Reviewing Decision Making:

from awareness to social decision making

By:

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2011

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Abstract

Decision making is a part of everyday life and is modulated by several factors. These factors include: gender, emotions, culture, development, and social influences. Each of these factors is described in this review. Two other aspects, that underlie decision making, are simulations and heuristic versus analytic processing of information. With every decision a prediction is made of the possible outcome of that decision, i.e. a simulation is made of possible future scenarios, which are based on past or future events. Via the theory of mind, the viewpoint of other individuals can also be simulated. Another important part of decision making is whether the decision occurs within or outside conscious awareness. Based on this dichotomy two systems are discussed: an analytic system 2 and a heuristic system 1. Whereas system 2 is conscious, time consuming and has a small capacity, system 1 is fast, unconscious and has a large capacity. In general, system 1 is the default process and is only inhibited by system 2 if an analytic intervention is required. This interaction between system 1 and system 2 is present throughout this review and the aforementioned influences on decision making are discussed with their possible implications on the two systems. Some neurological data for the system 1 and system 2 dichotomy are also presented. This review is concluded with a graph in which all the factors are merged in an attempt to illustrate the processes involved in decision making.

1. Introduction

In everyday human life there is an ability that is involved in every single thing we do. Do we go to the right, or to the left? Do we think that the piece of pie in the fridge is still edible, or not? Should we approach, or is withdrawal a better option? Sometimes the answer is clear (e.g. you go left because that road looks familiar) and sometimes the answer is difficult to obtain (e.g. standing on a unfamiliar crossroad while lost). In other words, we constantly make decisions of varying difficulty and most of the time we make decisions without even being aware of the precise reasoning preceding the decision. In general we make choices of which the outcome is certain, risky, or ambiguous.

This review will begin by introducing two abilities that are always present during decision making: conscious versus unconscious processes and simulations prior to decision making.

When making a decision, many factors can influence the process of decision making. These factors include: emotions, gender, culture, development, and social influences. In this review these influences will be discussed in greater detail. Many studies have focused on one or two of these influences on decision making, but never all influences at the same time. This is because of the methodological obstacles that would be inherent for such an all-encompassing study. Despite the benefits of dividing a difficult topic such as decision making into smaller sub-topics, one must not forget the bigger picture. The aim of this review is to provide an overview of different factors that influences decision making and link these to unconscious and conscious processes.

Special emphasis will be given to social decision making. Most of the decisions are made in some form of social context, but research on decision making often removes individuals from their social surroundings, place them in a lab and ask them to perform a task which involves decision making. Although impossible to test an individual in a completely natural environment, it is important to be able to manipulate the modulating factors of decision making if the results are to be generalized to the general population.

Finally, a practical note, there are tasks that not everyone is equally familiar with. These tasks need to be explained in more detail or are important in the field of decision making. In order to highlight these tasks, they are explained in separate boxes. Also, in this review several studies will be discussed and in order to help clarify these studies some original Figures will be reproduced, including their original captions which will be quoted in *italics*.

2. Main process behind decision making

2.1. Simulations

When we make a decision we must look ahead in time and try to anticipate the result of the decision. As will be explained in chapter 2.2., the making of a prediction need not be of a conscious nature. In case of the Iowa gambling task (see **Box 1**) an individual builds up a strategy of what he believes will be most beneficial and each time a card is picked from one of four decks, a prediction is made of the possibilities that the deck can unfold. Based on this prediction and combined with the strategy an individual uses, a decision is made. This section will focus on making simulations via prospection, projecting, and remembering, before making a decision.

Box 1.

The Iowa Gambling Task

	"Bad" decks		"Good" decks	
	A	B	C	D
Gain per card	$100	$100	$50	$50
Loss per 10 cards	$1250	$1250	$250	$250
Net per 10 cards	–$250	–$250	+$250	+$250

Replicated form Bechara et al. (2005) without permission.

As can be seen above the IGT generally consists of four deck of cards and each deck has a different pay-off to loss ratio. For example, a card form deck A can lead to an $100 gain or an $1250 loss and on average you will lose $250 per ten cards if you keep picking a card from this deck. Deck D on the other hand had cards that can either give $50 or take $250, but provide a net gain of $250 per ten cards. Decks that provide a net loss can be seen as "bad" decks and decks that will provide a net gain can be seen as "good" decks. The role of the participant is usually to pick cards from any deck, but he/se must try to win as much money as possible. The participants are not aware of the rules of each deck and generally the test stops after 100 cards but this is also not know to the participant.

Several species have been shown to use projection in order to make decisions, but most researchers agree that projection is far more developed in humans (Suddendorf & Corballis, 1997; Suddendorf & Busby, 2003). There is a distinct advantage in being able to predict future events and therefore it might not be unlikely for similar systems to have evolved in other species even if a common ancestor is very distant (Buckner & Carroll, 2007). Scrub jays, for example, are known to prioritize recovering food caches with perishable food over food caches that will last longer (Clayton & Dickinson, 1998; Emery & Clayton, 2001). Also they are careful when selecting storage sites, even going as far as to relocate the site if another bird was present when the site was originally selected (Emery & Clayton, 2001). In both cases they are indicating an anticipation of future events (inedible food and theft respectively). Also a very interesting study with rats showed that rats in some form predict the consequences of going right or left in a maze (Tolman & Gleitman, 1949). In this study Tolman and Gleitman placed rats in a typical T-maze with food in both ends of the maze, which they were forced to forage and one end of the maze was darkened. In the next step they removed the rats from the maze and placed them in a dark box where the rats received foot shocks. When these rats were returned to the original maze, with food in both ends, 88% chose the arm opposite of the darkened arm (see **Figure 1**). As the rats were never shocked during the first phase, they must have made a prediction of what could happen if they would have gone left or right and this prediction is based on events in the past.

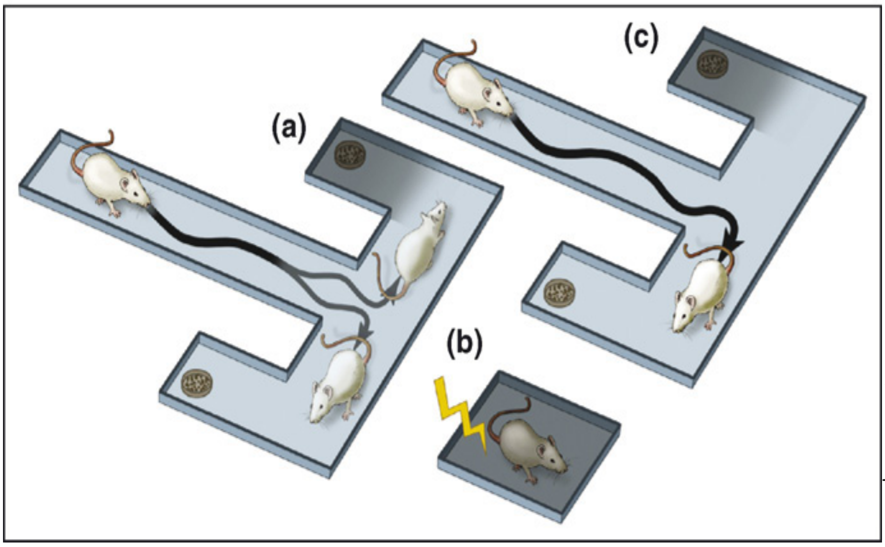


Figure 1. *"Candidate proto-forms of prospection in rats. Tolman and Gleitman's famous behavioral experiment on latent learning using a T-maze. The maze contained two arms: for illustration, the end chamber of one arm is darkened and the end chamber of the other arm is light. (a) Initially, the rat explores all parts ofthe T-maze. (b) The rat is removed and placed in the darkened chamber where it experiences a series of shocks. (c) When laced back in the T-maze, the rat chooses the safe path. The rat probably represents the decision choice, in some manner, in advance of the action, which raises the possibility of a proto-form of experience projection."* Replicated without permission from Buckner and Caroll (2006).

It is especially interesting that predicting future events is linked to our episodic memory. Episodic memory is the ability to remember events from the personal past. All our past experiences help to make a decision, we learn, and as a result our behaviour is guided by past experiences. For example, participants rarely keep choosing the bad decks in the IGT. In most situations the influence of past experiences would be very implicit. Usually when people think about memory, it concerns the past, but is seems that mental time travel based on episodic memory goes in both directions: the past and future (Szpunar, 2010) and it might even involve the same neurological mechanisms.

As will be discussed in section 3.5., social interactions are very important when making decisions. However, often these social signals are not very salient. In order to know what a person might want, people are able to imagine themselves in another person's situation and from this viewpoint think of possible actions that the other person could undertake. A recent study looked at the active brain networks involved in moral judgments with personal interactions, compared to the networks involved in moral judgments with impersonal interactions (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001). The results indicated that during moral judgment with personal interactions a very similar brain network was active when compared to individuals that are remembering or prospecting. See **Figure 2** for an overview of these areas.

It thus appears that one single network is implicated in generating simulations of past events, future scenarios, and social interactions. The frontal and medial temporal-parietal lobes are implicated in this network, and these brain areas are also involved in planning and episodic memory (Buckner & Carroll, 2007). These simulations are very important for making decisions. Past experiences teach us how to deal with certain scenarios, prospection helps us to anticipate possible scenarios and theory of mind allows us to perceive what other people could or would do. Much is yet unknown about the various mechanisms and capabilities of this "simulator". However, it is clear that these simulations guide our every day behaviour.

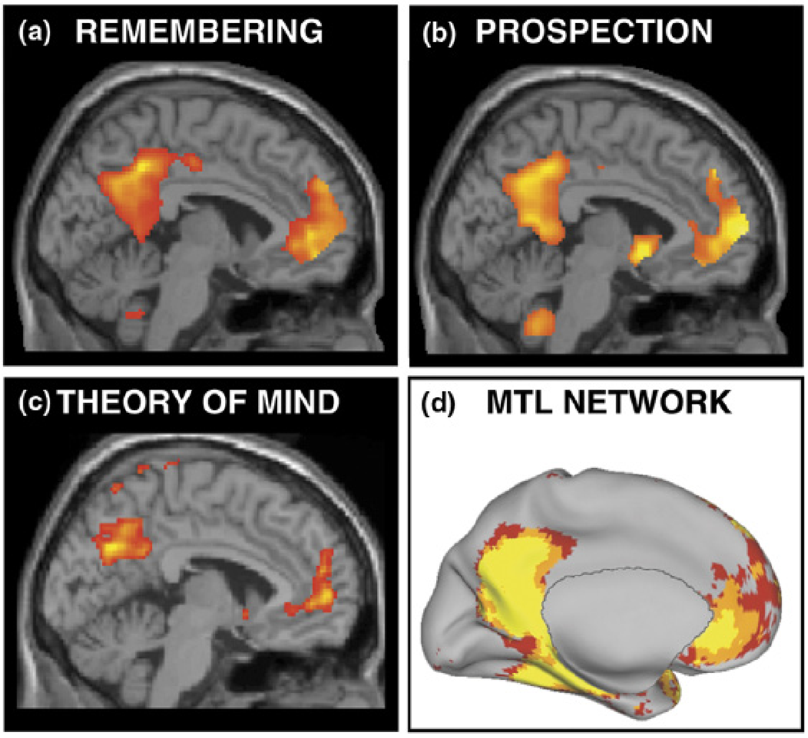


Figure 2. *"Brain activation during three forms of self-projection. Each image displays the midline of the left hemisphere with brighter colors, indicating regions of increased activation. There is a remarkable correspondence in activation during remembering (a), prospection (b) and theory-of-mind (c) tasks. Convergence also extends to lateral parietal regions (not shown), located within the inferior parietal lobule near the temporo–parietal junction. Within-subject studies are required to determine the extent of the overlap. Data in (a) and (b) adapted from Addis (2007) . Data in (c) based on Saxe, and Kanwisher (2003). (d) Cortical regions that functionally correlated with the medial temporal lobe (MTL). Note that the MTL network overlaps the regions that are recruited during the multiple forms of self-projection. (d) adapted from Vincent et al. (2006)."* Replicated without permission from Buckner and Caroll (2006).

2.2. Consciousness

Why are we sometimes highly aware of making a decision and why is decision making at other times almost automatic, without any awareness? This section will elucidate two different kind of decision making, with on one side the highly conscious decision and on the other side the unconscious decision.

Such a division of decision making is not new, and many authors have proposed a dual-processing view of higher cognitive processes such as decision-making (De Neys, 2006; Kahneman & Frederick, 2002; Stanovich, 2004). Most common is a distinction between system 1 and system 2. System 1 includes processes that are fast, automatic, unconscious and have a high capacity. Whereas system 2 includes processes that are slow, deliberate, conscious and have a low capacity. See **Table 1** for an overview of system 1 and 2 (Evans, 2008).

System 1	System 2
Unconscious (preconscious)	Conscious
Implicit	Explicit
Automatic	Controlled
Low effort	High effort
Rapid	Slow
High capacity	Low capacity
Default process	Inhibitory
Holistic, perceptual	Analytic, reflective

Table 1. Aspects of system 1 versus system 2. Modified without permission from Evans (2008)

Decision making can be fast and automatic (e.g. intuitive decisions), and decision making can be slow and deliberate (e.g. reflective decisions). System 1 would most likely be used for the former and system 2 for the later decisions. But are all decisions so easily fitted into either system 1 or 2? It is not difficult to imagine that some decisions are made using both systems. To use the example mentioned earlier in this text, when you have to decide to go left or right and you choose left because that road looks familiar, it is a conscious familiarity of the road that one experiences, but what gave rise to the feeling of familiarity? It seems that processes that are conscious in nature also have an unconscious (automatic) component (Kahneman & Frederick, 2002). In this scenario the processes of system 1 influences the processes of system 2. As mentioned earlier, via this section I would like to clarify the role of unconscious (system 1) and conscious (system 2) decision-making. One theory already attempts to explain the influences of the interactions between system 1 and system 2 on decision making.

2.2.1. Heuristic-analytic theory

The heuristic-analytic theory (Evans, 2006) focuses on two main aspects of thinking and reasoning. The heuristic process is fast, aims to focus our attention on relevant information and uses this information to select prior knowledge and beliefs to form a response. The analytic part of the theory is a slower process that uses the response from the heuristic process and either does nothing and allows this response to occur, or it inhibits the response and continues in a more conscious strategic thinking fashion. See **Figure 3** for a model of the theory. Three assumptions underlie the heuristic-analytic theory. The first is the idea that people will have great difficulty in processing and comparing two mental models at the same time. The theory states that one mental model will be constructed pre-consciously and that this 'hypothesis' will be evaluated by the analytic process. If the mental model does not satisfy the requirements, the model will be rejected and a conscious strategic thinking process begins. Second, people do not think in a deductive reasoning manner, but they satisfy by believing in a plausible or believable mental model, until proven otherwise. The basis of satisfying is drawn from the tendency of humans to create conclusions or beliefs that are beyond what could be achieved by pure deductive reasoning. The third assumption entails the influence of beliefs and prior knowledge on reasoning, i.e. a certain beliefs can overrule logical reasoning, even if this belief is unfounded or false.

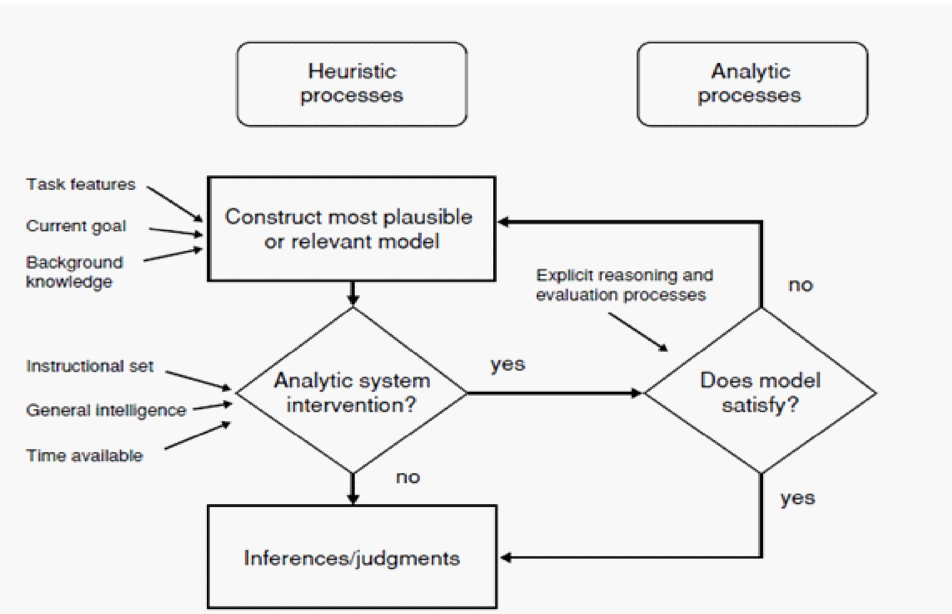


Figure 3. *"The revised and extended Heuristic-analytic theory."* Replicated without permission from Evans (2006).

It is clear that the heuristic-analytic theory can easily be linked to system 1 and system 2 mentioned earlier. Heuristic processes are equivalent to system 1 and the analytic processes are the equivalent of system 2. Also, mentioned in the previous section of this text was the problem of deciding to go left or right. In this example the left road was chosen because it looked familiar. The problem here was that system 1 seemed to influence system 2. The heuristic-analytic theory can explain this interaction between the two systems. The prior knowledge of the left road was used by the heuristic system to create a mental model, which led to the preference of the left road. This response from the heuristic process was translated into the a feeling of familiarity for the left road and this road was chosen over the right road. The heuristic response was satisfying and no inhibition of the analytic system was needed. This kind of connection between system 1 and system 2 gives rise to the question of how this interaction occurs. Are the processes of system 1 and 2 parallel to each other, sequential, or more interactive? According to Evans (2006) the heuristic and analytic processes are interdependent as preconscious heuristic processes provide information for analytic processing. But he refutes the role between the two processes as purely sequential and proposes a competitive role between heuristic and analytic processes. Heuristic processes create “default mental modes” that leans toward inferences, or decisions with little or no analytic processing. These default mental modes can be inhibited by the analytic processes, or the heuristic response can be accepted. However, the heuristic process will continue to influence analytic processing in both cases, since heuristic processes cue prior experience, and beliefs. At any time during this process, one can choose to engage in strategic conscious thinking.

The aforementioned already implies that not all decisions need be conscious decisions. There are many scenarios in which fast intuitive decisions need to be made for which the heuristic system is perfect, since it is fast and has a large capacity. Time is a crucial factor in these scenarios. The more time a person has, the more likely a more conscious strategic thinking process will precede the decision. But even for the fastest decisions, according to the heuristic-analytic theory, we always have the opportunity to inhibit the response from the heuristic process and engage in a analytic thinking process. For example, Bechara et al. (1997) used the IGT to study awareness of strategies during decision making. They continuously assessed the participants’ conceptualization of the game and the strategies they were using. The results indicated that in normal participants, covert biases preceded overt reasoning. Bechara et al. (1997) suggest that these covert biases do not necessarily lead to a decision, but facilitate the efficient processing of information needed for a conscious decision. However, recent finding indicate that decisions are made before any conscious awareness and that the conscious thought is a mere “afterthought”. In the example of deciding to left because that road look familiar, this means that you would already be preparing to turn towards the left by the time you are aware of the roads’ familiarity. The next section of this chapter will discuss the findings that lead to this idea.

2.2.2. Model of conscious will

The idea that conscious awareness with decision making is but a ‘post hoc’ thought, is very counter intuitive and is met with certain scepticism. The general idea is that things happen, because you actively want them to happen, e.g. you move your feet because you want to go somewhere, and it seems somehow backwards to think: “because my feet are moving, I must have wanted to go somewhere.” But, what if our brain is just making us believe we are always consciously in control of our own will, or as Wegner (2003) puts it: “Could it be that the deep intuition we all have about the power of our conscious will is the result of this ‘slight of mind’? “ Based on this concept, Wegner proposed a model of the experience of conscious will (see **Figure 4**), and there are several studies that provide evidence of pre-conscious will.

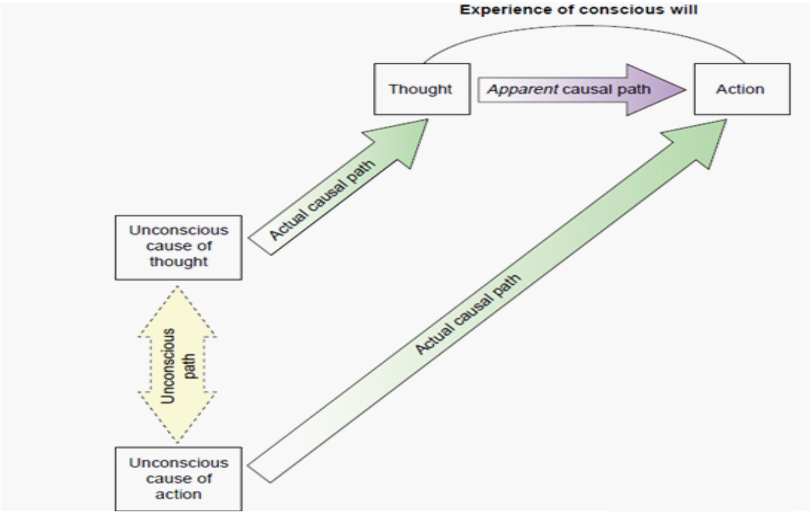


Figure 4. *“The experience of conscious will arises when the person infers an apparent causal path from thought to action (purple arrow). The actual causal paths (green) are not present in the person’s consciousness. The thought is caused by unconscious mental events, and the action is caused by unconscious mental events, and these unconscious mental events might also be linked to each other directly or through yet other mental or brain processes. Conscious will is experienced as a result of what is apparent, not what is real.”* Replicated without permission (Wegner, 2003).

Split brain patients, for example, will laugh if you communicate the word “Laughter” to their right brain. But when the patients were asked why they laughed, their left brain (which does not have all the information of the right brain and is needed for speech) will invent a story about remembering something funny (Gazzaniga, 1995). According to Wegner (2003) these patients misinterpret the conclusions from the left brain in order to satisfy the assumption that the actions of the patients is brought about by conscious will. The lateralized readiness potential (Libet, 1985) also provides compelling evidence of pre-conscious will. In this experiment, Libet discovered, via scalp recordings, that voluntary finger movement was preceded by an event related potential roughly 550ms before the execution of the voluntary finger movement. But even more astonishing was the report of the participants’ conscious awareness of wanting to initiate the voluntary finger movement, which was 350-400ms after the lateralized readiness potential. In other words, the conscious decision of wanting to move a finger was preceded by a preparation of the finger movement. This implies that the decision was already made well before the conscious will decided on the action. Further evidence on the fabrication of will can be derived from studies on agency, which is the feeling of being in control of your own actions. When participants are trained to expect a sound 200ms after pressing a button, they form a prediction of hearing a sound after pressing that button. If the participants press a button after the training phase, and 200ms later they hear a sound, they will believe to be responsible for generating that sound. However, if they believe someone else can also produce the sound and you manipulate the time between the button press and the sound, participants will at some point no longer believe that they produce the sound, while in fact they are (Sato & Yasuda, 2005). Without a link between action and the predicted result of that action people will no longer believe that their conscious will generated the sound and fabricate that “someone else” must have generated the sound. This indicates that a ‘will’ can easily be fabricated, and if your brain can fool you into thinking “someone else did it”, why should it not be able to pull off a “slight of mind” and lets you believe that you consciously willed something, while in fact you did not. These results fall in line with the three principles of the theory of apparent mental causation, which are the principles of priority, consistency, and exclusivity (Wegner 2003). Via this theory the source of the experience of conscious will can be explained. When conscious thought precedes an action, is consistent with the to be performed action and is the exclusive cause of the action, the experience is attributed to your conscious will. The agency experiment mentioned before, manipulated the exclusivity principle by delaying the time between the button press and the sound, combined with the instruction of a possible other source for the sound. This led to the attribution of conscious will to an external source.

To conclude this section, in his article Wegner stresses that even though the brain can fool us into thinking that we consciously will things to happen, conscious thought is still able to initiate actions and not all actions are unconsciously determined. This fits perfectly with the heuristic-analytic model mentioned in the previous section. If nothing out of the ordinary happens, heuristic (System 1) processes guide our decisions. We are bombarded with all types of information and this information influences our decision making behaviour. In fact, the amount of information is too much to actively analyse but due the great capacity of system 1, the needed information is filtered out and a decision can be made rapidly. At best, we are reflectively aware of why the decision is made but the decision itself occurred outside conscious awareness. In most scenarios, system 1 is fully capable of guiding our behaviour and only when something out of the ordinary occurs, the more slow and conscious system 2 takes over. This implies that any deficit in system 1 would greatly impair our decision making and possibly much more that any impairments to system 2. Without system 1, all information has to be actively analysed before a decision is reached, but due to its limited capacity, the information processing will be very slow and sensitive to information loss. As will be explained below, a failure in heuristic processes severely impairs decision making.

2.3. Neural evidence

2.3.1.Somatic marker theory

A very well known example of patients with severe impairments in decision making, is the case of Phineas Gage. Phineas Gage is perhaps the best know example of a patient with ventromedial prefrontal (VM) cortex lesions (**Figure 5**).

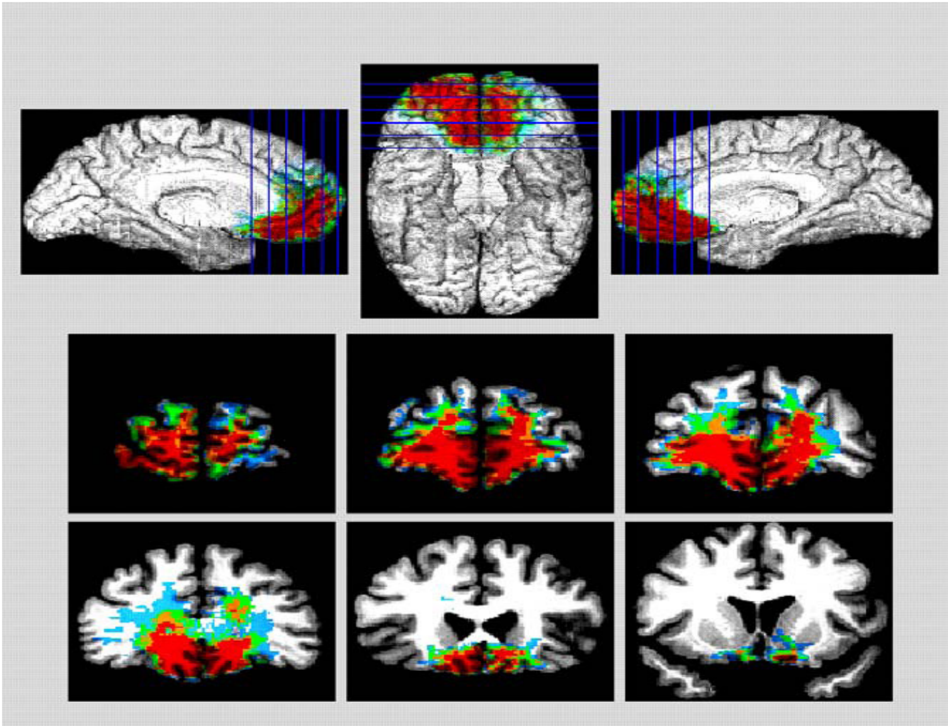


Figure 5. *"Overlap of lesions in a group of patients with lesions of the ventromedial prefrontal (VM) cortex. The redcolor indicates an overlap of 4 or more patients."* Replicated without permission from Bechara and Demasio (2005).

The signature symptoms of this group of patients are severe impairments in (social) decision making, while at the same time other cognitive functions seem to remain intact. For example, the intelligence of the patients prior to the VM lesions is the same as after the VM lesions.

Figure 6 shows the results of a comparison between VM patients, amygdala patients and healthy controls in an IGT (Bechara, 2004). During the task skin conductance responses (SCR) are measured. SCRs measure emotionally responses, which are the responses to winning or losing in the IGT. These results indicated that VM and amygdala patients keep choosing the disadvantageous deck even after realizing the consequences of choosing from such a deck. These results can be explained via the somatic marker theory of Bechara et al. (1997). Bechara refers to emotions as somatic states and he believes that somatic states can be induced from either a primary inducer or a secondary inducer. A primary inducer is an innate or learned stimulus that can elicit an emotional response (e.g. seeing a spider or winning a price). A secondary inducer is an event that is recalled of the primary inducer (e.g. remembering seeing a spider or imagining going on holiday). The primary inducer is linked to the amygdala and somatic states triggered by secondary inducers are linked to the VM. The VM functions to couple the information from a secondary inducer event to somatic state patterns in order to generate a emotional feeling in a specific scenario. The origin of this feeling is not conscious per se, and can elicit a covert response on the level of the basal forebrain or brainstem (Bechara, 2004). The VM is involved with secondary inducers of an emotional response, and damage to the VM disables the ability to 'remember' an emotional state that a patient has encountered in the past. When healthy participants become familiar with the gambling task they show an anticipatory SCR just before picking up the card, they are however unaware of experiencing an emotion. This anticipatory SCR possibly reflects the result of a simulation or prediction about the possible outcome of the decision, discussed in section 2.1. It appears that this anticipatory SCR is distinctively less or absent in VM patients and amygdala patients. Compared to healthy participants, VM patients also show a SCR when the card they pick-up is indicating a loss or a gain but the SCR is less pronounced. Patients with amygdala lesions show no SCRs.

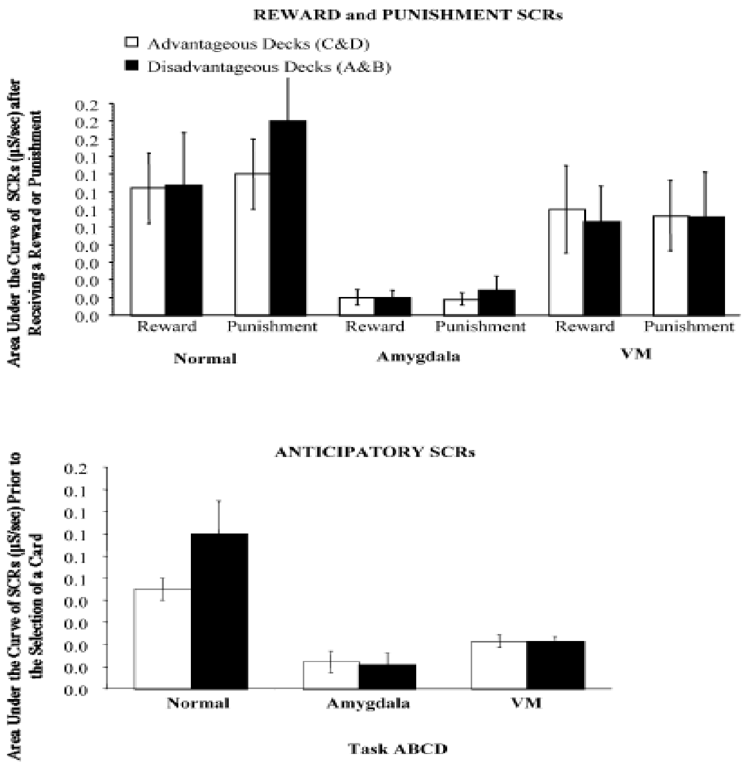


Figure 6. *"Means+s.e.m. of reward and punishment SCRs (top panel), and anticipatory SCRs (bottom panel), shown in (S/sec), which were generated by controls, amygdala, or VM patients in association with the advantageous decks (C and D) versus the disadvantageous decks (A and B)."* Replicated without permission from Bechara and Damasio (2005).

In patients with VM lesions, a primary inducer of emotions can still be initiated (i.e. induce a feeling when a loss/gain becomes clear), but fails to generate a secondary inducer of emotions (i.e. feeling of previous loss/gain is not translated in an anticipatory SCRs for the next card). In case of the amygdala patients, no primary inducer of emotion is possible and this disrupts the generation of a secondary inducer also. Take note that VM and amygdala patients are able to make rational and logical judgments similar to a healthy individual. These patients are aware of what is advantageous or disadvantageous, but without a right or wrong feeling, logical thought alone does not suffice to make the correct decision. The somatic markers theory reflects system 1 processes and the results support the idea that system 1 processes are vital to decision making and system 2 processes by themselves are insufficient.

2.3.2. Further anatomical evidence

In the previous section the example of a patient was described with lesions of the VMPC. There have been other patient studies since then (Manes et al., 2002; Tranel, Bechara, & Denburg, 2002) and from these data it becomes clear that the VMPC is very important for decision making. Also a PET study revealed that it is the right VMPC which is predominantly active during decision tasks (Rahman, Sahakian, Cardinal, Rogers, & Robbins, 2001; Rogers et al., 1999). These studies very often use gambling tasks in order to test the processes involved in decision making (**Box 1** and **Box 2**). When making a decision, it is very rarely known what the exact outcome of that decision will be. In other words, a decision comes with a level of uncertainty, which can be as low as 0% when you have all the information you need and can predict exactly what will happen or this can be as high as 100% when you do not have the slightest idea what is going on. But most times you do know what is going on and more often than not you will have the capability to gather information in order to reduce the amount of uncertainty as much as possible. Some recent findings have implicated the amygdala and the orbitofrontal cortex (Hsu, Bhatt, Adolphs, Tranel, & Camerer, 2005) in decision tasks with varying levels of uncertainty (see **Figure 7**).

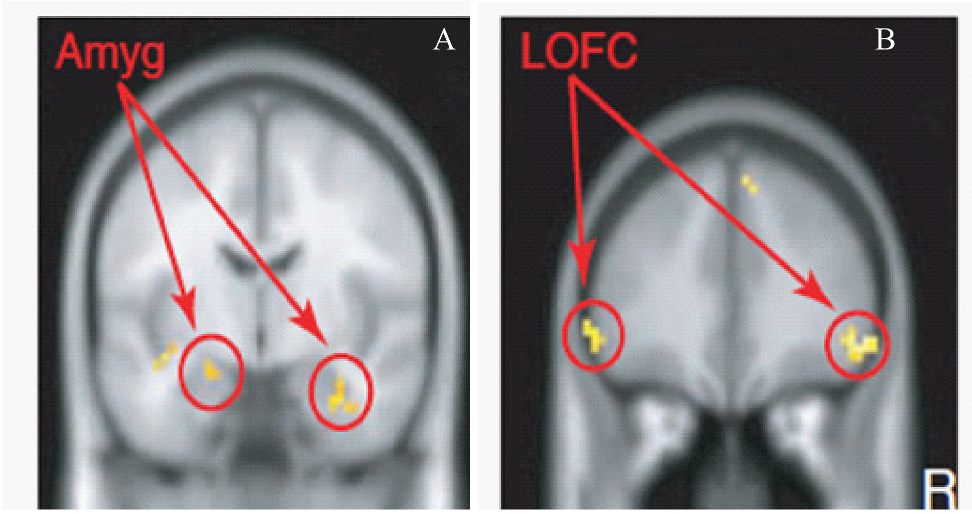


Figure 7. *"Regions showing greater activation in response to ambiguity than in response to risk. Random effects analysis of all three treatments revealed regions that are differentially activated in decision making under ambiguity relative to risk (P < 0.001, uncorrected; cluster size k Q 10 voxels). These regions include (A) left amygdala and right amygdala/parahippocampal gyrus (coronal section shown at y 0 7 in MNI space; heat map represents t statistic with 42 degrees of freedom) and (B) bilateral OFC."* Without permission from Hsu et al. (2005).

As discussed, decision making can be roughly divided into two systems: the heuristic system 1 and an analytic system 2. Further neurological basis for such a division has been found as well (Sanfey, Loewenstein, McClure, & Cohen, 2006). In a study where participants had to perform in the "Ultimatum Game" (**Box 3**), two distinct processes were revealed and two distinct brain areas seem to be involved for each one (Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003). The first was a deliberative process (System 2) and the second an emotional process (system 1). The fMRI data indicated that the dorsolateral prefrontal cortex, and the anterior insula were more active for deliberative and emotional processes respectively (See **Figure 8**). In short, there is a neurological basis for the dichotomy of an analytic system 2 and a heuristic system 1. The(right) VM, amygdala, ACC, and anterior insula are sensitive to heuristic processing and the dlPFC is sensitive to analytic processes.

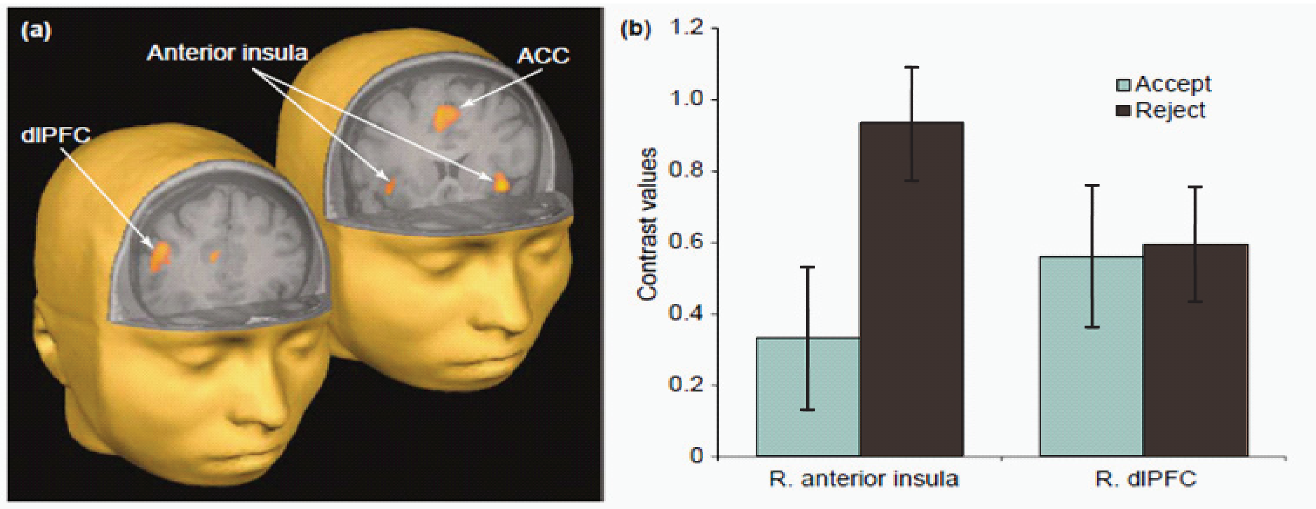
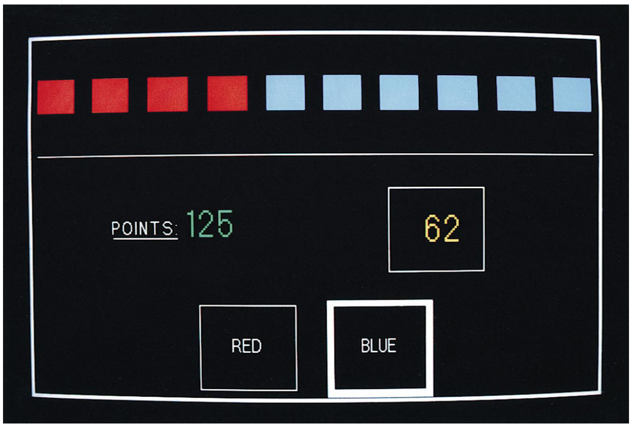


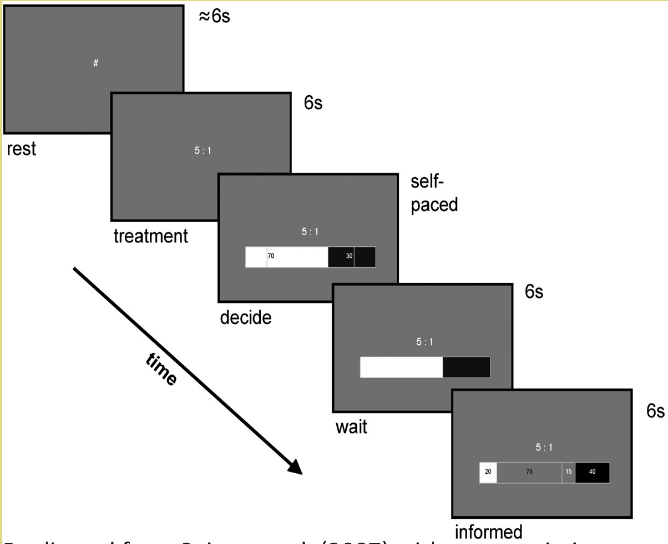
Figure 8. *"Deciding whether to accept or reject an unfair offer in the Ultimatum Game leads to conflict between emotional, 'reject', and cognitive, 'accept', systems. (a) Activation related to the presentation of an unfair offer from another human in the Ultimatum Game, showing activation of bilateral anterior insula and anterior cingulate cortex (ACC, right), and activation of right dorsolateral prefrontal cortex (dlPFC, left). Areas in orange showed greater activation following unfair as compared with fair offers (P<0.001). (b) Right anterior insula and right dlPFC activation for all unfair offer trials, categorized by subsequent acceptance or rejection. Trials in which the offer was subsequently rejected had significantly higher anterior insula activation than trials where the offer was subsequently accepted."* Replicated without permission from Sanfey et al. (2003).

Cambridge Gamble Task



A participant will be presented with a random arrangement of red and blue boxes and is told that in one of these boxes a yellow token is hidden. The participant has to decide whether the token is hidden in a red or yellow box. Furthermore, the participant has to place a bet (i.e. invest some points) on his answer. The possible bets would appear in succession and the participant has to decide which bet to place. In the example picture, the participant would be betting "62" points on his belief that the token hides in a blue box. The goal of the participant is to collect as many point as possible. In the example picture, the participant currently has a total of 125 points. The betting values were either: 95%, 75%, 50%, 25% or 5% of his current number of points. In the example, the participant is betting 50% of his points. With this task one can measure decision making (via manipulating red/blue box ratio), Quality of decision (via betting value) and Risk adjustment (rate in which the available point are bet, compared to blue/red box ratio).

Box 2.



Replicated from Spitzer et al. (2007) without permission.

The Ultimatum game is an example of a social decision task with multiple participants. The Ultimatum game version described here is used in the study of (Spitzer, Fischbacher, Herrnberger, Grön, & Fehr, 2007). This task consists of two participants (A and B) and they interact anonymously. At the beginning of the game, participant A receives 100 money units, these units represent real money and the participant is made aware of this. Participant A can divide the money units between himself and participant B freely. In the control condition, the role of participant B is completely passive and as such at the mercy of participant A who can freely decide how much money units will be given to participant B, if any at all. In the main condition of the experiment, participant B's role is no longer passive and he can punish participant A.

The main condition is very similar to the control condition but now both participants receive an extra 25 money units, which increases participant A's money units to 125 and participant B now has 25 money units. Also, after participant A has sent some money units (or none) to participant B, participant B is able to respond by punishing participant A. In order to punish participant A, participant B needs to invest his own money units. Each unit participant B invests in punishment results in a deduction of five money units from participant A. In the most extreme, participant B can punish participant A for all of his original money units (5 x 25).

Participant A will play 24 trials and with a different participant B per trial. Although the control or the main conditions are random, participant A knows beforehand what kind of trial it is.

Typically in the control condition participant A does not share equally or not at all. Only when punishment is possible does participant A share the money units more evenly in order to escape possible punishment.

Box 3.

3. Different influences on Decision making

3.1. Gender differences

It is well know that there are differences in behaviour between gender. In decision making this is true as well and many studies have reported gender differences (Bechara & Martin, 2004; Overman et al., 2004; Overman et al., 2006; Van den Bos, Den Heijer, Vlaar, & Houx, 2007). In a study by Overman et al. (2004) the authors found a significant difference in decision making behaviour between men and women, especially in the latter half of the IGT. Similar effects are found in other studies also (Van den Bos, Lasthuis, den Heijer, van der Harst, & Spruijt, 2007). Where men tend to favour the “good” decks over the long term “bad” decks, women keep returning to the “bad” decks. Decision making behaviour can be influenced by an exploration strategy or an exploitation strategy. An exploration strategy entails that a person keeps exploring other options and a person using an exploitation strategy has a clear preference for one or two options while ignoring the rest. In view of these strategies it would appear that males switch from an initial exploration strategy to an exploitation strategy, but females do not switch to a pure exploitation strategy and uphold an exploration strategy longer. See **Figure 9** for the tests performance in men and women on the IGT.

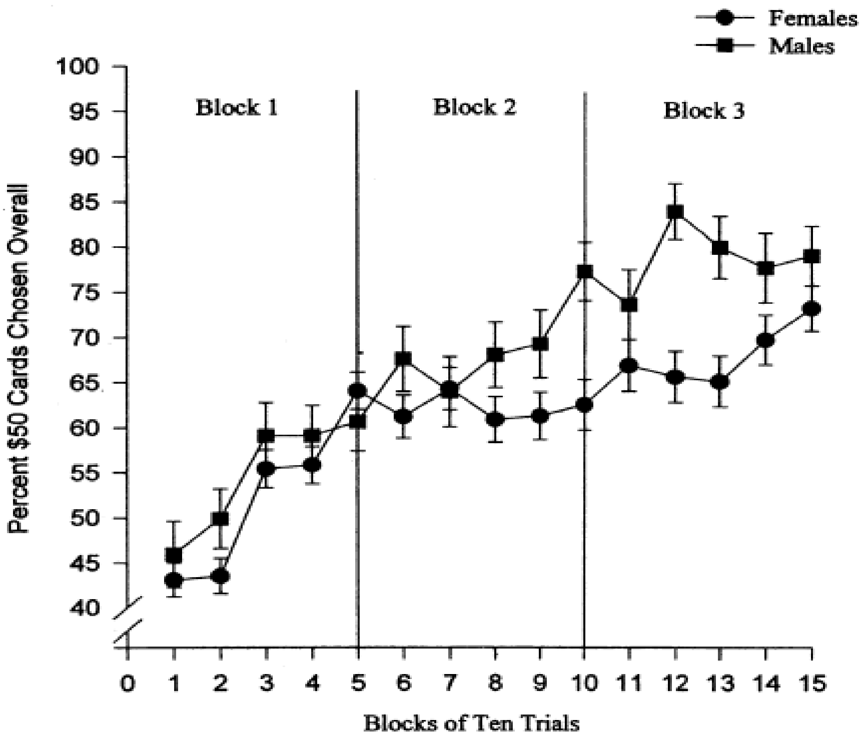


Figure 9. *“Mean percent of correct choice ($50 cards) in the IGT by adult men and women as a function of blocks of 10 trials. Vertical bars represent SEM.”* Replicated without permision from Overman et al. (2004).

In another study, van den Bos et al. (in press) further investigated these gender differences by combining a driving simulation test, with the IGT and the Cambridge gambling task (see **Box 2**). In the driving simulation tests, risky scenarios were included and used to measure the risk taking of the participant. Their data suggest that risk taking in the driving simulator was associated with immediate risk sensitivity but not with cognitive control. The same risk score was negatively correlated with the IGT results for women only. When female participants take more risks in the driving simulation, they would prefer “bad” decks over “good” decks in the IGT, which indicated a greater sensitivity to immediate rewards. Possibly indicating that the default system 1 in females might not be inhibited by system 2 processes as fast as in males or the threshold of when system 2 inhibits system 1 processes is higher in females. These differences cannot be explained by risk evaluation or risk taking, because in the same study no differences were found between men and women in the CGT with general risk sensitivity. In the driving test, the men and women also did not differ in response to a potentially risky scenario. The authors also noted that Suzuki, Hirota, Takasawa, & Shigemasu, (2003) did not find any differences in skin conductance responses (SCRs) in the IGT. It thus appears that are is no differences between men and women in their evaluation of emotional events. A previous study with the IGT also excluded mathematical capacities, differential perseveration, and generalized emotional arousal of being responsible for the gender difference in the IGT (Overman et al., 2006). An explanation for the gender differences can possibly be found in the differences in neurological activity between men and women when performing the IGT. The dorsolateral prefrontal cortex (dlPFC) is associated with a reflective system that encompasses cognitive control. In men the dlPFC shows a greater activation during the IGT when compared to women (Bolla, Eldreth, Matochik, & Cadet, 2004). Van den Bos et al (in press) concluded that women, are less capable to accept a loss that is not relevant to the long term success. Interestingly Overman et al. (2006) found that when the IGT is combined with a personal moral (PM) dilemma task the gender differences disappear. According to the authors PM dilemmas also involve the dlPFC. By introducing an element of cognitive control via the PM dilemmas the gender differences disappear. Overman et al. (2006) concluded that women might be more guided by the emotional aspects of the IGT when compared to men. It is possible that this reflects the different processes of system 1 and system 2. The heuristics of system 1 were not sufficient in dealing with the PM dilemma and as a result the analytic capabilities of system 2 were initiated. As stated earlier, females might not have the same threshold to triggers a system 2 response. By introducing a PM dilemma this threshold is reached much easier than during a standard IGT. As a result, females behave relatively similar as males during the IGT and the gender differences disappear. Another study also indicated that when a tasks become more demanding and an exploration strategy becomes more difficult, the gender differences disappear (Vlaar, 2007), i.e. when more cognitive control is needed both genders use a similar strategy.

The levels of Dopamine (DA) and Serotonin (5-HT) have been known to influence decision making. 5-HT seems to be involved in the maintaining of a choice behaviour, i.e. exploitation (Bechara, Damasio, & Damasio, 2001) and DA seem to be more involved in reward and forming representations of different options, i.e. exploration (Sevy et al., 2006). With this in mind, one potential answer for the gender differences is the menstrual cycle in females, which has a large influence on DA and 5-HT activity (Becker, 1999; Ho et al., 2001). Van den Bos et al. (2007) studied the influence of the menstrual cycle on decision making with two different versions of the IGT (standard and speed IGT). Their result however did not reveal a significant effect of the menstrual cycle on IGT performance. Van den Bos et al. (2007) propose that the gender differences in the IGT might already occur early in life, before the menstrual cycle starts and other studies do support that idea (Crone, Bunge, Latenstein, & van der Molen 2005; Overman et al., 2004).

When looking at **Figure 9** it becomes clear that the eventual payoff between male and females remain near equal. The gender differences seem to lie in the switching between the two earlier mentioned strategies of exploitation and exploration. With the previous mentioned links between 5-HT/exploitation and DA/exploration, it is plausible that females have higher levels of DA activity, which leads to more exploratory decision making (Van den Bos et al., 2007). In an experiment where the 5-HT reuptake was inhibited in female rats it was found that the female rats behaved very similar to male rats in the IGT, indicating that increased levels of 5-HT suppressed the exploration strategy in female rats(Homberg et al., 2008). According to Van den Bos et al. (2007) this could imply that gender differences are the result of differences in DA and 5-HT regulation. For example, in males the balance between the two is in favour of 5-HT whereas this is the opposite in females.

3.2. Decision making and emotion

Recently, more researchers study the effects of emotion on decision making. The idea is that emotions are necessary to make decisions. Simply put, people decide upon a specific action it they feel happy or good about the likely outcome of that decision and without this feeling decision making is impaired. As could be read in section 2.3.1., just prior to making a decision, people experience a good or bad feeling about the to be made decision, without being aware of this emotion. Also, people can actively predict a scenario and experience, via this prediction, an emotion. At the same time, people are in a certain emotional state when making the decision, e.g. feeling happy or depressed. Both influence decision making.

In general there are two different emotional influences: expected emotions and immediate emotions. When an individual makes a decision, he predicts the possible outcomes (see chapter 2.1.). This generates an expectation and the expectation in turn, is paired with an emotion, i.e., a future positive emotional result is chosen over a future negative emotional result (Loewenstein & Lerner, 2003). In the "decision affect theory" (Mellers, Schwartz, Ho, & Ritov, 1997) anticipated emotions predicted the choices made by the participants. In this experiment the participants had to choose between two gambles and indicate which they liked best (see Figure 10 for a gamble example). The black area of the gamble pie chart represented the win chance. A spinner would rotate in the centre of the chart of both gambles and when it stopped it would indicate a win (if it pointed to the black area) or loss (if it pointed to a white area). Before each outcome the participants had to rate their feelings on a scale ranging from 50 "very happy" to -50 "very unhappy".

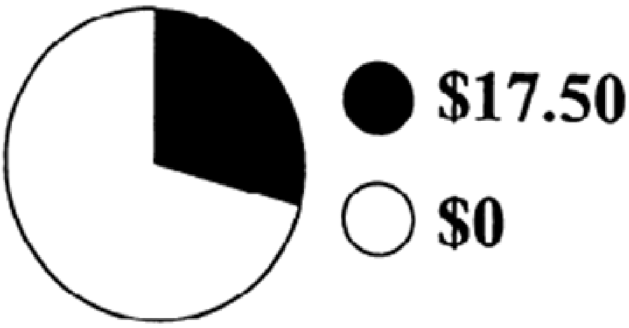


Figure 10. *"An example of a gamble option the participant recieved in the experiments."* Replicated from Meller et al. (1997).

After the participant was shown the outcome of the gamble, their predicted and current feelings were compared. The participants that overestimated their emotional feeling of a positive outcome, i.e. they thought they would be more happy, tend to be more risk seeking when compared to participants who overestimate negative outcomes (Mellers & McGraw, 2001).

Besides expected emotion, there is also the influence of immediate emotions on decision making. An example of immediate emotion is the emotional state of an individual which has a more general influence on decision making. A person in a happy mood will overestimate the positive outcome of a decision and underestimate negative outcomes. While the opposite is true for people in a depressed mood (Schwarz, 2000). Also, in a study by Van der Linde and Ridderinkhof (2007, http://www.seniorlab.nl), elderly participants were asked to watch either a happy video fragment or a neutral video fragment, after which the participants had to perform an IGT. The happy video fragment induced a positive mood, while the neutral video fragment did not alter the mood of the participants. When compared to the neutral group, the participants with a positive mood performed better at the IGT. The authors believe this improvement of performance is due to rebalancing of DA levels in an elderly brain. DA is known to decrease with age and DA is implicated in the generation of positive moods. Indeed, in younger individuals where the DA levels are still in balance, a positive mood does not lead to an improvement in IGT performance.

As can be surmised from this section, emotions have a fast influence on decision making. However, not in all cases will emotion be beneficial to the decision making process. The example given earlier that a happy person overestimates positive outcomes and underestimate negative outcomes, is already diminishing the effectiveness of decision making. However in patients with mood disorders, it is clearly shown that emotions in extreme are not beneficial to the decision making process. Think, for example, of a patient who is severely depressed. When such a patient needs to make a decision, the patient will be utterly unable to predict a positive result of a decision and would severely overestimate the negative outcome of the decision. But even outside the pathological range, emotions can be disruptive. If the induced emotion is not relevant to the current scenario it will very likely disrupt the decision making process.

Emotions help us to make quick decisions without the need for an active analytic analysis of the available data. Emotions are therefore part of the system 1 processes that guide our default decision making processes.

3.2.1 Stress

In a study by van den Bos et al. (2009), they compared risk taking behaviour of controls with a stress group via the IGT. The stress group was divided in a high and low cortisol responders group, determined via a median split of cortisol levels. For the high and low cortisol responders stress was induced via the Trier Social Stress test. Stress levels of all three groups (control, high/low stress responders) were measured via salivary cortisol levels (which in known to reflect stress levels). The stress test included a speech by the participant on a certain topic, selected from a list provided by the examiner, for which they had only three minutes to prepare. Afterwards the participant had to count backwards from 1022 to 0 in steps of 13. After the stress tests, the participant had to perform the IGT. The results of this study indicate that cortisol levels are related to behavioural effects during the IGT. In section 3.1. the gender effect of the IGT was already discussed and this gender effect, where men seem to outperform women, was observed in this study also.

However, men and women also differed in their reaction to stress and their consequential performance on the IGT. Men's performance was impaired by higher cortisol levels when compared to low cortisol responders and controls, but women seem to improve initially but then decline in their performance as well. Furthermore, it also seems that women under stress finish the IGT faster than women without stress. Remember that in section 3.1. an explanation of the gender differences was sought in the different strategies used by man and women. Where men switch from exploration to exploitation very quickly in the early phase of the IGT and women keep exploring the "bad" decks of the IGT keeping both strategies active. However, when women are under higher levels of stress, this changes and women switch to exploitation like men. Since they "waste" less time on exploration they become faster in their responses. This seems to improve the performance of women slightly in the beginning but as the task continues the performance of both men and women is impaired. Stress therefore seems to increase the need for cognitive control, which causes women to switch to a exploitation strategy (system 2). Also, higher levels of stress have a negative effect on system 2 like processes and therefore disrupt the performance of men and women both.

3.3. Development

Everyone knows that adolescents, do not always make the most sensible decisions. When compared to adults, adolescents are more involved in unsafe driving, unprotected sex and alcohol abuse (Arnett, 1992). Even though adolescents do seem to take more risks, this is not due to a lesser developed logical reasoning ability. Adolescents are equally capable as adults in perceiving risks and how this affects them (Reyna & Farley, 2006). However, there is a difference in the development of psychosocial capabilities between adults and adolescents (Steinberg, 2007). While logical reasoning capacities are fully developed around the age of

15, the psychosocial capabilities continue to develop until adulthood (**Figure 11**). In terms of the two systems model, this translates into underdeveloped structures that support system 2 processes, whereas the structures that support system 1 processes seem to be fully developed at a much earlier stage. As a result, system 1 processes have a much larger influence on decision making in early life up until adulthood.

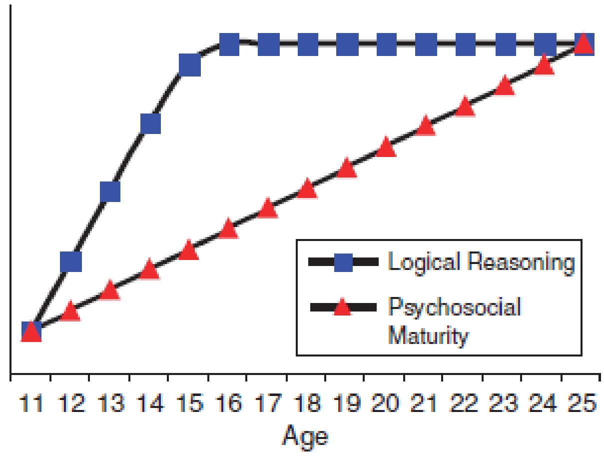


Figure 11. *"Hypothetical graph of development of logical reasoning abilities versus psychosocial maturation. Although logical reasoning abilities reach adult levels by age 16, psychosocial capacities, such as impulse control, future orientation, or resistance to peer influence, continue to develop into young adulthood."* Replicated without permission from Steinberg (2007).

Because the psychosocial capabilities of adolescents are still developing, the influences of emotion regulation, delay of gratification and resistance to peers is less than optimal. Decisions are influenced by the interaction between the logical reasoning capabilities and psychosocial capabilities. Adolescents are not fully equipped to smoothly handle strong emotions and peer influence. It is precisely this (strong emotions/peers) that a young adolescent is increasingly confronted with, and compared to adults they will be less able to cope with all the new emotions and peer pressures. The influence of peers was investigates in a study by Gardner and Steinberg (2005). In this study the adolescents and adults perform a driving task (see **Figure 12** for an example) alone, or with peers. The participants had to decide when to stop a driving car. If they stopped too late, the car would crash. Compared to adults, adolescents stopped much later and took more risks. When playing the driving game with peers, both adults and adolescents took more risks, but in comparison with adults, the adolescents risk increase was far greater (see **Figure 13**). As can be clearly seen, the influence of both risk taking, and peer influence seems to decrease with age.

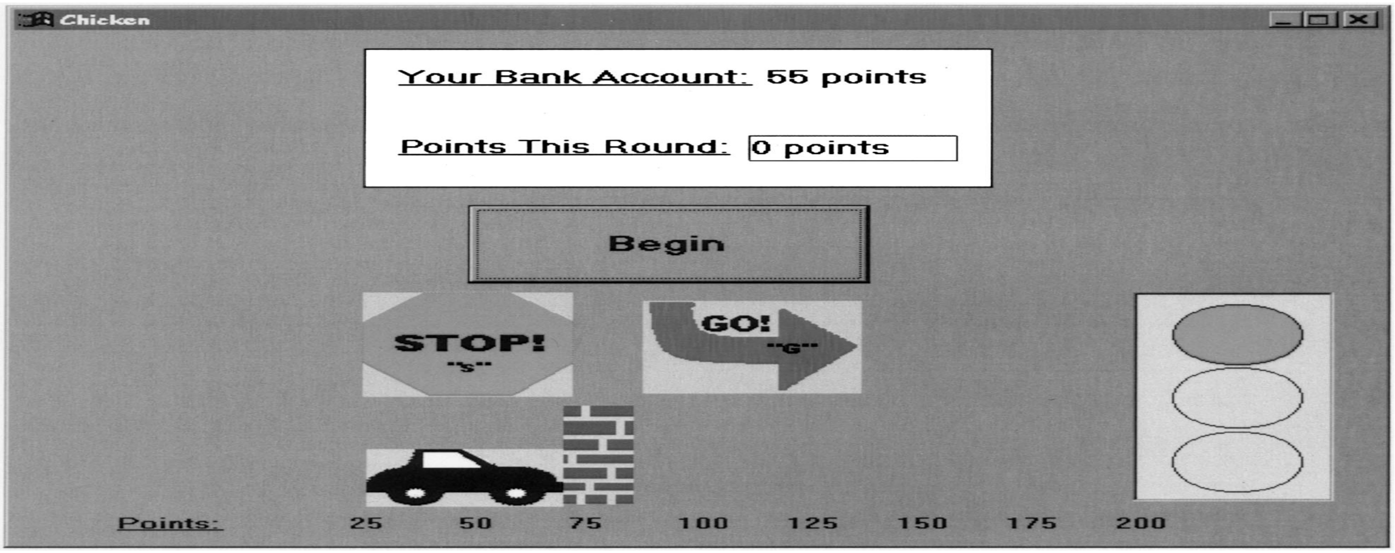


Figure 12. *"An image from the Chicken video game. In this frame, the traffic light has just turned red. The car was still moving when the light turned red; consequently, a brick wall appeared in front of the car, resulting in a crash."* Replicated without permission from Gardner and Steinberg (2005)

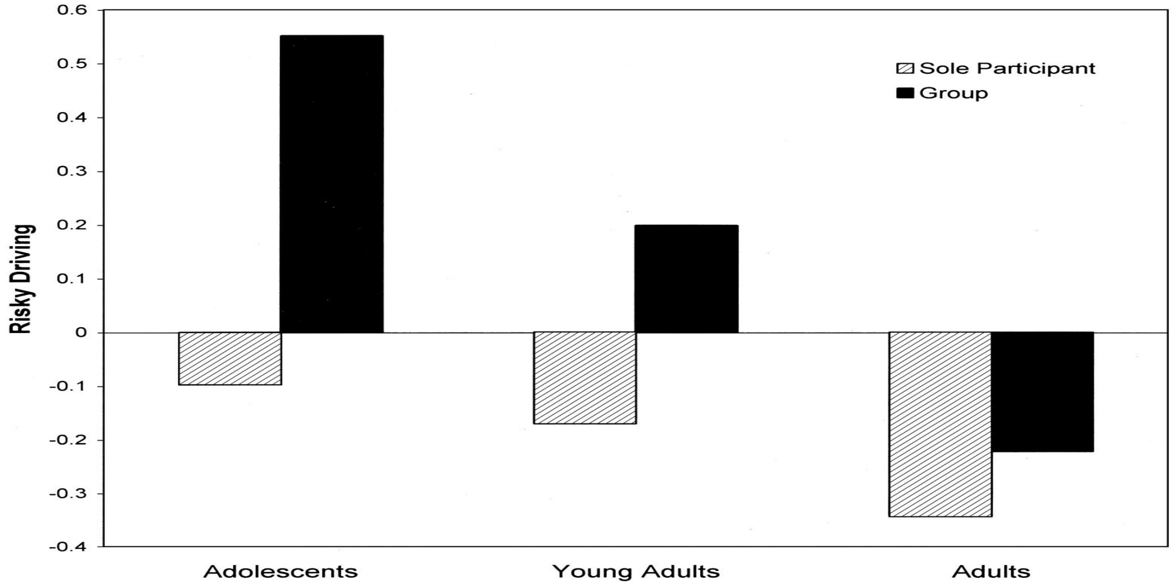


Figure 13. *"Age Condition interaction on Chicken game, where higher scores indicate more risk taking."* Replicated from Gardner and Steinberg (2005) without permission.

As a prelude to the next section about cultural influences, the experiment of Gardner and Steinberg (2005) also included participants of different ethnicities and the data was split up between "whites", and "non-whites" (see **Figure 14**). The "non-whites" consisted predominantly of African American individuals, but also included a much smaller group of Native Americans, Asian Americans, Latinos, and others. As can be seen in **Figure 14**, risk taking in the "non-whites" group was much greater when compared to the "whites" group and the results shown in **Figure 13** are much influenced by this effect. The adolescents of the "Whites" group seems very similar to the youths in terms of risk taking, but becomes significant when both the "whites" and "non-whites" are averaged together. These data indicate that, in this study, "non-whites" are more risk taking when in the presence of peers when compared to "whites" with the exception of the adults. However, when the difference scores of peer influenced participants and sole participants are compared another interesting finding becomes clear. In the whites group, the difference in risk taking between peer influenced participants or sole participants is roughly the same for the adolescents, youths and adults. But this is not so for the non-whites group. In the non-whites groups, the difference between a sole adolescent and an adolescent amongst peers is very large. This difference is smaller for the youths and virtually the same for the adults. This possibly indicates that for the whites group, the risk taking behaviour decreases with age but the peer influence remains relatively the same. For the non-whites group, the influence of peers is very large during adolescence, smaller for youths and the adults seem to be unaffected by peer influence. This could indicate that non-whites adults are less susceptible to peer influence when compared to their whites group counterparts.

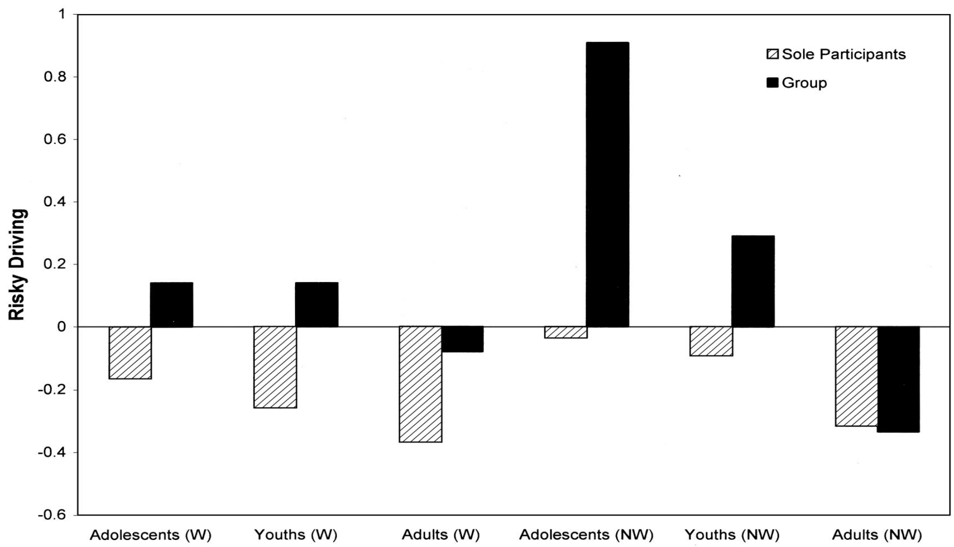


Figure 14. *"Age Condition Ethnicity Interaction on Chicken game, where higher scores indicate more risk taking. W White participants; NW non-White participants."* Replicated from Gardner and Steinberg (2005) without permission.

3.4. Culture

There is always a cultural influence on every decision we make. We are rarely aware of our own cultural rules and how this effects our everyday life. It describes our morals and taboos, which in turn guides our behaviour.

In order to measure these cultural differences, several studies have surveyed a large amount of different countries and created several value dimensions to compare different cultures (Hofstede, 1980; Hofstede, 1983; Hofstede, 1991; Schwartz, 1990; Schwartz, 1992; Schwarz, 2000; Trompenaars, 1993). One idea of cultural dimensions has received a lot of attention from researchers, and that is the idea of two extreme ends in a spectrum between individualism and collectivism, first mentioned by Hofstede (1980). Although different dimensions were created by other researchers, there was a strong correlation between the other proposed dimensions and the dimensions of individualism versus collectivism. For example Schwartz's (1994) dimensions of conservatism and affective/intellectual autonomy were closely correlated with collectivism and individualism respectively. According to Hofstede (1980) individualism is focused on the self and what an individual can achieve. In collectivism the opinion of the group is more important than that of the individual, the self is seen as part of a group and group decisions outweigh the need of the individual. The adjusting of an individual's behaviour to that of the group is termed conformity. The level of conformity is different across people and cultures and it greatly influences decision making. A meta analysis by Bond & Smith (1996) showed that conformity is higher in collectivistic cultures when compared with individualistic cultures. From the system 1 and system 2 viewpoint, it is possible that in collectivistic cultures, an automatic social response is part of the default system 2 process. Whereas in individualistic cultures, an automatic individualistic response is part of the default system 2 process. This remains speculative however and more research is required to study the differences between heuristic and analytic systems in different cultures.

In section 3.5.2. the effects of conformity will be described in greater detail and wherein will be shown that even within the same culture, people will differ in their levels of conformity. The take home message of this section is that decisions are influenced by a person's culture, even if they are not distinctively aware of the influence of that culture. Furthermore, if a study is focussing on social decision making, which, for example, is based on a western population sample (which tend to be highly individualistic), the results cannot simply be generalized to different cultures.

3.5. Social decision making

In the previous chapter I already eluded to a broader effect of social decision making via cultural influences. But social decision making is not just the influence from the culture we are from, but the people with whom we interact as well. Humans are social creatures and we tend to live in groups. When living in groups, there are general group rules (norms and values) but other kinds of group pressures as well. I already referred to the idea of conformity, which is the extent to which a person adapts his behaviour to the behaviour of others. Group influence can also be seen in the form of compliance, which is the urging by others for a person to acquiescence to a certain request. This can be implicit (documentaries about the beauty of nature, with underlying message to stop polluting) or explicit (commercials telling you to buy something). This section will discuss the various aspects of social decision making, which is a topic that is rapidly getting more popular as researchers are focussing more on the fact that decisions are rarely made in a social vacuum.

It is important to keep in mind that all behaviour, including social decision making, is influenced by several fundamental behaviours (Cialdini & Goldstein, 2004). First of all, everything we do costs energy and it is in our best interest to waste as little as possible of our energy when pursuing our goals. Therefore it is important to correctly interpret and respond to incoming information. Second, as mentioned several times in this text, humans are social creatures and therefore it is our very nature to create social relationships with others and to maintain these relationships. Third, our actions and beliefs cannot clash with each other without generating stress and diminishes an individuals' self concept. In other words, individuals need to believe and act (past and present) in a consistent manner.

3.5.1. Compliance

As mentioned, compliance is the silently agreeing to requests of another person (or group). But then why do we comply? We certainly do not agree with every group or person when we acquiescence to their request. An easy answer is that, when you do what your told to do, there is often a reward for doing so. However a person that is asking something of someone must be an authority figure (Cialdini & Goldstein, 2004), Authority can be gained either via an hierarchal structure or via expertise. For example, a drill sergeant giving orders in the military or a dentist recommending some toothpaste. A brilliant example of compliance via an authority figure is the famous study of Stanley Milgram (1974). In this experiment participants were willing to painfully shock a fellow participant simply because the experimenter told them to (Milgram, 1974). Despite their reluctance and emotional distress, the participants proceeded by dealing painful shocks to the alleged fellow participant because the authority figure (in this case the experimenter with the expertise) kept urging them on by saying "the experiment requires that you continue". In this way, authority can influence people to do something that will go against their own norms and values. However, for compliance via authority to work, the person or instance must be acknowledged to be an authority figure. Previous research indicated that the influence of advertisement can be more easily resisted if the participants were demonstrated their vulnerability to the advertisement combined with rules for indentifying frauds who claim to be experts (Sagarin, Cialdini, Rice, & Serna, 2002).

Another reason for compliance is the feeling of liking someone. When a person likes someone, they are more likely to comply with the wishes of that person (Lynn & Simons, 2000). The stories that pretty people get what they want is true in this perspective. Psychically attractive people are more likely to be liked than people who are psychically unattractive and this influences compliance in their favour. But also family and friends will increase the likelihood of compliance. This does not mean that strangers will always decrease the likelihood of compliance. In fact it seems that only a short face to face talk can easily increase the level of compliance (Burger, Soroka, Gonzago, Murphy, & Somervell, 2001), but if the short talk is not liked or appreciated it can just as easily reverse the effect of compliance. Also, we use information from others in order to determine what we like or value. For example, if others like certain clothing, food, or have a preference for a certain medicine, that liking is communicated to the individual and will most likely alters his behaviour to match the group (Cialdini & Goldstein, 2004).

In the beginning of this section, norms and values were mentioned which influence our behaviour. Adapting our behaviour to the cultural and personal social norm is a form of compliance as well. In a broader spectrum, the influence of culture on the decision making process was already discussed in the previous section. Previous research has shown that norms direct our behaviour but one must be consciously aware of the norm in order to influence behaviour directly (Kallgren, Reno, & Cialdini, 2000).

With all the aforementioned aspects of compliance, there are several techniques one can use to selectively influence compliance in one's favour. This makes compliance an interesting topic for economists. However, the many techniques are beyond the scope of the current review. Several of these techniques are mentioned and analysed in the thorough review of compliance and conformity by Cialdini and Goldstein (2004).

3.5.2.Conformity

When in a group, we behave in concordance with the general rules of that group. The adapting of your own behaviour in order to match the behaviour of others, even against your own preference, is called conformity (Deutsch & Gerard, 1955). When confronted with a group (often confederates in a experimental setup) individuals are likely to conform their behaviour to fit with the group. But only if the individual is not focussed on making the “right” decision. For example, when participants are held accountable for their decisions, they will be able to resist the group-pressure to conform (Lerner & Tetlock, 1999). Not only do we behave according to the general wishes of a group, even our beliefs are influenced by the group-majority. Previous studies found a strong correlation between expressing and/or tolerating prejudices of an individual and the number of people who agree and share those prejudices (Crandall, Eshleman, & O’Brien, 2002). An interesting study by Sechrist & Stangor (2001) showed that Americans with prejudices will sit farther away from African Americans, but this effect is increased if they believe this prejudice is shared by the group majority. This is nicely summarized in a part of the Dynamic Social Impact Theory (DSIT). One aspect of this theory states that: “When everything else is equal, an individual occupying a given social space will be more likely to conform to the attitudes, beliefs and behavioural propensities exhibited by the local numerical majority than by either the local numerical minority or less proximate persons.” (Latané, 1996). It is important to realize that these processes can occur on a conscious or unconscious level. An interesting phenomenon of conformity that occurs outside of conscious awareness, is behavioural mimicry. When individuals interact with other people, they will pick up subtle social cues and tend to mimic these cues, such as facial expressions and mannerisms (Chartrand & Bargh, 1999). The result of this mimicking is that the person who is doing the mimicking is liked more by the person who is mimicked.

But why must we conform? Obviously we, as social creatures, want to belong to a group and once we belong to a group we would not like to be rejected by the group. Once individuals believe to be outside the group, they report lower self esteem and a need to belong (Tafarodi, Kang, & Milne, 2002; Williams, Cheung, & Choi, 2000). As described in the previous chapter, the more important the group becomes (individualism versus collectivism) the more likely an individual will conform to the group.

3.5.3. Neural evidence of social decision making

The neural correlates of compliance are as yet not well understood. In a review, participants where asked to rate a song (Campbell-Meiklejohn, Bach, Roepstorff, Dolan, & Frith, 2010). The participants received feedback in the way of expert reviewers which were either disagreeing with each other or were unanimous. When contrasting a divided expert review with an unanimous review, the right anterior insula became more active when the expert reviewers agreed with each other. This finding was unexpected since the anterior insula is often associated with uncertainty and according to the authors a divided expert review should yield more uncertainty than an unanimous review. This lead the authors to conclude that the anterior insula might represent current and predicted feeling states associated with the opinion of others. They further speculate that activity in the anterior insula might relate to why unanimous opinions are critical for normative influences (compliance).

In another study, compliance was enforced via threat of punishment in an economic game were two anonymous participants played a game against each other. In this task one participant (participant A) had to divide 100 money units between the other participant (participant B) and himself (for details see **Box 3**). The results showed that in the punishment trial , participant A would be more willing to distribute the money units evenly amongst Participant B and himself. The equal dividing of the money units was paired with a significant increase of activation in the dorsolateral prefrontal cortex and the ventrolateral prefrontal cortex of participant

A. This study possibly implicates the roles of the vlPFC and the dlPFC in social norm compliance. However, threat is the initiator of the response, and it is possible that the availability of threat initiates a reanalysis of the situation. Without threat the participant would quickly (automatic, via a heuristic model) make a decision in their own favour, but when the threat of punishment appears, an analytical process is enforced because the heuristic model no longer suffices. In short, the activation of the dlPFC and vlPFC might reflect the activation of system 2 processes. Nonetheless, both studies raise interesting questions concerning the neurological substrates of compliance, but more research is needed.

Other studies have looked at the social phenomenon of conformity. In a recent study participants had to rate the attractiveness a picture of a face in a fMRI session and after the participant rated the picture, they were shown a group rating which could either be the same as theirs or different. After the fMRI session a behavioural session followed where faces had to be rated anew (Klucharev et al., 2009, See **Box 4** for a detailed overview of the picture rating task). When the group rating was different from the participant's rating, a conflict would occur. This social conflict was reflected in an activation of the rostral cingulate zone (RCZ) and a deactivation of the nucleus acumbens (NAc) (**Figures 15A** and **15B** respectively). These results led the authors to conclude that the RCZ might reflect a neural signal similar to a prediction error, which can be seen as the perceived difference between groups judgements and personal judgements (social conflict). The deactivation of the NAc seems to predict conforming behaviour and stronger conformists displayed a greater deactivation of the NAc. **Figures 15C** and **15D** shows the areas that were more active when a participant adapted his behaviour to match the rating from the group. When Klucharev et al (2009) conducted a conjunction analysis to identify the active brain areas of both conformity and the conflict contrasts, they revealed that the same areas are active during social conflict and conformity.

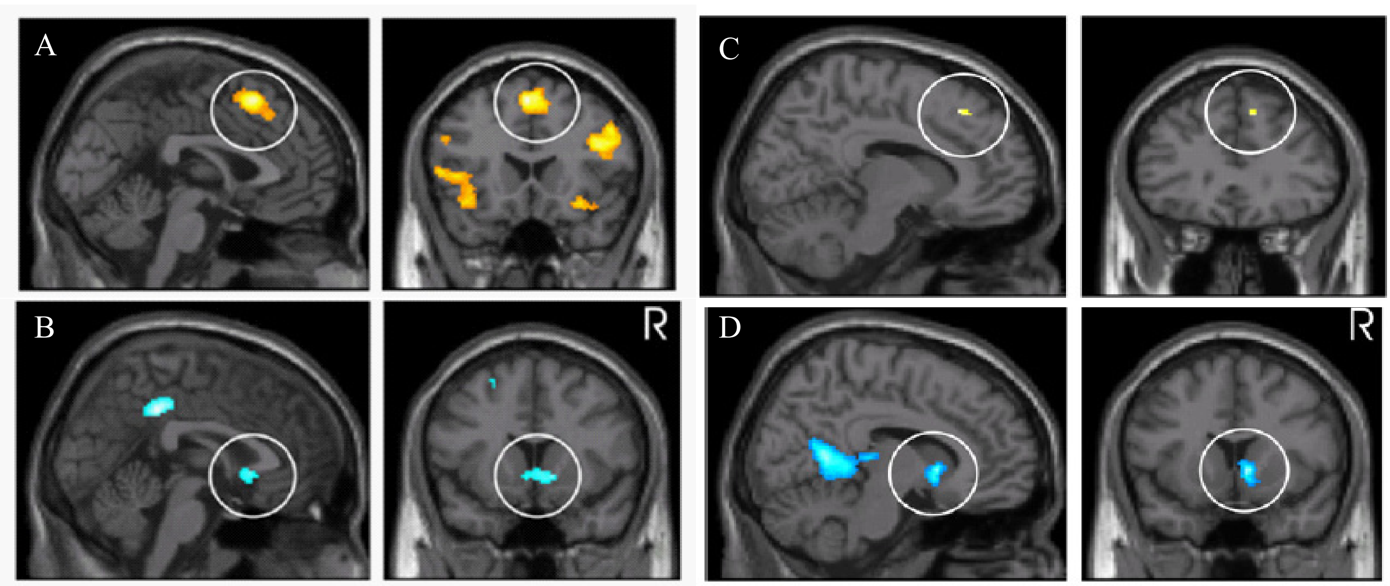


Figure 15. *"Social Conflict Effects: Neural Response to Group Ratings in Conflict versus No-Conflict Trials. z-maps of activations (A) and deactivations (B) induced by a conflict with group ratings.*
Conformity Effects: The Social Conflicts Followed by the Subsequent Change of Facial Attractiveness in Line with Group Ratings (i.e., Conformity) versus the Normative Conflicts that Were Not Followed by Changes in Attractiveness Ratings (i.e., No Conformity) Activations (C) and deactivations (D) predicting the conformity with group ratings." Replicated without permission from Klucharev et al. (2009).

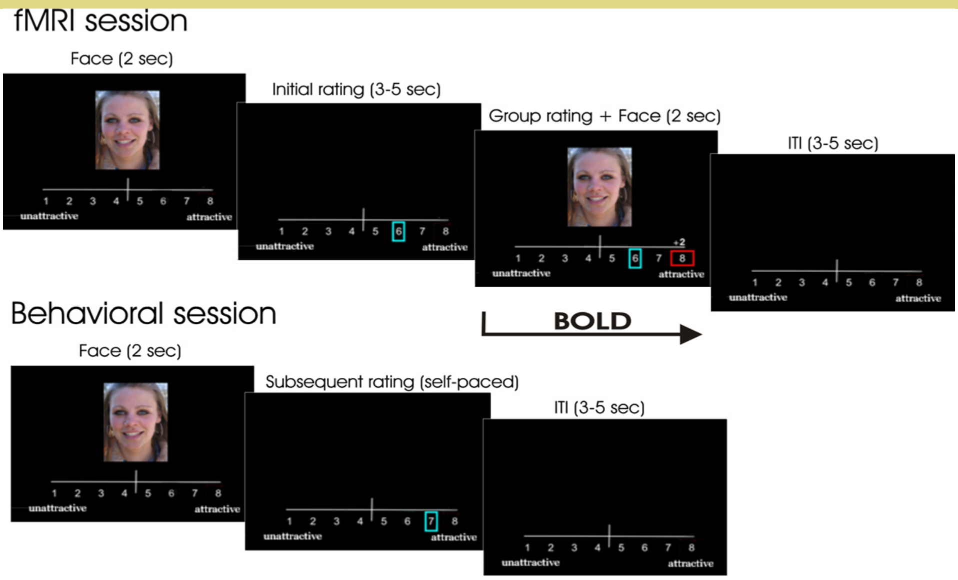
Combined with a recent study by Burke, Tobler, Schultz, & Baddeley (2010), where they tested the social influence on financial decision making, it becomes apparent that the anterior cingulate is responsive to social information, even more so if an individual's current behaviour deviates from the group. The ventral striatum (NAc) seems to be sensitive to social/group information and is possibly involved in adapting one's own behaviour to match the behaviour of the group.

3.5.4. Von Economo neurons

When looking at the level of neurons, there is a special kind of neuron which is implicated in social behaviour. This type of neuron is called the von Economo neuron (VEN) and appears especially in animals that display complex social behaviour, with a high brain/body ratio (Allman, Tetreault, Hakeem, & Park, 2011; Pauc & Young, 2010). Because the VEN is especially present in 'social animals', it is very interesting to see how these neurons and social behaviours are connected. The anterior insula contains a relative high amount of VENs and this is especially so for the right anterior insula (Allman et al., 2011). In the beginning of the previous section, the importance of the right anterior insula in social behaviour was already discussed. It might very well be that the VEN is very important in comparing the current and predicted feelings associated with the opinion of others. Meaning that the VENs are in the perfect position to guide our behaviour in social situations. However, future research is needed to elucidate on the role of VEN in the anterior insula.

group rating

Box 4.

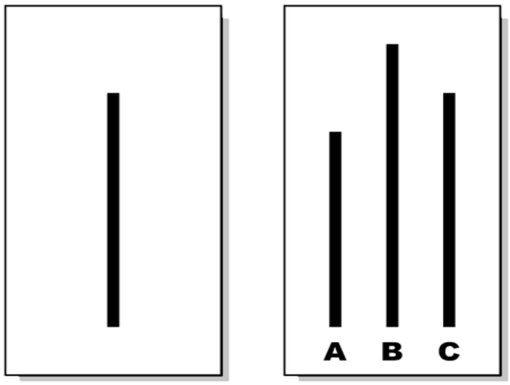


"The Task (fMRI Session) Evoking a Conflict with Group Ratings Followed by the Behavioral Session." Replicated without premission from Klucharev (2008).

One more example of a social decision task, is an experiment which uses group rating to influence social behaviour (Klucharev, Hytönen, Rijpkema, Smidts, & Fernández, 2009).Participants were presented with a picture of a face and were asked to rate the attractiveness of the face on a scale of one to eight. When they have rated the picture they will receive feedback in the form of a group rating. After 30 minutes, they are asked to perform the task again, but this time without any feedback.

Naturally, the goal of this task is not to measure the attractiveness of the face in the picture, but to measure if the group rating influences the personal rating that the participant provided before the group rating was given. In this test the participants actually did conform to the rating of the group, but more importantly as this was an fMRI experiment, valuable data was acquired about possible neural candidates for social conflict and conformity.

Asch conformity experiment **Box 5.**



A very famous example of a study with confederates are the conformity studies by Ash (see Bond & Smith, 1996, for a meta study of ash-like experiments). The conformity study is beautiful in its simplicity. A participant enters a room with several confederates and they are then asked several questions about the line on a paper in front of them (See example picture). For example, one of these questions was to compare a reverence line with three other line and say which one is of the same length. As you can see, these were not very difficult questions. The participant believed to be part of a vision experiment and the confederates were always first to answer the question. All the confederates gave the same answer but at times they would all say the wrong answer. The true purpose of this experiment is to measure the level of conformity of the participant. For example, when asked to compare the reverence line with lines A, B, and C from the above Figure, all the confederates would answer “A”. This is clearly the wrong answer but in many cases, the participant would conform to the group and answer “A” also.

4. Conclusions

This review began with aspects of decision making which are always present: consciousness and simulations. When people make a decision, depending on the scenario, they will use their past, present and/or future knowledge to gather information. It was explained that this works via simulations of the past, future or theory of mind.

Of many decisions people are not aware of the reasoning behind the decision or are not even aware of making decisions. In general, there is too much information to actively analyze. Therefore it is believed that the default system of processing information and making decisions is automatic and primarily unconscious, with a large processing capacity. Only when a task becomes difficult or when something unexpected occurs, the switch is made to a more active, controlled and conscious process. However, this analytic system is much more time consuming and its capacity for processing information is much more limited. In other words there are two systems at work that guide our behaviour: the default heuristic system 1 and an inhibitory controlling analytic system 2. When system 1 is not sufficient, system 2 kicks in to help people make a more conscious decision.

The logical reasoning capabilities fully develop at a much earlier stage when compared to psychosocial or emotional capabilities. This led to the proposal that the influence of system 1 is stronger and the controlling influence of system 2 weaker in adolescents when compared to adults. Besides development, this review covered several other possibilities that can influence the interaction between system 1 and system 2. In gender differences, females seem to have a higher threshold for when system 2 processes are initiated. Emotions also strongly influence decision making, either via predicted emotions, emotional state or the emotions during the decision making process. Emotions can be seen as part of or linked to system 1 processes. Cultures influence the default response by system 1, where conformity might be the default response in a collectivistic culture but not in an individualistic culture. The influence of social factors can only be counteracted if a person is made aware of these social influences or in other words, when the influence of system 1 is reduced and the influence of system 2 is increased. Al these factors will be used in order to propose a simple graph via which decision making is affected.

4.1. Effect on decision making

This review is concluded by proposing a graph of the different influences on decision making (see **Figure 16**). Via this model I wish to illustrate that the influences of system 1 and system 2 are not the same throughout life. As the cognitive functions develop all the way to adulthood (and beyond but this is not covered in this review), an individual is less dependent on system 1 and learns to reason more via system 2. This does not imply that system 1 is without any influence on decision making, but it will be relatively less dominant in guiding behaviour. As system 2 gains more influence, resistance to emotional processes, social peer pressure and culture increases. This is due to better cognitive regulations capabilities.

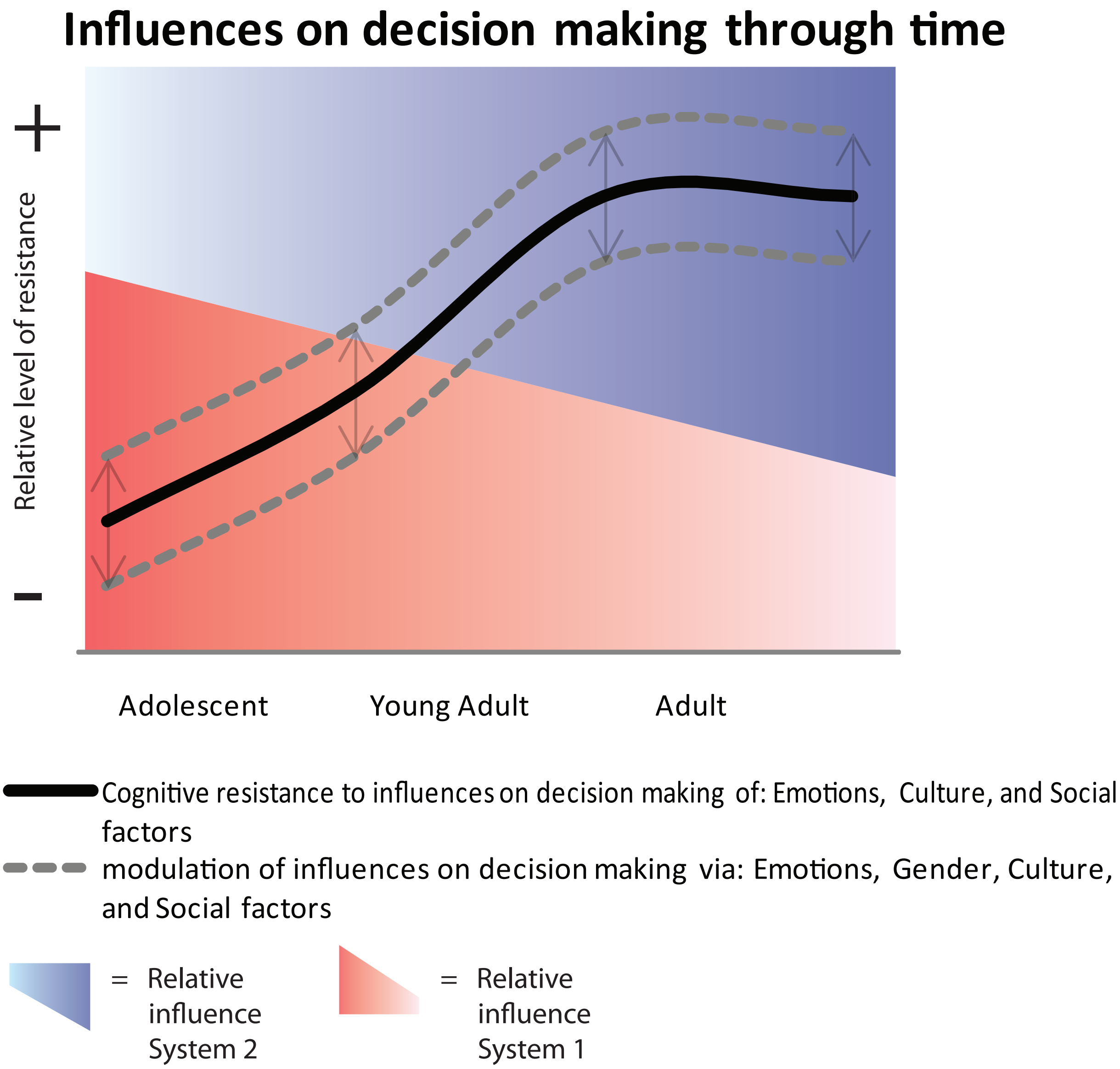


Figure 16. Graph of different influences on decision making. See text for explanation.

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