The WAGER, 8(32) – Biology, Addiction, and Gambling: Unraveling Decision-Making

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Last week, the WAGER described some neurological correlates of reward-driven behaviors in monkeys (see WAGER 8(31)). Expanding on this topic, this week's WAGER focuses on a recent study of reward-related decision-making functions in humans. Smith, Dickhaut, McCabe and Pardo (2002) examined human decision-making strategies and biological processes affected by risk, uncertainty, and payoff potential. This study is among the first to link human choice with specific brain activity.

Smith et al. recruited nine healthy, right-handed medical students (6 male, mean age 27 years) to participate in their study. The authors monitored participants' neural activity via Positron Emission Tomography (PET) as participants made a series of choices between four pairs of reward scenarios: (1) less risky gain vs. more risky gain (RG), (2) less risky loss vs. more risky loss (RL), (3) ambiguous (uncertain outcome) gain vs. more risky gain (AG), and (4) ambiguous loss vs. more risky loss (AL). As Figure 1 shows, each gamble had the same expected value for payoff in the long run1. However, the scenarios could be considered more or less risky in the short run: in the less risky scenario the subject stands to gain (or lose) $30 two-thirds of the time compared to the more risky scenario in which the subject stands to gain (or lose) either $6 or $4 dollars two-thirds of the time (i.e., the first two scenarios in Figure 1). The choice is ambiguous in the last two scenarios in Figure 1: the total number of blue and yellow marbles is given, but the individual numbers of blue and yellow marbles are unspecified. Researchers defined less risky gambles as those with a low spread (variance in payoff)2. More risky gambles had a high spread, and ambiguous gambles had a low spread with an undefined payoff structure3.

Figure 1. Experimental Design, Risky v.
Ambiguous Scenarios (Smith et al., 2002)

To determine the importance of risk, ambiguity, and payoff structure (i.e., gains versus losses), the authors conducted 27 trials on each condition for each participant. For each participant, the researchers recorded the percentage of trials where the less risky scenario was chosen and subtracted the percentage of trials where the more risky strategy was the choice (see Figure 2). When they were playing to win money, the less risky strategy was favored (a difference of 46%). When playing to lose money, the more risky strategy was chosen more often (difference = -11%). For the ambiguous conditions, subjects favored the ambiguous strategy when facing gains (difference = 15%) and had no preference when facing losses (difference = 0%). An ANOVA established that the four conditions were not equivalent ($F(3, 24) = 5.87$, $p<.005$). Specifically, participants highly preferred less risky gambles under the gain scenario and more risky gambles under the loss scenario but had less of a preference for ambiguity in both the gain and loss scenarios.

Figure 2. Interaction in Choice Behavior Between Knowledge Structure (Risk/Ambiguity) and Payoff Structure (Gains/Losses) (Smith et al., 2002)

PET scans measured each participant’s brain function as he or she chose between each scenario. Whether facing gains or losses, there was no cerebral blood flow change (BFC) for the decisions involving ambiguous gambles (i.e., AG or AL). For non-ambiguous risk decisions, however, the researchers observed a significant BFC in the orbitofrontal region for gains (i.e., RG) and for losses, a significant BFC in the cerebellum (i.e., RL). These findings suggest that humans utilize one region of the brain to make risk/gain decisions and a separate region to process risk/loss decisions. This might suggest that humans have developed a separate, sensitive “alarm system” in the cerebellum for analyzing situations of potentially dangerous loss. In evolutionary terms, such a system would be vigilant of wide range of destructive situations (e.g., injury, death). The corollary for gambling is that people who exhibit impaired decision-making skills in less serious situations of loss (e.g., pathological gamblers) may have some dysfunction in the alarm system of the cerebellum not shared by people who make healthier decisions.

While intriguing, it is questionable whether Smith et al’s results are applicable to the general population. For example, the authors chose medical students because they hoped the students’ familiarity with the medical environment would minimize the possibility of erroneous PET scans. However, this sample is limited in scope: it is both small and homogeneous. The authors’ results provide no indication as to how those outside the study population (e.g., the elderly, those with low education levels) would perform given the same reward scenario choices. Further, the authors did not screen participants for gambling problems, nor was a comparison made between the brain functions of normal subjects versus PGs. Thus, further research is necessary before this framework can be applied directly to PGs. Viewed in the context of the available pathological gambling literature, however, Smith et al's findings provide additional insight into the neurobiological component of disordered gambling. For example, WAGER 7(43) presented a recent study suggesting neurobiological characteristics unique to pathological gamblers may lead PGs to make different risk-related decisions than non-PGs (Cavedini, Riboldi, Keller, D'Annucci, & Bellodi, 2002). Studying these neurobiological characteristics in terms of the risk and ambiguity choices that gamblers face could provide additional information about how gamblers make their decisions. Moreover, the authors' framework provides a starting ground for further study examining whether the regions of brain activity triggered by different risk scenarios are fundamentally different in PGs and healthy subjects.

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Notes

1. Expected value is the sum of the products of the payoffs and their probabilities. The expected value of the first scenario described is (30*$30+30*$30+30*0) / (30+30+30) = $20. The expected value of the second scenario is (30*$50+30*$6+30*$4) / (30+30+30) = $20. Thus, over time or when all the balls are selected, two subjects exclusively playing one or the other of these scenarios would gain equal profits.

2. Spread refers to the difference between payoff possibilities. For example, Gamble 1 in the relative risk row has a spread of (30 – 0) = $30, while Gamble 2 has a spread of (50 – 4) = $46. Participants who prefer a gamble with a smaller spread (given the same expected value) are labeled "risk-avoiding."

3. In the ambiguous scenario, the definite numbers of blue and yellow marbles were unspecified: subjects only knew that there were a total of 60 blue and yellow marbles. Thus, the payoff potential was undefined.

References

Cavedini, P., Riboldi, G., Keller, R., D'Annucci, A., & Bellodi, L. (2002). Frontal lobe dysfunction in pathological gambling patients. Biological Psychiatry, 51, 334-341.

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