Biological Psychiatry

The Behavioral Economics of Anxiety

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Individuals with anxiety disorders tend to focus on threat-related information and are more likely to interpret ambiguous information as negative than as positive (1). Therefore, it is natural to assume that when anxious individuals make economic decisions, they preferentially attend to potential negative outcomes rather than positive outcomes. Consistent with this notion, a few studies have documented reduced economic risk taking in anxiety (2). However, enhanced perception of potential losses—or loss aversion, as economists call it—is only one of several basic cognitive processes that may suppress risk taking. Prior studies have employed experimental paradigms that did not allow independent evaluation of each of these cognitive processes. In a study reported in this issue of *Biological Psychiatry*, Charpentier *et al.* (3) take a behavioral economic approach to decision making under risk in generalized anxiety disorder (GAD). Their primary goal is to distinguish between the effects of loss aversion and risk aversion (4) on choice behavior. To understand these effects, let us consider the choice of whether to accept a mixed lottery—a lottery that offers a potential gain but also a potential loss. Figure 1A presents such a mixed lottery with 50% chance of winning $8 and 50% chance of losing $4. The subjective value, or utility, of the lottery depends not only on these amounts and probabilities but also on the individual's attitudes toward these amounts and probabilities. Figure 1B–D presents the utility curves for gains and losses of three different individuals and marks the utilities of an $8 gain (green) and a $4 loss (red). Utility functions are typically concave in the gain domain and convex in the loss domain, indicating diminished sensitivity for increased value. In the gain domain, this diminished sensitivity is translated into risk aversion. Participant 1 (Figure 1B) exhibits slight risk aversion in the gain domain, obtaining just over 5 utility units from a gain of $8. This participant places the same weight on gains and on losses and thus expects the utility of a $4 loss to equal half of that of the $8 gain, with a negative sign. The lottery's expected utility for this participant therefore is high, and she is likely to accept the lottery. Participant 2 (Figure 1C) exhibits a similar degree of risk aversion. For this participant, however, losses loom larger than gains, such that his negative utility from a $4 loss is quite high, leading to an overall negative expected utility for the lottery. Thus, increased loss aversion may drive reduced risk taking in this participant compared with Participant 1. Participant 3 (Figure 1D) is also less likely to accept the lottery, but for a different reason. Like Participant 1, Participant 3 weighs gains and losses equally. This participant, however, exhibits increased risk aversion (reflected in a more curved utility function in the gain domain), which decreases the utility of the gain and reduces the overall desirability of the lottery.

Charpentier *et al.* (3) had both unmedicated anxious individuals and healthy individuals make a series of choices with mixed lotteries. Importantly, to distinguish between the effects of risk aversion and loss aversion on choice, the experimenters also included another type of choice trials—between a sure gain and a risky lottery with 50% chance of winning a higher amount and 50% chance of winning nothing. If reduced risk taking in anxiety is driven by loss aversion (illustrated by Participant 2 vs. Participant 1 in Figure 1), individuals with anxiety will choose the sure bet more often in the mixed-lottery condition but not in the gain-only condition. Conversely, if increased risk aversion is at the core of the behavior (Participant 3 vs. Participant 1), individuals with anxiety will be less likely to gamble both in the mixed-lottery condition and in the gain-only condition. Fitting participants' choice behavior with a prospect theory model (4)—which did better than several other potential models—Charpentier *et al.* estimated participants' risk and loss aversion. Contrary to expectations, they observed no difference in loss aversion but rather an increase in risk aversion in individuals with anxiety compared with control individuals. Moreover, the degree of risk aversion was associated with trait anxiety across the entire subject population. Thus, it is possible that anxious individuals avoid potential risks not because they exaggerate the loss but rather because they are averse to the uncertainty of the prospect.

This study is an example for the utility of behavioral economic constructs and model fitting to studying psychopathology. Decomposing behavior into basic cognitive components can shed light on the impaired mechanisms underlying particular symptoms and guide potential interventions. Choice paradigms like the one used here may also be of diagnostic value. Unlike self-report questionnaires or clinician-administered interviews, these choice paradigms do not require patients to refer to their symptoms, bypassing self-report and clinician biases. Moreover, by providing incentives, such as monetary rewards, these techniques encourage patients to make choices that reflect their true preferences.

Attitudes toward loss and risk are important factors in determining individuals' risk-taking behavior, but other factors are likely at play. One simplification that Charpentier *et al.* (3) have made in their model is the assumption of an identical curvature for the utility functions of gains and losses (Figure 1B, C). This means that individuals who exhibit increased risk aversion in the gain domain (reflected in a more concave utility function) will also exhibit increased risk seeking in the loss domain (reflected in a more convex utility function). Although this is consistent with the original formulation of prospect theory (4), more recent studies report little or no correlation between these two parameters (5). This suggests that risk attitudes toward uncertain losses may contribute to risk-taking behavior independently from risk attitudes toward uncertain gains and may be differentially associated with psychiatric symptomatology.

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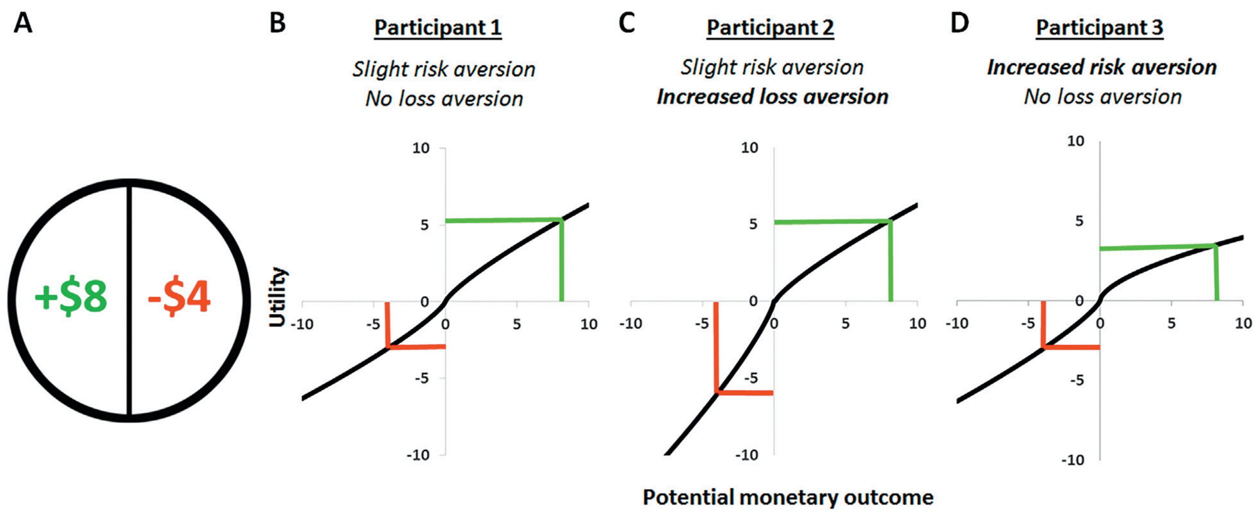

Figure 1. Both risk aversion and loss aversion could affect the utility of a mixed lottery. **(A)** An example of a mixed lottery, offering 50% chance of winning $8 and 50% chance of losing $4. **(B–D)** Examples of three hypothetical participants considering whether to accept the mixed lottery. The graphs plot the utility curve of each subject for monetary gains and losses. The y axes depict the utility of the gain (green) and the loss (red) in arbitrary units. Participant 1 **(B)** has slight risk aversion but no loss aversion, Participant 2 **(C)** shows similar risk aversion but also loss aversion, and Participant 3 **(D)** shows no loss aversion but stronger risk aversion compared with the other participants. The overall utility of the lottery is lower for Participants 2 and 3 compared with Participant 1, but for different reasons—either increased loss aversion (Participant 2) or increased risk aversion (Participant 3). Charpentier *et al.* (3) found heightened risk aversion, but not loss aversion, in individuals with pathological anxiety.

Another personal trait that seems to strongly affect choices is individuals' attitude toward missing information—or "ambiguity"—about outcome probabilities. Most people are averse to this type of economic ambiguity, at least under some conditions (6). When choosing, for example, whether to place a bet on a lottery whose outcome probabilities are fully known (a "risky" lottery) or on a lottery whose outcome probabilities are not precisely known (an "ambiguous" lottery), many people prefer the former even if the latter offers a much larger reward (6). Ambiguity attitudes are not strongly correlated with risk attitudes and, like risk attitudes, differ for gains and for losses (7). Individual attitudes toward ambiguous gains and losses therefore may contribute to psychiatric disorders independently from risk attitudes. Indeed, a recent study (8) reported increased aversion to ambiguous (but not risky) losses (but not gains) in combat veterans with posttraumatic stress disorder compared with combat veterans without posttraumatic stress disorder. Interestingly, the degree of aversion was associated with the degree of posttraumatic stress disorder symptoms. Whether increased ambiguity aversion extends to other anxiety-based disorders is a matter for future research.

The emotional state of decision makers can also affect their willingness to take risks. Charpentier *et al.* (3) have attempted to probe this question by preceding some of the trials with emotional faces (either happy or fearful) and preceding others with neutral faces or objects. A model that accounted for these various emotional conditions, however, did worse than one that did not, suggesting that this particular emotional manipulation did not affect choices. Future research will need to determine what types of emotional cues affect risk taking and under which circumstances.

Characterizations of basic cognitive processes are also crucial for investigating the neurobiological basis of the complex behavioral processes. For example, using a similar formulation of risk aversion, magnetic resonance imaging studies identified neural activation patterns (9) and neuroanatomical features (10) that reflected these attitudes. Interestingly, the decline of gray matter volume with aging, in a region of the parietal cortex, accounted for the increase in risk aversion observed in older adults (10). An intriguing question is whether similar structural changes may account for the increased risk aversion exhibited by anxious individuals and, if so, whether these changes have a causal role in the behavioral variations. Much research is still needed to carefully validate potential biomarkers for basic behavioral and cognitive traits, but once such biomarkers are confirmed they could also serve as objective diagnostic tools. To achieve this goal, longitudinal studies examining clinical, behavioral, physiological, and neurobiological changes within individuals over a long period of time are crucial. Causal manipulations, such as transcranial magnetic stimulation in humans and optogenetics in animals, will also be important in determining the role that particular neural circuits play in various cognitive processes. Identifying the behavioral building blocks of complex behavior and linking changes in these building blocks to psychiatric symptomatology is the first step on this path.

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Article Information

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