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# Attention in risky choice☆

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ABSTRACT

Previous research on the processes involved in risky decisions has rarely linked process data to choice directly. We used a simple measure based on the relative amount of attentional deployment to different components (gains/losses and their probabilities) of a risky gamble during the choice process, and we related this measure to the actual choice. In an experiment we recorded the decisions, decision times, and eye movements of 80 participants who made decisions on 11 choice problems. We used the number of eye fixations and fixation transitions to trace the deployment of attention during the choice process and obtained the following main results. First, different components of a gamble attracted different amounts of attention depending on participants' actual choice. This was reflected in both the number of fixations and the fixation transitions. Second, the last-fixated gamble but not the last-fixated reason predicted participants' choices. Third, a comparison of data obtained with eye tracking and data obtained with verbal protocols from a previous study showed a large degree of convergence regarding the process of risky choice. Together these findings tend to support dimensional decision strategies such as the priority heuristic.



## 1. Introduction

Importance attracts attention. Be it a shattering event like the 2008 economic crisis, a famous movie star, or the smartphone you intend to buy—people pay more attention to important events, persons, or goods than to unimportant ones. When buying a car, it is the favored Volvo one plans to purchase rather than the Dacia one expects to decline that captivates the mind during the buying process. Intuitions such as these receive empirical support from sophisticated laboratory experiments showing that people allocate more attention to the alternative they will later choose than to the one they will decline (Glaholt & Reingold, 2009; Krajbich, Armel, & Rangel, 2010; Shimojo, Simion, Shimojo, & Scheier, 2003; Stewart, Hermens, & Matthews, 2013). This is not surprising, because the favored alternative is usually more important than the non-favored one. The underlying assumption here is that important aspects attract more attention and thus determine the choice.

But what if the chain "importance–attention–choice" does not hold? This would be disturbing, since one would have to seriously question attention as a valid measure of importance. Suppose a participant must choose between an expensive, high-quality smartphone with a high-resolution display and an inexpensive, low-quality phone with a low-resolution display. Further suppose that process-tracing measures, such as those used in Mouselab or eye-tracking studies, reveal that resolution attracts most of the participant's attention during the choice process, which suggests that the choice will be the high-resolution phone. Contrary to this prediction, the participant chooses the phone with the lower resolution. A finding such as this would call into question the validity of process-tracing data. Linking process-tracing data to choice, we assert, is essential to taking that data seriously as a valid measure of the process.

Apart from studies finding that people allocate more attention to the alternative they will choose than to the one they will decline, research on the attention–choice link is scarce. And when such studies have been done, the evidence is, at best, equivocal. In their 1993 landmark book *The Adaptive Decision Maker*, Payne, Bettman, and Johnson investigated accuracy and effort of various choice strategies in different environments. These researchers predicted and confirmed that the superior performance of a particular strategy (e.g., a lexicographic rule) in a particular condition (e.g., time pressure) triggered processes (e.g., search by attribute rather than alternative) that were compatible with that strategy.[1] Within this elegant paradigm, the authors found different processes under different conditions—but the essential link

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[1] A lexicographic choice strategy searches by attributes and selects the alternative that performs best on the most important attribute (all other attributes are ignored). If two or more alternatives are equal on the most important attribute, it selects the alternative that performs best on the second most important attribute, and so on.

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to choices was missing (see also Arieli, Ben-Ami, & Rubinstein, 2011; Ayal & Hochman, 2009; Brandstätter, Gigerenzer, & Hertwig, 2006, 2008a,b; Hilbig, 2008; Johnson, Schulte-Mecklenbeck, & Willemsen, 2008; Katsikopoulos & Gigerenzer, 2008; Pachur, Hertwig, Gigerenzer, & Brandstätter, 2013; Su et al., 2013).[2] This is not to say that choices were always neglected—in fact, in some of these studies researchers extensively tested the predictive accuracy of various decision strategies (e.g., Brandstätter et al., 2006; Su et al., 2013). The essential point is that models of choice can be tested on two different levels: the level of outcome and the level of process—or on both. Predicting choices with measures of the process – and measures of attention in particular – has rarely been done.

When measures of attention were used to predict risky choices, results were often disappointing: Koop and Johnson (2013) investigated choices between simple gambles and summarized that "eye-tracking data demonstrate that the majority of acquisitions on each trial were of task-critical information" (p. 174). This means that participants looked more often at the gambles than they looked at the screen beside the gambles. No relation between choice and eye-tracking data was found (see their Fig. 11). Stewart et al. (2013) concluded from their eye-tracking data that people "look a little more at larger attributes and choose the gamble they look at more" (p. 26)—which is the well-known finding that the chosen alternative attracts more attention. Orquin and Mueller-Loose (2013) reported that "attempts to classify heuristics based on attention are largely unsuccessful" (p. 202). Pachur et al. (2013) found that acquisition frequencies were inconsistent with the two models they tested and further concluded that "acquisition frequencies are not predictive of people's choices" (p. 13). The astonishing observation was that people paid attention to specific pieces of information but used other information for choosing. In particular, researchers found that maximum gains (and their probabilities) attracted more attention than minimum gains (and their probabilities; Pachur et al., 2013; Su et al., 2013). However, when predicting choices, a lexicographic strategy that prioritized minimum gains (and their probabilities) performed much better than a strategy that prioritized maximum gains (and their probabilities). Findings like this seriously call into question the appropriateness of attention as a valid measure of importance. Taken together, research on risky choice seems to suggest that measures of attention may at best show the familiar finding that the chosen alternative attracts more attention than the non-chosen one.

This is surprising, since choice models such as the priority heuristic (Brandstätter et al., 2006) and models relying on weighting and summing of information such as expected utility theory (von Neumann & Morgenstern, 1947), subjective expected utility theory (Savage, 1954), prospect theory (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992), disappointment theory (Bell, 1985; Brandstätter, Kühberger, & Schneider, 2002; Loomes & Sugden, 1986), the transfer of attention exchange model (Birnbaum & Chavez, 1997), and decision affect theory (Mellers, 2000) directly lend themselves to testable predictions. The latter models are rooted in Bernoulli's expected utility framework. Interpreted as process theories, they predict that people value payoffs with a utility function, multiply the utilities by decision weights, sum the products, and finally select the gamble with the higher sum of weighted utilities. These theories assume examination within gambles and predict that all pieces of information will receive the same amount of attention.

The priority heuristic represents an instance of a different class of models—those requiring examination between gambles (Brandstätter et al., 2006). To illustrate the heuristic, consider a choice between two simple gambles of the type "a probability $p$ of winning amount $x$; a probability $(1 - p)$ of winning amount $y$". A choice between two such gambles contains four reasons for choosing: the maximum gain, the minimum gain, and their respective probabilities; because probabilities are complementary, three reasons remain: the minimum gain, the probability of the minimum gain, and the maximum gain. For choices between gambles having two non-negative outcomes (all outcomes are zero or positive), the heuristic consists of the following steps:

*Priority rule*: Go through reasons in the order of minimum gain, probability of minimum gain, maximum gain.

*Stopping rule*: Stop examination if the minimum gains differ by 1/10 (or more) of the maximum gain; otherwise, stop examination if probabilities differ by 1/10 (or more) of the probability scale.

*Decision rule*: Choose the gamble with the more attractive gain (probability).

We refer to the one-tenth of the maximum gain as the aspiration level for gains, and to .1 as that for probabilities. Note, the aspiration level for gains is not fixed but changes with the maximum gain of the problem. For probabilities, which are bound between 0 and 1, the aspiration level of .1 is fixed. This is a simple hypothesis and empirical evidence suggests that people typically do not make more fine-grained differences (Albers, 2001). The term "attractive" refers to the gamble with the higher (minimum or maximum) gain and to the lower probability of the minimum gain. For gambles involving losses, the term "gain" is replaced by "loss." The priority heuristic (a) makes predictions whether gamble $A$ or $B$ will be chosen, (b) assumes examination between gambles, and (c) predicts that different pieces of information will receive different amounts of attention.

To demonstrate the different process predictions for both classes of models consider the problem taken from Kahneman and Tversky (1979) between the safe gamble $S$ (\$2400 with $p = .34$) and the risky gamble $R$ (\$2500 with $p = .33$). This problem was devised to support prospect theory, not the priority heuristic. The priority heuristic predicts that people start by comparing the minimum gains. Since they are equal, the heuristic predicts that they attend to the next reason, which is the probabilities of the minimum gains ($p = .67$ and $p = .66$; or their logical complements of .33 and .34). Because the difference of .01 falls short of the aspiration level of .1, people are predicted to turn to the maximum gains of 2400 and 2500. The higher maximum gain thus decides choice, and the prediction is that people will select $R$, which is the majority choice. The prediction therefore is that maximum gains are relatively more important than probabilities for participants who choose $R$ compared to those who choose $S$. Consequently, maximum gains are expected to attract relatively more attention than probabilities for risk seekers compared to risk avoiders.

However, whenever there is a majority (choosing $R$) there is a minority (choosing $S$). Participants choosing the minority choice $S$ either have a different order of reasons (i.e., probability before maximum gain) or use different aspiration levels. In both cases probabilities are predicted to be relatively more important than maximum gains for participants who choose $S$ compared to those who choose $R$. This is because within a lexicographic strategy no other reason than probability would favor $S$. Consequently, probabilities are expected to attract relatively more attention than maximum gains for risk avoiders compared to risk seekers.

Models that rely on weighting and summing assume that there is no relation between attention and choice. That is, regardless of whether participants choose gamble $S$ or $R$, these models predict no differences in attentional allocation between risk avoiders and risk seekers for each of the four reasons. This does not mean that all four reasons get the same amount of attention; in fact, the two minimum outcomes of 0 might get less attention than the two non-zero, maximum outcomes, but the essential point is that attention and choice are unrelated. If differences are found across choices, thus, it is quite likely that participants used a dimensional rather than a weighting and summing strategy.

[2] To avoid misunderstanding: Payne, Bettman, and Johnson (1993) used a measure called "GAIN" that captures the accuracy of a particular strategy in relation to the weighted additive difference rule and to random choice (p. 128 & p. 158). However, they did not investigate if different process measures could predict people's choices. The latter is the focus of the present article.