Literature Review

The Somatic Marker Hypothesis

The SMH proposed that decision making is guided by emotion. According to Damasio (1994), the somatic state (e.g., gut feeling) which relates to past emotional experiences, either positive or negative, will appear as guidance or alarm before individuals make a decision. If the somatic state is negative, it may lead individuals to withdraw from the choice. In contrast, if it is positive, it will guide individuals to approach to this choice.

Iowa Gambling Task

For testing the SMH, Damasio and his colleagues designed a task which is named Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994). As claimed by Bechara et al., the IGT is very complicated because there are immediate gains mixed with delayed loses, altogether resulting in an uncertain and conflicting decision making condition. The task consists of four decks. Each deck is associated with different gains and losses, as well as with different expected values. Participants are instructed to select one deck in each trial. Since some decks are relative good and some others are relative bad, participants are encouraged to win money as much as possible by figuring out the relative valence of the decks and then selecting more cards from good decks or fewer cards from bad decks. .

The good decks in the IGT are labeled as C and D, whereas bad decks are labeled as A and B. The most ingenious design of IGT is that, there are two kinds of outcomes, immediate gain and delay loss, which compete to each other. The immediate gain means that, each time when a deck is selected, participants gain some money. The immediate

gain for good decks is US $ 50, but for bad decks is US $ 100; thus while only considering the immediate gain, bad decks are more positive than good decks. However, the delayed loss, which is scheduled in some cards for each deck, is higher for bad decks (up to US $ -1250) than for good decks (up to US $ - 350). As the result, when considering the net outcome (i.e. expected value), selecting good decks makes participants win more (see Figure 1).

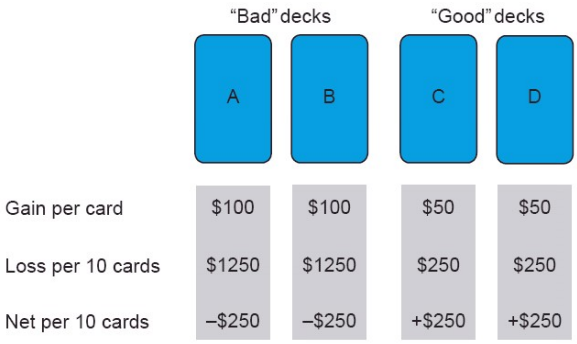

Figure 1. In the IGT, selecting a card from deck A or B brings a $100 gain every time, but sometimes causes a loss that is even higher. The 100% gain and sometime loss together contribute a negative net outcome of deck A and B. Deck C and D are on the opposite ways. Adapted from Bechara, Damasio, Tranel, & Damasio (2005), p.160.

The key feature of the IGT is that, say, selecting bad decks for sure brings higher gain, but the associated delayed loss is even much higher. Consequently, bad card selection is disadvantageous because its expected value is negative. Therefore, this design makes an opportunity to directly examine whether or not an individual can concern both of the immediate gain and delayed loss. If the delayed loss is neglected, he/she would be attracted by the high immediate outcome of bad decks, thus resulting in losing money in the long run.

Skyrocketed SCRs Warn Normal Participants

It is obvious that the immediate gain and delayed loss are both important for playing advantageously in IGT. The thing is that, while observing normal participant's card selection in IGT, both of these outcomes can be considered, and consequently normal participants win money in the task (Bechara et al., 1994). More intriguingly, the skin conductance responses (SCRs), which represent SMs, are skyrocketed before participants

select cards from bad decks (see Figure 2; SCRs measured before card selection is called “anticipatory SCRs”). The elevated anticipatory SCRs, serving as alarms, warn participants not to select bad cards or they might lose money (Bechara, Tranel, Damasio, & Damasio, 1996).

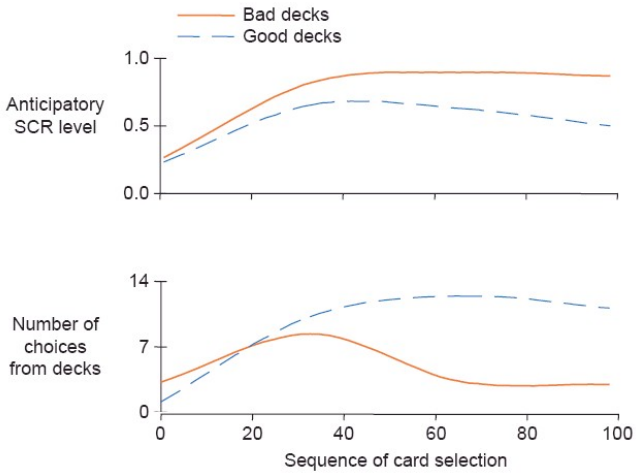

Figure 2. Normal participants eventually generated higher anticipatory SCRs before selecting cards from bad decks (top). Consequently they selected fewer cards from bad decks (bottom). Revised from Bechara et al. (2005), p.161.

Ventromedial Prefrontal Cortex Underlines SM Operation

Brain regions underlining the SM operation is suggested as the ventromedial prefrontal cortex (VMPFC). The VMPFC is located in the medial part of the orbitofrontal cortex, including Brodmann’s area 10, 11, 12, 13, 25, 32 (Bechara, Damasio, & Damasio, 2000). VMPFC has a huge number of connections with many other cortical and subcortical brain areas (e.g., sensory cortex, limbic system), thus this area is suggested to play a convergent-divergent function in which cognitive and emotional, internal and external information is integrated (Bechara & Damasio, 2005; Beer, Shimamura, & Knight, 2004).

Clinical observations reported that patients with VMPFC damage only care about immediate outcomes (Damasio, 1994). Thus, given the fact that the delayed loss is important for playing advantageously in IGT, the VMPFC patients who have deficits in processing delayed outcomes, showed disadvantageous preferences in IGT (Bechara et al., 1994). The most importantly, unlike normal individuals who generate distinguishable anticipatory SCRs before selecting good versus bad decks, the VMPFC patients do not generate observable anticipatory SCRs before card selections (Bechara et al., 1996).

Accordingly, Damasio and his colleagues concluded that, without generating SMs (i.e., SCRs) before decision making, VMFPC patients are not able to concern the delayed outcomes, as the result their selections in IGT as well as their decision making in their daily life are disadvantageous (Damasio, 1994).

Summary

In summary, the SMH proposed that past emotional experience related somatic responses would reappear before decision making. Through experiencing it, the possible delayed outcome of the choices would be accessible, thus the final decision making would be facilitated. Brain regions underlining the SM operation is VMPFC. It is observed that patients with VMPFC damage can not generate SMs before decision making. As the result, they show impaired decision making both in everyday and in laboratory conditions.

Consciousness in the IGT

SM Operation May be Independent From Consciousness

It was proposed that the SMs may operate without coming into consciousness (Bechara et al., 2000; Bechara et al., 1997). Empirical evidence comes from a study in which both normal and VMPFC damaged participants were asked to play IGT with simultaneously answering questions of how much they know about the game (e.g., tell me all you know about what is going on in this game). In that study, Bechara and his colleagues found that at the phase normal participants had no idea about the task design, their anticipatory SCRs to good versus to bad decks were getting differentiated, and the good deck preference was also shown. Furthermore, within the 6 VMPFC patients, there were 3 who did discovered the task design when the task was progressing (i.e., they knew they should not select bad deck because it would result in negative outcome), but they still

showed disadvantageous selections regardless their intact knowledge of the task (Bechara et al., 1997). The above findings implied that the SMs may operate without coming into consciousness. In other words, the SM operation exerts effect while normal participants have totally no idea about the task. More remarkably, explicit knowledge about the situation can not change the disadvantageous selection among VMPFC patients.

Maia and McClelland's Critiques

The notion that SMs may operate under consciousness is criticized by Maia and McClelland (2004). They suggested that questions in Bechara et al. (1997) are too simple to probe participants' full knowledge about the game. Thus, they replicated the IGT with a larger amount and more complicated questions (Figure 3). Their finding indicated that most normal participants knew very much about the game, including the valence, expected outcome, and the calculated net outcome of each decks, even just in the beginning of the task (i.e., by card 20). This finding suggested that conscious knowledge may play a more influential role than what Bechara and his colleagues asserted. More importantly, while the influence of conscious knowledge could not be completely ruled out, the observed SM effects (i.e., good deck preference in normal individuals) might be accounted by the process of cognitive strategy, rather than the SM operations. In short, the conscious knowledge of the IGT is a possible confounding that may undermine the fundamental evidence of SMH.

Does SM Operation Require Working Memory?

It is important to review studies investigating the relationship between working memory (WM) and SMH because WM involvement directly implies conscious demands in IGT. However, as the scenario in preceding sections, inconsistent findings make it still

Q1. Rate, on a scale of –10 to +10, how good or bad you think deck 1 is, where –10 means that it is terrible and +10 means that it is excellent.

Q2. Okay; why did you rate deck 1 with …?

[Repeat questions Q1 and Q2 for decks 2 through 4.]

Q3. In answering the questions that follow, consider the following definitions. Your "winning amount" for a trial is the amount you won on that trial. Your "loss" on a trial is the amount you lost on that trial. Your "net result" for a trial is the amount you won minus the amount you lost on that trial. Do you understand these definitions and the differences between the three terms? [If not, explain again using examples.]

Okay, now suppose you were to select 10 cards from deck 1.

Q3.1. What would you expect your average net result to be?

Q3.2. What would you expect your average winning amount to be?

Q3.3. In how many of the 10 trials would you expect to get a loss (not necessarily a net loss)?

Q3.4. For those trials in which you would get a loss, what would you expect the average loss to be?

[Repeat question Q3 for decks 2 through 4.]

Q4. Okay, now tell me, on a scale of 0 to 100, how much you think that you know what you should do in this game in order to win as much money as possible (or, if you can't win, to avoid losing money as much as possible). 0 means that you have no idea of what you should do and feel that you still need to explore the game more and 100 means that you know exactly what you should do and have no doubts that that would be the best strategy.

Q5. Now suppose I told you that you could only select cards from one of the decks until the end of the game, but that you were allowed to choose now the deck from which you would draw your cards. Which of the four decks would you pick?

Figure 3. Questions used in Maia and McClelland (2004) to probe participant's knowledge about the IGT. These questions were repeatedly given from after the first 20 trials and then every 10 trials. Adapted from Maia & McClelland, 2004, p. 16076.

unclear whether (or how much) the WM is involved in SM operation.

Bechara and his colleagues provided evidence suggesting that WM might be double disassociated with SM operation (Bechara et al., 1998). In a study with VMPFC patients, dorsolateral prefrontal cortex (DLPFC; which is identified to be highly related to WM function) patients, and normal participants, Bechara and his colleagues revealed that right DLPFC patients could play advantageously in IGT but showed impairment in two WM

tasks. In contrast, anterior VMPFC patients showed deficits in IGT but had intact performance in the WM tasks.

Evidence coming from other researches provided inconsistent findings to the double disassociation of WM and SM operation. For example, Hinson and his colleagues found that deprival in WM during IGT, especially in central executive capacity, could block normal participant's IGT performance (Hinson, Jameson, & Whitney, 2002; Jameson, Hinson, & Whitney, 2004). Furthermore, in a PET (photon emission tomography) study, Adinoff and his colleagues reported that resting state activity in DLPFC is correlated to IGT acquisition (Adinoff et al., 2003). These findings altogether suggest that working memory can more or less mediate SM operation.

Summary

In the past decade, Damasio and his colleagues have provided evidence to support the idea that SMs can operate without coming into consciousness. However, as addressed above, their findings are more or less questionable (Maia & McClelland, 2004), and with the use of different experimental paradigm (e.g., Jameson et al., 2004) and measuring tool (Adinoff et al., 2003), the findings so far are still mixed. It would be agreed that this issue is absolutely crucial to the SMH because if normal participant's advantageous selections in IGT could be accounted by any kinds of conscious processes, it is likely that SM operation is not necessary in IGT, thus the keystone of SMH is undermined.