Somatic Markers and Frequency Effects:
Does Emotion Really Play a Role on Decision Making in the Iowa Gambling Task?

Danilo Fum (fum@units.it)
Antonio Napoli (napoli@psico.units.it)
Dipartimento di Psicologia, Università degli Studi di Trieste
via S. Anastasio, 12 34124 Trieste (Italy)

Andrea Stocco (stocco@cmu.edu)
Department of Psychology, Carnegie Mellon University
5000 Forbes Ave., Pittsburgh, PA 15213

Abstract

The role of the frequency of wins and losses in the Iowa Gambling Task (Bechara, A., Damasio, A., Damasio, H., & Anderson, S. 1994. Insensitivity to future consequences following damage to human prefrontal cortex. Cognition, 50, 7–15) was investigated in 2 experiments manipulating the long-term expected value of the decks participants had to choose from. The first experiment adopted the typical setting of the task in which every card selection was followed by a monetary win, while losses happened only occasionally. In the second experiment every decision led to a loss while the contingent event was represented by wins. In both experiments the long-term expected value of the decks did not seem to influence the participants’ choices that were, however, sensitive to the frequency with which the decks produced the contingent event. Immediate gains or losses associated with the decks exerted their effect on the first few choices only. The relevance of these findings for Damasio’s Somatic Markers Hypothesis are discussed.

Keywords: Decision making; Emotion; Somatic markers hypothesis, Iowa gambling task; Frequency effects.

The Somatic Markers Hypothesis

The last years have witnessed a deep revaluation of the role of emotions in decision making, and the idea that feelings and sentiments could affect the way people make their decisions has gained increasing acceptance (Connolly, & Zeelenberg, 2002; Lee, 2006; Loewenstein, 2000; Rottenstreich & Hsee, 2001; Schwarz, 2000; Slovic, Finucane, Peters, & MacGregor, 2004; Wang, 2006). An influential part in this revaluation has been played by the Somatic Markers Hypothesis (SMH) put forward by Antonio Damasio and coworkers (Damasio, 1994; Damasio, 1996; Bechara & Damasio, 2005).

The SMH originates from the attempt to understand the difficulties experienced by patients with neurological damage in the ventromedial prefrontal cortex (VMPFC) who present both emotional problems and difficulties in making decisions in their personal and social sphere.

These patients are unable to express their feelings and to experience those affects that are normally evoked by emotionally arousing situations. On the other hand, while their basic cognitive capabilities (attention, memory, reasoning, etc.) are preserved, they run into troubles in making decisions concerning work, family and friends, money, or moral issues. People with VMPFC damages are unable to foresee the long term consequences of their actions, and are incapable of learning from their mistakes. Their choices are characterized by a “myopia for the future” (Bechara et al., 1994), and are very different from those that were made before the neurological damage.

According to the SMH, there exists a relationship between these problems: the difficulties experienced by VMPFC patients in their decision making could depend on the faulty workings of an emotional mechanism that in healthy persons is capable of rapidly signalling the (positive or negative) consequences of an action, freeing people from pondering about any possible option, and helping them to make advantageous and profitable decisions. This regulatory mechanism is constituted by the so-called “somatic markers”.

The SMH assumes that decision making is influenced by neurobiological biasing signals (markers) generated by the system underlying emotions. When experiencing an emotionally arousing event, a set of changes is produced that concern both the body and the brain. The bodily (or somatic) modifications deal with the internal milieu (viscera, heart, glands, smooth muscles, etc.), the external posture and behaviour, while brain effects lead to neurotransmitters release, the updating of somatosensory maps and the transmission of signals to somatosensory regions. Once a somatic state has been induced by an emotionally arousing experience, a pattern is made for it. Any stimulus capable of triggering memories or thoughts related to the experience reenacts this pattern generating a somatic state similar to that generated by the original event.

While making a decision, for any possible choice a somatic marker is produced that indicates the positive or negative value of what is being taken into account. In dealing with complex and uncertain situations, the somatic markers help to reduce the options space to treatable dimensions by marking them with an emotional signal. Only the options marked as promising are considered for further deliberation, while the less attractive ones are ignored. Rational decision making could thus be considered as a combination of deliberate top-down reasoning, in which an in-depth analysis of the effects of a conceivable action is performed, and a quick bottom-up screening, based on somatic markers, that indicates how likely a given action is to lead to positive or negative effects.
The VMPFC plays a critical role in the generation of somatic markers because it is the brain area where the representation of environmental stimuli is coupled with the states associated with the actions triggered by them. A damage to the VMPFC and to the regulatory structures implied in the representation and control of somatic states leads to faulty decision making because the somatic markers system could not be activated. In situations in which a complete rational analysis is not possible, this leads to lengthy deliberation (trivial matters could take a huge amount of time to be decided upon) or to inappropriate choices that would be immediately discarded by people with intact somatic markers.

The Iowa Gambling Task
The SMH relies not only on clinical evidence but is endorsed also by experimental findings. The most important empirical support for it is constituted by the results obtained through the Iowa Gambling Task (IGT).

Participants in the IGT are required to repeatedly choose a card from one of four decks. Every time a card is selected, participants gain a given amount of money but sometimes, unexpectedly, a card selection leads also to a monetary loss.

Two of the decks (called A and B) produce always a $100 gain but are also associated with strong, and variable, monetary losses (on average $-1250 every 10 card selections) leading thus to long-term monetary deficit. Decks C and D produce instead a small $50 win for every selection but give rise to smaller, and variable, losses ($-250 every 10 choices, on average) resulting advantageous in the long run.

While decks A and B are both “bad” and share the same long-term expected value ($-250), they differ from each other according to the frequency of losses they give rise to: deck A yields 5 losses every 10 selections, while deck B produces only 1 out of 10. The same is true for the “good” decks C and D, that lead in the long run to the same gain ($+250): losses in C occur 5 times out of 10 while in D they happen only once.

Participants are instructed to try to gain the greatest amount of money (or to loose the smallest) by attempting to figure out which decks are good and which ones are bad. By using a complex matrix of wins and losses associated with the various decks, the IGT tries to replicate the uncertainty conditions that characterize the decisions carried out in daily life where it is difficult to figure out the exact consequences of each choice, and where is often necessary to make a trade-off between the immediate and long-term effects of actions.

Working with the IGT, Bechara, Damasio, Damasio, & Anderson (1994) found that normal controls were initially drawn toward decks A e B, which led to high immediate gains, but after a series of losses they started to prefer the less attractive, but in the long-term economically more advantageous, decks C and D. Patients with VMPFC lesions, on the other hand, stuck to their initial choices and kept choosing preferentially from the bad decks, apparently insensible to the financial losses induced by their behavior.

An important support for the SMH came from the discovery of a neurophysiological correlate of successful performance in the IGT. Bechara, Tranel, Damasio, & Damasio (1966) measured the skin conductance responses (SCRs) developed by participants during the execution of the task. Normal controls and VMPFC patients did not differ in the SCRs that were induced after a card had been picked up. Following a series of selections, however, normal controls started to develop anticipatory reactions, i.e., SCRs produced before a choice, that were stronger for the disadvantageous decks. Frontal patients, on the other hand, were unable to develop such physiological reactions before a card choice. The lack of anticipatory SCRs correlated with bad performance in the card selection task. According to Bechara et al. (1966), this result would depend on the incapability of these patients to activate the somatic markers (as revealed by the SCRs) that would help them to distinguish between the advantageous and disadvantageous options under uncertainty conditions. More particularly, it was impossible for these patients to activate, when taking into account a selection from a disadvantageous deck, a negative somatic marker based on the previous losses that would warn them about the likelihood of receiving a possible punishment when choosing from these decks.

To establish whether the negative performance of VMPFC patients in the IGT could be explained by an altered sensitivity to punishments or rewards, Bechara, Tranel, & Damasio (2000) employed a variant of the original task in which any card choice would lead to a monetary loss while wins would happen only occasionally. In this variant, the advantageous decks were those that initially looked less attractive because they produced high losses ($-100) even if, in the long run, they led to still higher gains ($1250 every 10 choice, on average). The disadvantageous decks, on the other hand, were associated with a lower initial cost for each card selection ($-50) but led to still smaller gains ($250 every 10 choices). Participants with VMPFC lesions: (a) choose more cards from the disadvantageous decks both in the standard and in the modified version of the task even if (b) their SCRs, after having experienced a reward or a punishment, were similar to those developed by normal controls.

According to Bechara et al. (2000) the simplest explanation for the behavior of VMPFC patients is that they stuck to bad decks because they were insensitive to future consequences: they considered only the immediate effects of their choices unable to taking into account the long-term results.

A neglected factor?
The seminal work carried out by Damasio and coworkers on the IGT inspired a conspicuous amount of studies that analyzed the situational variables that could influence the selection behavior, investigated several aspects of the SMH and applied the IGT to several clinical populations (for a critical review, see: Dunn, Dalgleish, & Lawrence, 2005). The results obtained with the IGT are quite robust and attest both
the capability of normal people to discriminate between good and bad decks, and the difficulties encountered by several categories of participants, not only VMPFC patients, to make this discrimination.

An idea shared by the majority of researchers working within the IGT paradigm is that the key factor underlying it is the capability to figure out the long-term expected value of the decks while possible differences between decks of the same “goodness” were considered as irrelevant. Consequently, most researcher used as dependent variable to measure the quality of performance in the IGT the difference in the number of total choices from the advantageous and disadvantageous decks; in the standard version of the IGT this is given by the formula (C+D)–(A+B). A significant difference would show the capability of the participant to discriminate between profitable and unprofitable decks; a difference near zero is considered as a sign of lack of discrimination.

By concentrating only on this difference, however, we run the risk of disregarding an interesting phenomenon, potentially embarrassing for the SMH, that is highlighted in those few papers that report analytically, deck by deck, the choices performed by participants in the IGT.

The phenomenon relies on the fact that the decks differ not only according to their long term expected value but also in the frequency of the losses associated with them, making thus possible to distinguish between decks with high frequency losses (A and C) and low frequency ones (B and D). This distinction is orthogonal with the goodness dimension and is completely ignored when data are presented only in aggregate form.

Several papers (e.g., Fernie & Tunney, 2006; Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2005; O’Carroll & Papps, 2003; MacPherson, Phillips, & Della Sala, 2002; Wilder, Weinberger, & Goldberg, 1998; Yechiam, Stout, Busemeyer, Rock, & Finn, 2005) report findings that suggest that, contrary to the common-held assumption, decks of the same expected value could not be considered as equivalent, but some of them are chosen systematically more frequently than others. Participants tend to concentrate their selection on those decks (B and D) that are associated with a low number of losses, suggesting the existence of a possible frequency effect.

Lin, Chiu, Lee, P., & Hsieh, (2007) explicitly tested the so-called “prominent deck B” phenomenon, i.e., the fact that deck B, a “bad” deck that originates a small number of strong losses, is preferred not only to deck A, which has the same expected value, but it is chosen as frequently as (or even more frequently than) the good decks C and D. The somatic markers system, in this case, would assist the decision maker in situations characterized by frequent losses, but could not prevent the choice of disadvantageous decks in the case where the losses, even if they were rare, would be disadvantageous in the long run for the decision maker. Instead of being discouraged by the negative somatic markers, selections from deck B seemed favored by the low frequency of punishments.

To investigate whether the frequency of the unexpected events (e.g., losses in the standard version of the task) could be a critical factor in determining the performance in the IGT in addition to (or in substitution of) the long term expected value of the decks, we performed the following experiments.

**Experiment 1**

Three factors may influence the behavior of participants in the standard IGT paradigms: the immediate gains associated with each selection, the long term expected value of the decks, and the frequency of losses. Immediate gains vary inversely with the expected value (i.e., the decks with the highest immediate gain are those leading to disadvantageous results) while the frequency of losses is counterbalanced among the low-value, high-immediate-gain decks A and B, and the high-value, low-immediate-gain decks C and D. A further variable, i.e. the magnitude of the losses, could play a possible role in this paradigm, but it is generally considered a function of the previous ones and it is not directly manipulated in the experiments. For example, the huge losses in deck B depend on its high immediate gains, its occasional losses and its negative value; on the other hand, because deck C is a “good” one with low immediate gains and frequent losses, each loss is kept small.

In Experiment 1 we manipulated the long term expected value of the decks to investigate whether this could be the critical factor in determining the participants’ choices. Three conditions were utilized in the experiment. The standard (STND) condition replicated the typical settings of IGT in which the immediate gains vary inversely with their expected value (see Table 1 for details, where + indicates a high or positive effect and – a small or negative one).

In the NULL condition, the expected value of the decks was set to zero, (indicated by = in Table 1) i.e., the amount of money that in the long run participants were expected to win was identical to that they were expected to lose. In the last FRQN condition we contrasted the expected value of decks with their loss frequency by making them co-vary, i.e., the decks with frequent losses were the most profitable ones.

If the long term expected value of the decks (as assumed by the SMH) is the determinant factor in this task, participants should prefer decks C and D in the STND condition, A and C in the FRQN, while they should choose more or less randomly in the NULL one. On the other hand, if the participants choices are influenced by the frequency of losses, they should show the same behavior in the three conditions consistently preferring decks B and D to A and C.

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1. Of the 27 papers cited in the Dunn et al. (2005) review that utilized normal controls, only 4 failed to replicate the original results.
2. Among the populations that have been investigated through the IGT we mention, by way of example, schizophrenic patients, pathological gamblers, substance dependent individuals, alcoholics, adolescents with attentional deficit hyperactivity disorder, Parkinson and Hungtington patients, etc.
Method

Participants. Ninety-six participants (49 males) were recruited from the students enrolled at the University of Trieste. They were aged between 18 and 29 years (M=21.8, SD=2.2) and none of them was suffering from any neurological disease. The participants were randomly assigned to the experimental conditions.

Procedure. Experimental sessions were held individually by having participants interact with a computer-based implementation of the IGT. Decks were visually presented in the lower part of a 15 in. LCD screen, and participants used a mouse to point and select the deck they had chosen. Immediately after each card selection, the amount of money won (and possibly lost) was displayed in the upper half of the screen. The running total of money was coarsely indicated by a colored bar in the uppermost part of the screen that was updated after each selection. In each experimental condition participants had to perform 100 card selections.

Results

Table 2 reports the mean number of selections from the four decks in each experimental condition.

By even a cursory look at the table, two results come immediately about: the similar number of selections from the four decks in each experimental condition, and the consistent preference for the low-frequency-loss decks B and D. The fact that an explicit manipulation of the long term expected value of the decks did not lead to different selection patterns, and the fact that decks B and D were consistently chosen not only in the NULL condition, in which the expected value was zeroed out, but also in the FRQN one, in which they lead to low term monetary deficits, suggests that the frequency of losses could play a critical role in determining the selection decisions in the IGT. The following statistical analyses support this intuition.

Table 2: Mean number of deck choices in Exp. 1.

<table>
<thead>
<tr>
<th>Deck</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>STND</td>
<td>14.87</td>
<td>32.84</td>
<td>17.09</td>
<td>35.19</td>
</tr>
<tr>
<td>NULL</td>
<td>14.75</td>
<td>36.72</td>
<td>14.62</td>
<td>33.91</td>
</tr>
<tr>
<td>FRQN</td>
<td>15.34</td>
<td>32.87</td>
<td>22.40</td>
<td>29.37</td>
</tr>
</tbody>
</table>

An independence analysis carried out through a chi-squared test confirmed that the number of selections from the decks in the three experimental conditions were not significantly different. Two separate ANOVAs were conducted to highlight possible differences among the experimental conditions in the number of selections from decks with high and low loss frequencies (i.e., (B+D) – (A+C) and from decks leading to high and small immediate gains (i.e., (A+B)-(C+D).) No significant difference was found. The manipulation of the expected value of the decks did not seem to have any influence on the decisions performed by participants in the IGT.

Independently from the particular experimental condition to which they were assigned, however, participants showed a well-defined preference for decks with low frequency losses (M=33.93, t(95)=11.26, p<.000001) while immediate gains did not seem to play any significant role in determining their choices.

According to the SHM, participants should be initially attracted by high immediate gains and only through the influence of the somatic markers, and after experiencing a few losses, they should be led to prefer the more advantageous decks. To test this assumption, we contrasted the number of choices between high and low immediate gains through successive blocks of 20 choices. A mixed design ANOVA was carried out that revealed a significant effect of blocks (F(8)=4.83, MSE=191.6, p=.001) while there was no significant effect of the conditions nor of their interaction. A t-test (M=1.48, t(95)=2.87, p=.005) carried out for the initial block of choices (1-20) confirmed that in the first few selections the immediate gains associated with a deck could be a relevant factor in determining the participants selections. Further analyses carried out for the following blocks confirmed that the effect of the immediate gains was limited to the first block choices.

A similar analysis was performed on the differences between the selections from decks with low vs. high loss frequency. A mixed design ANOVA showed a significant effect of blocks (F(4)=15.12, MSE=576.7, p<.000001), but no effect of the experimental conditions nor of their interaction. Table 3 reports the results of the t-tests carried out for the blocks of choices showing that the frequency effects were replicated in every single one.

In summary, Experiment 1 showed that the main factor determining the selection behaviour of participant in the IGT seems to be constituted by the frequency of losses. Changes in the expected value of the deck did not have any effect on the pattern of choices displayed by participants while a possible effect of immediate gain seem to be limited to the first block of choices.

Table 1: Deck features in the experimental conditions

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>STND</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>NULL</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>FRQN</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>–</td>
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<th></th>
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<tbody>
<tr>
<td>STND</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>NULL</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>FRQN</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>–</td>
</tr>
</tbody>
</table>

| Expected Value | – | – | + | + |
| Immediate Gain | + | + | – | – |
| Loss Frequency | + | – | + | – |
Table 3: Frequency effects for the different blocks

<table>
<thead>
<tr>
<th>Block</th>
<th>Mean</th>
<th>df</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-20</td>
<td>2.69</td>
<td>95</td>
<td>5.15</td>
<td>0.000000</td>
</tr>
<tr>
<td>21-40</td>
<td>6.35</td>
<td>95</td>
<td>8.63</td>
<td>0.000000</td>
</tr>
<tr>
<td>41-60</td>
<td>8.15</td>
<td>95</td>
<td>9.55</td>
<td>0.000000</td>
</tr>
<tr>
<td>61-80</td>
<td>8.65</td>
<td>95</td>
<td>9.23</td>
<td>0.000000</td>
</tr>
<tr>
<td>81-100</td>
<td>8.10</td>
<td>95</td>
<td>8.22</td>
<td>0.000000</td>
</tr>
</tbody>
</table>

**Experiment 2**

In the second experiment we kept the same design of the first one but applied it to the variant of the IGT developed by Bechara et al. (2000) in which every card selection leads to a monetary loss while the contingent event is represented by wins. There are several reasons to assume that people react differently to rewards and punishment (Kahneman & Teversky, 1979), and we wanted to ascertain whether the factors that were effective in the standard condition would work also for the variant task.

**Method**

**Participants.** The participants were 81 University of Trieste students (51 males), aged between 20 and 31 years ($M=21.4, SD=2.5$), that were randomly assigned to the experimental conditions. None of them reported any neurological problem.

**Materials and procedure.** The procedure was identical to that utilized in Experiment 1. In this experiment, however, the payoff matrix of the decks was reversed by transforming the wins in losses, and vice versa, while keeping their frequency and absolute value the same. As a result, the “good” decks in the STND condition were A and B, while C and D were the disadvantageous ones. In the FRQN condition A and C were associated with frequent wins but led to negative expected values, while B and D were the advantageous ones even if they were associated with a low number of rewards. In the NULL condition, obviously, there was no difference about the expected value of the decks.

**Results**

The number of selections for each deck of the experimental conditions are reported in Table 4.

Table 4: Mean number of deck choices in Exp. 2.

<table>
<thead>
<tr>
<th>Deck</th>
<th>STND</th>
<th>NULL</th>
<th>FRQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck A</td>
<td>36.74</td>
<td>35.33</td>
<td>31.59</td>
</tr>
<tr>
<td>Deck B</td>
<td>17.48</td>
<td>14.78</td>
<td>21.48</td>
</tr>
<tr>
<td>Deck C</td>
<td>27.48</td>
<td>29.78</td>
<td>25.89</td>
</tr>
<tr>
<td>Deck D</td>
<td>18.30</td>
<td>20.11</td>
<td>21.04</td>
</tr>
</tbody>
</table>

Again, the pattern of selections from the decks was similar among the experimental conditions. A chi-square test on the proportion of choices from the various decks failed to reveal any significant difference among the conditions. One-way ANOVAs testing the effect of the conditions on the number of choices from high vs. low immediate losses, and from high vs. low frequency wins did not reveal any difference.

Analogously to what was obtained in the previous experiment, participants were influenced by the frequency of wins, in this case ($M=24.54, t(81)=5.68, p<0.00001$) while the immediate losses did not seem to influence their selection behaviour.

Separate mixed-design ANOVAs were carried out that highlighted (a) a significant effect of the blocks on the selections from low vs. high immediate loss decks ($F(4)=6.35, MSE=290.1, p<0.00001$) and of the interaction block x condition ($F(8)=3.50, MSE=160.0, p=0.001$) but no main effect of the conditions and (b) the main effect of blocks on the selection from high-frequency vs. low frequency decks ($F(4)=4.22, MSE=194.2, p=0.002$).

Even in this experiment the frequency effect was evident throughout the blocks (detailed analyses omitted due to space limitations), while that of immediate losses was restricted to the first and third block.

**Conclusions**

According to the SMH, emotions play a critical role in the decision processes through the somatic markers which would allow to discriminate between options that lead only to immediate advantages and options that in the long run are beneficial for the decision maker. By protecting against the myopia for the future, they would support rational decisions that are not granted to people which are unable to activate the somatic markers mechanism.

In this paper we presented empirical evidence showing that a stronger factor in determining the decisions made in the IGT is represented by the frequency of the contingent event, both in the case it is constituted by a reward (Experiment 1) and it is represented by a punishment (Experiment 2).

In the normal scenario in which the IGT is usually run (STND conditions), frequency of the contingent event is confounded with the expected value of the decks. This fact gives raise to the “prominent deck B” phenomenon and could contribute to explain a common result found in the IGT findings—and acknowledged also by Damasio’s group (Bechara et al., 2000)—i.e., the fact that a remarkable proportion of normal controls do not seem to be able to discriminate between good and bad decks, showing a pattern of choices similar to that produced by frontal patients.

In the situations in which the long term expected value of the decks was kept the same and in which only the options with immediate appeal should be taken into account (NULL conditions), participants consistently choose according to the frequency of the contingent event. In the situations in which the frequency of the contingent event contrasted directly with the long-term expected value (FRQN conditions), they systematically preferred the options which led to the highest number of rewards or to the least number of punishments, even if their choices lead to negative outcomes which somatic markers should have warned them against.

The main result of this paper is to highlight the role of a critical factor determining the behavior of participants in the
IGT that was somehow hinted at in previous studies but never directly investigated. The frequency of the contingent event is alien to the pattern of explanations developed within the SMH and is more in line with results deriving from probability matching and n-bandits studies (Berry & Fristedt, 1985; Shanks, Tunney, & McCarthy, 2002). While the present findings do not directly refute the somatic markers hypothesis, they put, however, some serious doubts on the real role of emotions on the decision making that occur in the IGT and, indirectly, on the main non-clinical support for the theory.

References


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