the money exchange for the good and bad decks; it is unclear what factor these other differences had on the anticipatory SCRs, if any. However, this does not alter the strong suggestion that the somatic marker hypothesis cannot explain the data of experiment 2.

The somatic marker hypothesis posited that, in previous experiments, anticipatory SCRs were higher for bad decks than good decks because of the decks' inherent "goodness" or "badness" (Bechara et al., 1996; Bechara et al., 1997). Thus, the same should hold for experiment 2. Indeed, the somatic marker hypothesis would predict this outcome regardless of any of the differences in card scheme between

experiment 1 and 2.