Your Brain: the Decider-in-Chief

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INTRODUCTION:

While there are a number of forces that factor into decision-making – including rational thought and the influence of emotions – all of these are ultimately derived from and processed in the brain.

At the age of 35, patient EVR had a portion of the front of his brain removed in order to treat a tumor. Before the surgery, patient EVR was a respected accountant with a stable marriage and high intelligence. But after the surgery, though EVR retained his superior intelligence, his social life and interpersonal relationships began to unravel. He went bankrupt, divorced his wife and married a prostitute, and became estranged from his family and friends. It was as if EVR's ability to make sound and sensible decisions had vanished[1].

Cases like EVR's have helped scientists establish that there are certain regions and circuits in the brain that are responsible for our capacity to make good decisions. While there are a number of forces that factor into decision-making – including rational thought and the influence of emotions – all of these are ultimately derived from and processed in the brain. The particular region of EVR's brain that was removed was part of the prefrontal cortex, a section of the brain's frontal lobe that sits near the front of our skull, and one which scientists have found is of critical importance for facilitating sound decision-making. The following sections will discuss the neuroscience behind three kinds of decision-making: "deliberative decisions", "snap decisions", and "moral and emotional decisions".

"DELIBERATIVE" DECISIONS

You are offered the option of taking $100 today or $110 a year from today – which option would you choose? This scenario is representative of a classic laboratory task that neuroscientists use to gauge deliberative decision-making capacity. It is called a "delay-discounting" task, so-called because scientists have found that people tend to think less of – or "discount" – long-term rewards and instead favor immediate rewards – even if the actual value of the immediate reward is less[2]. Delay-discounting tasks are representative of "deliberative" decisions because subjects in these tasks have time to think, or "deliberate", about which choice they would prefer. In the context of deliberative decisions, people usually must weigh the value of one option compared to the value of one or more other options. Perhaps the most challenging type of deliberative decision comes when people encounter the choice between a small but immediate reward and a large but delayed reward. Life is full of such scenarios, ranging from the rather trivial ("Do I eat another piece of cake (small, immediate reward) or stay on track with my diet to get that lean body I've been working toward (large, delayed reward)" to the rather substantial ("Do I have a one-night stand (small, immediate reward) or remain faithful and keep my family intact (large, delayed reward)".

What exactly is going on in the brain during these scenarios? What is generating the

impulsive urge that pulls us toward the small immediate reward, and what gives us the capacity to override or inhibit this impulsive urge in order to choose the large delayed reward?

Decades of research have identified a small region near the center of the brain called the "nucleus accumbens" as the source of our cravings for immediate reward[3]. When neuroscientists give delay-discounting tasks to subjects while they are in an fMRI scanner that measures brain activity, the nucleus accumbens shows greater activity when subjects choose the small immediate reward compared to when they choose the large delayed reward[4]. Fortunately, these same studies show that another region of the brain can rein in these impulsive urges and allow us to hold out for the large delayed reward[5]. This region of the brain is the prefrontal cortex, which is situated behind our foreheads. The prefrontal cortex becomes activated when subjects choose the large delayed reward over the small immediate reward[6].

Individuals with damage or impairment to the prefrontal cortex tend to have difficulty inhibiting cravings for the immediate reward on the delay-discounting task, which translates to problems with deliberative decision-making out in the world. One group of people who are thought to have a dysfunctional prefrontal cortex[7] and also display profound decision-making deficits[7] is individuals with psychopathy. In part due to their problem with making sound deliberative decisions, it is estimated that over 90% of all adult males with psychopathy are in contact with the criminal justice system[8]. Another group of individuals that displays deliberative decision-making problems is substance abusers[9]. Abuse of a range of substances has been associated with a loss of gray matter volume in the prefrontal cortex[10], and has also been associated with higher than normal selection of immediate rewards on delay-discounting tasks[11]. A final group with prefrontal cortex issues and associated decision-making problems are: children! Interestingly, the prefrontal cortex is one of the last areas of the brain to fully develop during the course of the human lifetime, not reaching full developmental maturity until about the age of 25[12]. The fact that the prefrontal cortex remains underdeveloped for much of early life is thought to partially account for the observation that young children and adolescents tend to be more uninhibited and act more impulsively than adults, because an essential component of their inhibition system has not fully developed yet. Even among healthy adults, the total amount of gray matter volume in the prefrontal cortex has been shown to correlate with levels of impulsivity[13].

"SNAP" DECISIONS

In contrast to deliberative decisions, in which individuals usually have a few seconds or minutes to consciously deliberate over a choice, "snap" decisions require individuals to make instantaneous decisions without much or any time for conscious deliberation. As was the case with deliberative decisions, snap decisions can range from the relatively trivial ("do I pass the ball to my teammate or take the shot myself") to the relatively substantial ("do I let out my anger by striking my spouse or walk away and cool down"). One of the most frequently used laboratory tasks to investigate snap decisions is the "go/no-go" task[14]. In this task, subjects must press a button as fast as they can when they are presented with certain "go" stimuli, and must withhold their button-press when they are presented with "no-go" stimuli. For example, subjects might be told to press the button whenever the experimenter plays a recording of a word starting with the letter "a" and must withhold their response whenever a word starting with the letter "b" is played. Experimenters will usually play a number of "a" words in a row to build up a pre-potent, habitual tendency to push the button, and then suddenly play a "b" word. Subjects must then instantaneously – essentially without time for thinking – put the brakes on and withhold their button-press. The number of incorrect "no-go" trials – trials in which subjects press the button when they are not supposed to – gauge the subject's inhibitory capacity during snap decisions.

The ability to put the brakes on in the context of snap decisions relies on largely the same brain circuitry as inhibitory control during deliberative decision-making, but also on a few additional players.

Again, the prefrontal cortex is an essential component in executing inhibitory control during snap decisions[15]. Other regions of the brain such as the putamen and caudate – neighboring regions to the nucleus accumbens – also have been found to be very important for inhibiting movement during snap decisions[16]. It is thought that the prefrontal cortex, putamen and caudate interact to help momentarily turn off the brain's "motor center" in the motor cortex[17] (located behind the prefrontal cortex), in order to restrain movement and maintain control during a snap decision like withholding a button-press during the go/no-go task. In addition to these brain regions, a neurotransmitter (or cellular messenger) called "dopamine" has also been found to be essential for putting on the brakes during snap decisions. Communication between the prefrontal cortex and putamen and caudate relies largely on dopamine, so having just the right amount of it is crucial for the braking system to work. Studies have shown that people with too much[19] or too little dopamine[20] tend to do worse on snap decision tasks in the laboratory.

MORAL AND EMOTIONAL DECISION-MAKING

Imagine a fast-moving trolley is approaching a fork in the tracks. On one side of the fork – the one that the tracks are currently directed toward – are five workers unaware of the trolley's approach and are standing on the tracks. On the other side of the fork, one worker unaware of the trolley's approach is standing on the tracks. As the trolley nears the fork, you happen to be standing next to a lever that, should you pull it, would redirect the tracks so that the trolley goes down the fork with one worker on the tracks instead of five. Doing this would result in the death of the one worker. If you decide not to pull the lever, the trolley will continue on toward the fork with five workers on the track, killing all five. Would you pull the lever to kill the one worker instead of the five? Now, what if you were standing on a bridge and saw five workers tied to the tracks, and realized the only way that you could save them was to push a large man in front of you down onto the tracks in order to stop the train. Would you push the one man to his death in order to save the five?

These classic dilemmas, known respectively as the "trolley dilemma"[21] and "footbridge dilemma"[22], are used in the laboratory to investigate how the brain makes decisions about moral and emotional problems. These dilemmas pit two considerations against each other: rational, utilitarian thinking (sacrifice the few to save the many) versus the emotional aversion to being responsible for somebody's death. How do you (and how does the brain) reconcile these competing considerations and come to a decision? One theory posits that during such deliberations a subregion of the prefrontal cortex called the vmPFC weighs the emotional considerations of the problem, while a neighboring brain region called the dlPFC weighs the rational, utilitarian considerations[23]. Other regions in the frontal lobe, such as the ACC, help to integrate these competing considerations, resolve the conflict, and ultimately select a choice of action[23]. Researchers have also posited a role of the amygdala in decision-making[18] in emotional or highly salient contexts.

Normal subjects typically elect to pull the lever in the trolley dilemma, indicating a willingness to kill the one worker in order to save the five. But in the footbridge dilemma, more subjects elect not to push the man off the bridge in order to save the five workers. This finding is striking because the end result of both actions (pulling the lever and pushing the man) is the same – one person is killed and five people are saved – and yet people tend to make a different decision in each situation. What accounts for this difference? At the psychological level, the action of pulling the lever in the trolley dilemma represents an "impersonal harm"; even though we are causing someone's death, it is via indirect means. On the other hand, pushing the man off the bridge in the footbridge dilemma represents a "personal harm", in which we are directly and physically causing someone's death. At the level of the brain, we may conceptualize that the impersonal harm only fires up the vmPFC "emotion center" a little bit, allowing the dlPFC "rational center" to win out in the competition of considerations and compelling us to pull the lever. But the thought of carrying out the personal harm of pushing a man off a bridge to his death fires up the vmPFC emotion center strongly – in most people overcoming the influence of the dlPFC rational center – and compels us not to push the man. Fascinatingly, individuals with a damaged or dysfunctional vmPFC emotion center tend to choose the personal harm of pushing the man off the bridge at a higher rate than normal subjects[24].

These findings bring up another interesting question: do emotions and emotional sensibilities strengthen or weaken our ability to make good decisions?

Many might interpret the results of the footbridge dilemma (the tendency to allow five people to die instead of sacrificing one) to indicate that emotions hamper our ability to make rational decisions. Perhaps this is true in some cases. However, another line of research indicates that emotional sensibilities – such as guilt and empathy – may have a positive influence on good decision-making in some circumstances. Another common decision-making task that is used in the laboratory is called the "ultimatum game"[25]. The ultimatum game is played with two people: a "proposer" and a "responder". The proposer is given $10 to start the game off, and must then make a "proposal" to the responder of how to split the money between them (e.g. "I keep $8 and you get $2"). The catch is that, if the responder does not like the proposal and chooses to decline it, neither the proposer nor the responder keeps any of the money. Thus, in this game a purely self-interested proposal ("I keep $10 and you get 0$) is likely to elicit a decline from the responder, ultimately resulting in $0 for the proposer. On the other hand, emotional sensibilities like guilt ("I would feel guilty giving this person $0") and empathy ("I want this person to have money too") actually end up contributing to good decisions, as the responder is more likely to accept offers where they receive a fair allotment of the money. As in the footbridge dilemma, individuals with a damaged or dysfunctional vmPFC emotion center (who often lack the capacity to feel emotions such as guilt or empathy) tend to undervalue emotional considerations in these situations. For example, on a related task called the "dictator game", where the proposer makes an offer that is immediately final (i.e. the responder does not have a say in whether to accept or reject), individuals with vmPFC damage offer less than half the amount of money that healthy individuals offer[26].

CONCLUSION

In sum, our ability to make sound and sensible decisions ultimately relies on the proper functioning of our brain. Does this mean that we can blame our bad decisions on our brain? Not quite. While it may be true that certain people's brains allow them to make good decisions with less effort – maybe because they have a more ideal level of dopamine or amount of gray matter in the prefrontal cortex – everybody with an intact brain still has the capacity to make good decisions. Some of us may just have to exert a little more effort and will-power to do this than others.

ABOUT US

COLE KORPONAY is a graduate researcher in the Neuroscience and Public Policy program at the University of Wisconsin-Madison. His research focuses on understanding the neurobiological basis of impulsive behavior, both in healthy and clinical populations, and on evaluating the efficacy of interventions to reduce impulsive behavior. His interests include using structural and functional brain imaging to examine how abnormal neurobiology may contribute to criminal behavior and in evaluating the potential for emerging knowledge and technology in neuroscience to strengthen the criminal justice system. He holds a B.A. in Cognitive Science from the University of Pennsylvania.

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