DOI:
10.1002/bdm.1872

Document Version
Peer reviewed version

Citation for published version (APA):
Ashby, N. J. S., & Rakow, T. (2016). Eyes on the Prize? Evidence of Diminishing Attention to Experienced and Foregone Outcomes in Repeated Experiential Choice. *Journal of Behavioral Decision Making*, *29*(2-3), 183-193. https://doi.org/10.1002/bdm.1872

Eyes on the prize? Evidence of diminishing attention to experienced and foregone outcomes in repeated experiential choice

Nathaniel J. S. Ashby

Tim Rakow

University of Essex

Word Count: 9227 all inclusive (6981 main text)

Author Note

Correspondence concerning this article should be addressed to Nathaniel J. S. Ashby, Department of Psychology, University of Essex, Colchester CO4 3SQ U.K.

E-Mail: nathaniel.js.ashby@gmail.com

We thank Jacob Lund Orquin, Lukasz Walasek, and Rebecca Wright, plus three anonymous reviewers and the journal editor, for helpful comments on earlier versions. The work reported here was supported by a Leverhulme Trust Research Project Grant to the second author.

Abstract

Recently there has been increased interest in *decisions-from-experience* (where decision makers learn from observing the outcomes of previous choices), which provide valuable insights into the learning and preference construction processes underlying many daily decisions. Several process models have been developed to capture these processes, and while such models often fit the data well, many assume that the decision maker is a vigilant observer, processing each outcome. In two studies, we provide a critical test of this assumption using eye tracking to record directed visual attention when participants choose repeatedly among two options, each time being shown the outcome for their chosen option and for the foregone option. Consistently, we find that the vigilance assumption is not supported, with decision makers often not attending to outcome information. Moreover, (in)attention to outcomes is predictable, with vigilance decreasing as more choices are made, and being greater for obtained than for foregone outcomes, and when options deliver only gains as opposed to losses, or a mixture of gains and losses. Furthermore, we find that this variation in attentional allocation plays a central role in the apparent indecisiveness (inconsistency) in choice, with increased attention to foregone outcomes predicting switches to that option on the next choice. Together, these findings highlight the value of eye tracking in investigations of decisions-from-experience, providing novel insight into cognitive processes underlying them.

Keywords: Decisions from experience; risky choice; eye tracking; attention; foregone outcomes; loss aversion

Risk preferences are typically investigated by examining choices among monetary gambles. Until recently, however, these investigations have primarily examined choices between options where each option's outcomes and probabilities were stated (Glöckner & Pachur, 2012; Lopes & Oden, 1999; Rieskamp, 2008; Weber, Shafir, & Blais, 2004). While investigations of these *decisions-from-description* have proved fruitful, one might question the generality of their findings given that many decisions under risk are based either on our own prior experiences (e.g., different routes to work), or on the experiences of others (e.g., movie reviews). The *decisions-from-experience* paradigms, which require decisions to be made based on past observations (Erev et al., 2010), have sought to address this oversight; providing novel insights into the cognitive processes involved in many everyday decisions (Rakow & Newell, 2010).

In one decisions-from-experience paradigm – *decisions-from-feedback* – individuals make repeated consequential choices between non-described options (i.e., *without* prior information about the payoff distributions), and see the outcome that occurred following each decision (Barron & Erev, 2003). In the "full feedback" variant (used in this paper) individuals also see the outcome of the non-selected option (i.e., the foregone payoff; Ert & Erev, 2008; Grosskopf, Erev, & Yechiam, 2006; Yechiam & Busemeyer, 2006). Commonly, each option delivers monetary payoffs that are drawn from a pre-determined distribution, allowing for direct comparison to decisions-from-description. One finding arising from such comparisons is that small probabilities appear to be underweighted in experience-based choice (Barron & Erev, 2003) – not over-weighted, as is typical in decisions-from-description (Gonzalez & Wu, 1999; Prelec, 1998; Kahneman & Tversky, 1979). Given this divergence between decisions-from-experience and those from description, researchers have sought to understand *how* people use experience to inform their choices (Barron & Ursino, 2013; Dutt & Gonzalez, 2012; Erev et al., 2010; Lejarraga, Hertwig, & Gonzalez, 2012).

One profitable route to understanding the cognitive processes involved in decisions-from-experience has been via formal process models, which attempt to capture how previous outcomes are used to inform preferences (for an overview of such models, see Erev et al., 2010). Many of the more successful models posit that individuals integrate, or store, each new piece of information (i.e., each outcome observed) then use that information to compute which option is superior (Gonzalez & Dutt, 2011; Hau, Pleskac, Kiefer, & Hertwig, 2008; Sutton & Barto, 1998). Some of these models also allow for sequence-order effects whereby information is weighted depending on when it was encountered (e.g., because this affects the probability of recall at a later time-point; Hertwig, Barron, Weber, & Erev, 2006). These models can account for behavior in decisions-from-experience; however, many of their formulations make untested assumptions about the decision maker's cognitive processes that may not hold.

One implicit assumption underlying the majority of models for decisions-from-experience (and for other experiential learning tasks) is that individuals are vigilant, paying attention to each outcome that occurs, and then storing or aggregating that information on each successive choice (Ashby & Rakow, 2014; Gonzalez & Dutt, 2011; Hau et al., 2008; Sutton & Barto, 1998). Unfortunately, this critical assumption is – to our knowledge – untested. There are, however, several reasons why such an assumption might not hold. First, the assumption of constant vigilance neglects the cost-benefit trade-off inherent in acquiring information: while attending to each outcome allows for a clearer estimation of each option's expected value (EV), that improvement in accuracy incurs costs of spent time and effort. Given that for non-dynamic options very little is gained by integrating additional outcomes beyond a given point, one might expect vigilance to decrease because there is diminishing marginal benefit for additional observations. Thus, when the costs of vigilance outweigh its benefits, a rational decision maker *should* decrease the level of attention they allocate to the task (Payne, Bettman, & Johnson, 1988; Orquin, Bagger, & Muller-Loose, 2013).[1] Second, research examining *decisions-from-samples* (another decisions-from-experience paradigm, in which participants observe "for free" before making a one-shot consequential choice) has found that individuals generally make very few observations before making their final decisions: often fewer than 10 (Hertwig et al., 2004; Lejarraga et al., 2012; Rakow, Demes, & Newell, 2008; Weber et al., 2004). Thus, even when free to seek out as much information as they wish, individuals seem content to rely on small numbers of observations (Hills & Hertwig, 2010). Given this, one might expect that in repeated-choice tasks where participants may make hundreds of repeated decisions, individuals might – having already determined their preferred option – reduce vigilance in later trials and opt to complete the task more quickly by selecting the option that provided the best return in an initial small sample of choices for most of the remaining trials.

There are other assumptions about the role of attention that are implicit in models of decisions-from-experience; specifically, either: a) each outcome is attended to and processed equally, or b) the amount of attention received is irrelevant. Thus, most models of experiential choice assume that choices are *independent* of attentional processes. For instance, a reinforcement-learning model developed by Sutton and Barto (1988) assumes that, as each choice is made, the resulting outcomes are integrated into the constructed values of each option. This model, however, does not consider the level of attention paid to each option, or outcome. This is at odds with a large literature suggesting that biases in directed visual attention can directly impact valuation and choice. For example, valuations are higher when more attention is paid to higher outcomes (Ashby, Dickert, & Glöckner, 2012), and increasing attention to an option has been shown to increase the propensity of selecting it (Krajbich,

[1] Peterson and Beach (1967) expressed this normative principle succinctly: "Sample another datum if its cost is less than the expected increase in payoff from the information it will provide" (p. 37). In decisions-from-experience the cost of each additional datum is relatively constant, whereas the added value of each additional datum diminishes with increasing sample size. At some point, the marginal value of additional data will fall below its cost.

Armel, & Rangel, 2010), or rating it more favorably (Shimojo, Simion, Shimojo, & Scheier, 2003).[2] One might therefore expect that, just as in decisions-from-description, attentional allocation might also impact choices in decisions-from-experience. For instance, from an evidence accumulation perspective, increased focus on a foregone option (having only positive outcomes) would lead to more evidence speaking in its favor, which could result in a switch to that option on a subsequent choice (Busemeyer & Townsend, 1993)

One way to test assumptions of vigilance and attentional independence is via eye tracking as it allows for direct insight into what information is attended to (Glaholt & Reingold, 2011; Russo, 2011). Eye tracking methodologies have been used successfully to test assumptions of decision models, and to identify ways to improve them (Ashby et al., 2012; Glöckner & Herbold, 2011). For example, Fiedler and Glöckner (2012) provided support for the assumption made by Decision Field Theory (DFT; Busemeyer & Townsend, 1993; Roe, Busemeyer, & Townsend, 2001) that information sampling varies with the probability of an outcome occurring. Additionally, they found that the magnitude of the outcome predicted information sampling; suggesting how DFT might be reformulated and improved. Eye tracking has also been use to explore differences between decisions-from-description and those from experience: Glöckner, Fiedler, Hochman, Ayal and Hilbig (2012) found that experiential choices were best explained by evidence accumulation processes.

In the current studies we employ eye tracking to measure directed visual attention (a proxy for information processing; Just & Carpenter, 1980) and test the assumptions of vigilance and independence of attention. First, we predict that the strong vigilance assumption will not hold[3], and that over time vigilance will decrease further as the incremental reward for maintaining it (i.e., increased precision in estimates of value) diminishes:

---

[2] For an alternative account see Orquin and Mueller Loose (2013).

[3] Such *inattention to outcomes* is distinct from *ignoring cues* when choosing – something which it has long been known to occur (Payne, 1976)

H_1: Not all outcomes will be attended to and vigilance will decrease with experience.

Second, we predict that attentional allocation will have a direct impact on choice, with a greater focus on "what could have been" increasing the propensity to switch options:

H_{2a}: The larger the proportion of attention directed towards the foregone outcome the more likely a switch (i.e., selecting a different option) will occur on the following choice.

We also predict that the information being attended to will moderate the influence of attention, with increased attention to foregone outcomes which are higher than obtained outcomes further increasing the likelihood of making a switch; a *chasing* or *win-stay lose-shift* strategy (Biele, Erev, & Ert, 2009; Ert & Erev, 2007):

H_{2b}: The effect of attention to foregone outcomes on switching will be greatest when the foregone outcome exceeds one's obtained outcome.

Study 1: Testing the constant vigilance assumption

Methods

Participants. Fifty-one participants (M_{age}: 21.08; 57% female) received either course credit, or £6.00, for their participation and were entered in a lottery to have all their decisions incentivized, with possible earnings exceeding £150.00.

Materials & Equipment. The 14 choice sets each consisted of pairs of gambles with each gamble having two possible outcomes (*Table 1*). Four of the gamble pairs were from Holt and Laury (2002) with two pairs each over gains and losses; six were from Hertwig et al. (2006); and four gamble pairs contained mixed outcomes (both losses and gains were possible). Outcomes were presented on a 22' HD LCD monitor with a resolution of 1680 x 1050, attenuating approximately 1.39° x 0.45° of visual angle; outcomes were presented 0.69° of visual angle left and right of the horizontal center and were approximately 9.53° of visual angle above and below the monitor's midpoint (*Figure 1b*). Eye movements were recorded using a SMI RED250 binocular eye tracking system with an accuracy of 0.45° of visual angle.

Table 1

Procedure. Participants were calibrated to the eye tracker using 9 points; calibration was accepted if the amount of error was less than 1° of visual angle. Participants read instructions from the screen informing them that they would make repeated choices between different pairs of options and that one participant would be selected from the project and receive the accumulated earnings from all their choices. Participants were informed that on each choice they would see the outcome both for the option they picked (obtained outcome) and for the other unpicked option (foregone outcome). Options were presented on the left and right side of the screen (option location randomly determined for each choice set) and were labeled "LEFT OPTION" and "RIGHT OPTION" (see *Figure 1a*). After any questions were answered, participants choose between each pair 40 times at their own pace by clicking the left (right) mouse-button to select the left (right) option. Following each choice, outcomes (obtained and foregone) were presented on the top and bottom of the screen with the location of each being counterbalanced between participants; participants were told that the outcomes would be displayed in these locations. Participants could view the outcomes of their previous choice for as long as they wished, and then pushed the space bar to move to their next choice. This procedure (for making choices and displaying outcomes) was used in order to separate eye movements related to information search from those related to choice; ensuring that if a participant is found to fixate on an outcome it is not an artifact resulting from orienting towards that option to select it. After completing all choices across all option pairs participants were debriefed and paid.

Data Preparation. We defined our areas of interest (AOIs) to allow for a 5° visual angle border around each outcome (outlines in *Figure 1b*); AOIs took into account both the outcomes themselves and leading symbols (the currency-symbol and minus-sign). This large region – five times the minimum calibration accuracy – was selected to ensure that we captured all fixations to an outcome even if such fixations relied on peripheral perceptual processing (parafoveal fixations). This large AOI definition increases the number of false positive fixations (classifying a fixation as belonging to an AOI when it was not); therefore, the vigilance rates that we report likely overestimate the true rates of vigilance. Fixations were defined as continuous gaze within, or outside, one of our AOIs. As per convention, we excluded fixations lasting less than 50ms (Glöckner & Herbold, 2011).

Figure 1 a

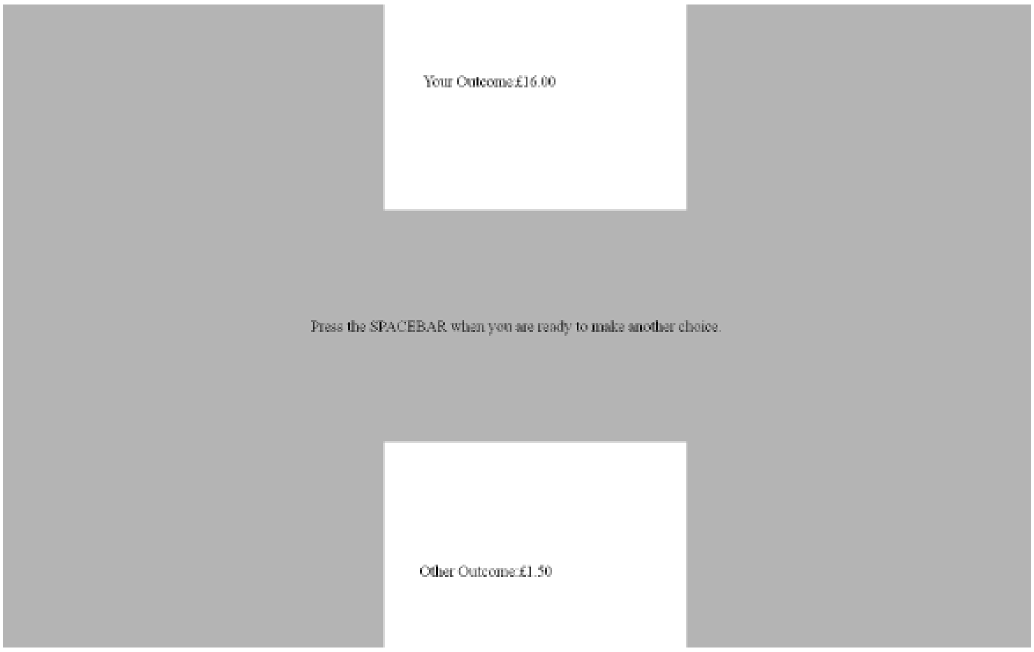

Figure 1b

Results

The Vigilance Assumption. To test H_1 we collapsed across choices and option pairs, to compute the rate of *inattention* for each participant (the percentage of occasions they observed *neither* the obtained *nor* the foregone outcome following a choice). The mean rate of inattention was 5% (95% CI [.021, .073]); therefore, the strict vigilance assumption cannot be sustained. This inattention rate varied greatly between individuals, ranging from 0% (constant vigilance) to 42%. We also tested whether there was a difference in how obtained and foregone outcomes were attended to by comparing the average inattention rates for obtained and foregone outcomes (separately). We find that inattention was significantly greater for foregone outcomes (31%) than for obtained outcomes (11%), $t(50) = -4.58$, $p < .001$; perhaps indicating that participants assigned differential importance to each outcome type.

To test whether inattention increased as more choices were made we performed a multi-level logit regression predicting whether both outcomes were observed (coded 0) or whether only one, or neither, outcome was observed (coded 1), by choice number (choices one through 40) on Level 1, and participant on Level 2 (Nezlek, Schröder-Abe, & Schütz, 2006). We find inattention increased as more choices were made in a given choice set, b = .02, z = 5.51, p < .001 (*Figure 2* upper left panel).

Given that losses often loom larger than gains (Kahneman & Tversky, 1984) vigilance should be greater (i.e., less inattention) when outcomes involve potential losses (Yechiam & Hochman, 2013). One might also expect the outcome makeup of an option pair to influence vigilance because the comparison between positive and negative outcomes (in mixed-outcome gamble pairs) should amplify feelings of regret and rejoicing (Bell, 1982). Furthermore, given that decision times increase when options have similar EVs (Busemeyer & Townsend, 1993) vigilance should increase as options' values become similar. Lastly, because higher variance in outcomes leads to greater exploration (Lejarraga et al., 2012), one might expect higher vigilance rates for option pairs containing more outcome variance. Therefore, we examined whether these effects were present by performing analysis as above but including dummy variables for frame (coded 1 if all outcomes were losses, 0 otherwise), the outcome makeup of an option pair (coded 0 if all outcomes were either gains or losses, 1 for mixed), the absolute difference in EVs between the two options (abs|EV1 – EV2|), and the *SD* of the option pair (over both options' outcomes). Counter to expectation (outlined above), frame was not a significant predictor, p = .95; nor was the effect of absolute EV-difference, p = .49, suggesting that vigilance was not influenced by the relative superiority of one option over the other. The effect of *SD* also failed to reach significance, p = .48. Outcome makeup was found to be a significant predictor, b = .55 z = 6.50, p < .001, with the rate of inattention being higher when options consisted of both gains and losses (6%) rather than only gains or losses (4%).

Performing similar analyses, but predicting vigilance to the obtained (*Figure 2* lower left) and foregone (*Figure 2* right panel) outcomes separately, we find that frame is a significant predictor for obtained outcomes, with less attention being paid to outcomes involving only losses, $p < .001$; an effect not found for foregone outcomes, $p = .87$. Outcome makeup was a significant predictor for both, with inattention being greater for outcomes involving gains and losses, *p*'s < .001. The absolute EV-difference and *SD* did not significantly predict inattention to either outcome, *p*'s > .11.

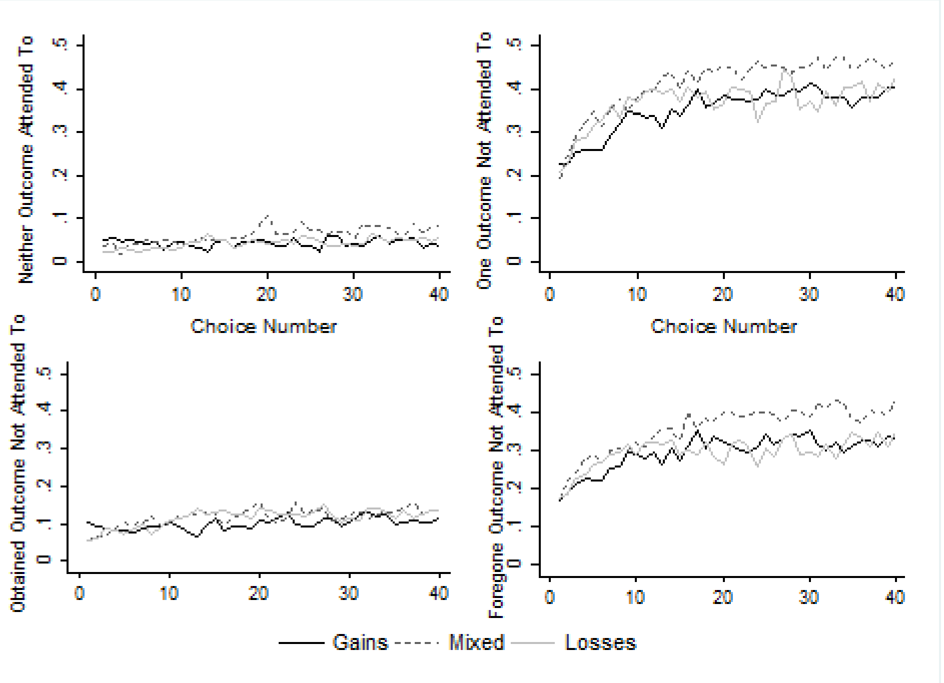

Figure 2

Given that we find overlap in what predicts vigilance to obtained and foregone outcomes, we investigated whether vigilance rates between the two were related. Performing a multi-level logit regression, predicting attention to the foregone outcome from attention to the obtained outcome (both coded 0 for not attended to, 1 for attended to) we find inattention to the foregone outcome was significantly higher when the obtained outcome was not attended to (44%) than when it was (29%), $b = .57$, $z = 10.57$, $p < .001$. Thus, if a participant didn't observe one outcome they were more likely to not observe the other.

Lastly, given that experiential choice has been found to become more normative with greater experience (i.e., showing a greater preference for higher EV options; Hills, Noguchi, & Gibbert, 2013) we examined whether decreased vigilance predicted the ability to pick the better (EV-maximizing) option. To do so we performed analysis as above, but predicted a choice for the better option in an option pair (coded 0 if the poorer option was picked, 1 if the better – higher EV - option was) by choice number and the proportion of choices within an option pair in which both obtained and foregone outcome information was not attended (i.e., the rate of inattention). We also include the option pairs *SD*, as increased outcome variability is often associated with decreased selection of the better option (*pay-off variability effect*; Busemeyer & Townsend, 1993; Myers & Sadler, 1960). As anticipated, we find that the probability of choosing the better option increased with experience (49% in the first choice to 54% in the last), $b = .006$, $z = 5.11$, $p < .001$; and observe a pay-off variability effect, with increased variability in outcomes reducing the likelihood of picking the better option, $b = -.19$, $z = -38.49$, $p < .001$. As expected increased inattention (lower vigilance) decreased EV-maximization, $b = -.29$, $z = -2.86$, $p = .004$.

Attentional Independence Assumption To test $H_{2a/2b}$, (that the distribution of attention impacts choice) we performed analysis as above, but predicting a switch (coded 0 if the same option was selected on the previous choice, 1 if the other option was chosen) by the difference in the previously observed outcomes (previous obtained outcome minus previous foregone outcome), choice number, and the proportion of time spent attending to the foregone outcome (PF = total duration of gaze to foregone divided by the total duration of gaze to both outcomes), and the interaction between PF and the difference in previous outcomes (both centered). We find, as is often reported (Gonzalez & Dutt, 2011), that as the number of choices made for a given gamble pair increases the likelihood of a switch occurring decreases $b = -.006$, $z = -5.17$, $p < .001$.The effect of outcome difference was significant, $b = -.12$, $z = -20.08$, $p < .001$, with the likelihood of switching decreasing the larger one's obtained outcome was relative to the foregone outcome. In support of H_{2a} we find that attention predicts choice with increased PF leading to a significant increase in the likelihood of making a switch, b = .33, z = 5.70, p < .001. In line with H_{2b} the interaction between the difference in the previous outcomes and PF was marginally significant with the effect of attention to the foregone being reduced when the foregone outcome was smaller than the obtained outcome, b = -.04 z = -1.80, p = .07.

Discussion

In Study 1 we find that the standard assumptions regarding sustained vigilance in experiential decision tasks are not supported: at a conservative estimate, there is a 5% chance that neither outcome is attended to, a probability that increases to 11% and 31%, respectively, when examining the obtained and foregone outcomes alone. In addition, the rate of vigilance decreases as the number of choices made within a gamble pair increases. This suggests that after sufficient experience participants may adopt a less resource-intensive strategy to monitor and adjust their preferences.

Interestingly, vigilance was lower when options had mixed outcomes or involved only losses (effects seen more clearly for obtained outcomes alone). At first blush, these findings run counter to loss aversion; losses should receive more attention than gains if they “matter more”. However, if losses do loom larger than gains then participants might choose not to attend to obtained outcomes to avoid the pain of experiencing losses, or might prefer not to see foregone outcomes to avoid experiencing regret (Josephs, Larrick, Steele, & Nisbett, 1992). Regret aversion might also explain why vigilance rates were lower for foregone rather than obtained outcomes as participants might not have wanted to know that they could have done better.

Regarding the impact of attention on choice, we find that increased attentional allocation to the foregone outcome (relative to the obtained outcome) predicts switching between options. The difference in the obtained and foregone outcome predicts a switch in line with a win-stay lose-shift strategy (Barraclough, Conroy, & Lee. 2004; Biele, Erev, & Ert, 2009), an effect amplified by attentional allocation. This suggests there are two independent, but interrelated, attentional influences on choice: what one attends to, and how long one attends to it. It therefore appears that directed attention itself might also impact experiential choice in line with recent research showing that options which receive more attention are preferred (Shimojo et al., 2003), or where evidence is weighted by the level of attention it receives (Milosavljevic, Malmaud, Huth, Koch, & Rangel, 2010; Rieskamp, 2008).

While we find support for our prediction that common assumptions underlying models of experiential choice are not supported, there are two factors which may place limits on our conclusions. First, because incentivization only occurred for one (randomly selected) participant, a participant might be less motivated and vigilant if they felt that the odds of incentivization occurring for them were low. Second, having outcomes appear away from option labels might have decreased vigilance since attending to an outcome came at a cost of at least one eye movement. We therefore conducted a second study to investigate whether these factors influenced vigilance.

Study 2: The influence of task structure on vigilance

Method

Participants. Forty participants (M_{age} = 25.25; 70% female) took part in Study 2. The payment schedule was a manipulation: half of the participants received £3.00 and incentivization from each of their choices, while the other half received £5.00 and the chance of having all of their choices incentivized as in Study 1.

Materials. We employed nine new gamble pairs, each option containing two possible outcomes (*Table 2*). Three of the pair's outcomes consisted of gains, three contained a mixture of gains and losses, and three consisted of only loses. In each pair, one option had greater variance than the other and the option with more variance (i.e., the riskier option) was always the better (higher EV) option if EVs differed. Specifically, in one option pair in each domain (i.e., gains, mixed, or losses) the options had nearly identical EVs (*Table 2*; O-pairs 1, 4, 7); in another there was about a £0.05 difference in EVs (O-pairs 2, 5, 8); while the last pair had a £0.09 difference in EVs between the two options (O-pairs 3, 6, 9). Study 2 used the same eye-tracking equipment and processing methods as Study 1.

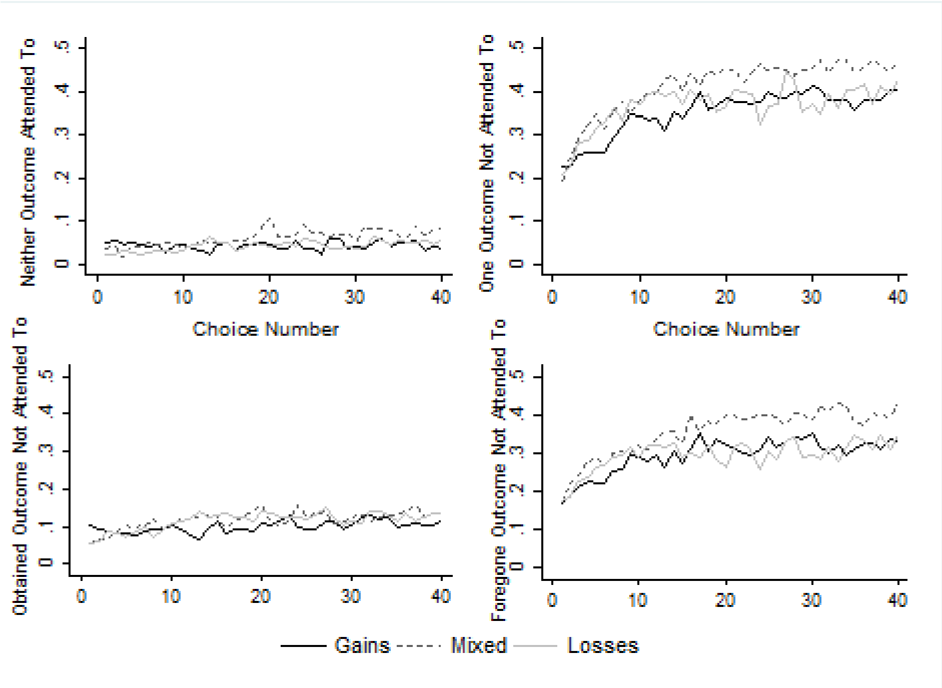

Table 3

Procedure. The procedure was identical to Study 1 except for two key changes. First, half of the participants were informed that they would be incentivized for each of their choices; while the other half were informed that one (randomly selected) participant would have all their choices incentivized, as in Study 1. This split allows us to determine whether the type of incentivization affects vigilance. Second, for choices in five of the pairs, outcomes were presented directly under the options labels (as is typical for experiments that present both obtained and foregone payoffs; Ert & Erev, 2007; Yechiam & Busemeyer, 2006); while for four of the pairs the outcomes were presented at the top and bottom of the screen, as per Study 1. The assignment of option pairs to outcome display location was random and participants were informed before each trial began where each outcome would be displayed (e.g., foregone outcome on upper portion of screen). This manipulation was used to investigate the impact of outcome location on vigilance. The only other change was that participants made 50 choices within each pair.

Results

The Vigilance Assumption. We replicate the finding of Study 1 that the strict vigilance assumption is not supported, though the rate of inattention (i.e., failing to observe both outcomes) was only marginal (1%; 95% CI [-.002, .0197]); inattention rates ranged from 0% to 19% across participants. Again, inattention to one of the outcomes was relatively common, and there was a significantly higher rate of inattention to foregone outcomes (19%) than obtained outcomes (12%), $t(39) = -4.44$, $p < .001$. Counter to Study 1, we find inattention to obtained outcomes was negatively related to vigilance to foregone outcomes, $b = -1.94$, $z = -21.55$, $p < .001$, with rates of inattention to the foregone outcome being higher when the obtained outcome was attended to (21%) than when it was not (8%). Thus, there appears to be an attentional trade-off, with vigilance to one outcome decreasing vigilance to the other.

To examine the impact of experience and task structure (incentivization and outcome locations) we performed analysis as in the previous study predicting whether both outcomes were observed (inattention; coded 0 if they were, 1 if they weren't) by: choice number, frame, outcome makeup, a dummy coded variable for the difference in the options EVs (no difference coded as the base level), type of incentivization (coded 0 for incentivization by lottery, 1 if all choices were incentivized), and the position of the outcomes (coded 0 for outcomes displayed directly under labels, 1 for outcomes displayed on the top and bottom of the screen). Replicating the results of Study1, we find that the rate of inattention increases as more choice are made, $b = .02$, $z = 2.86$, $p < .01$. The effect of frame was significant with inattention for loss-only option pairs being higher than when some outcomes were positive, $b = .74$, $z = 3.41$, $p = .001$ (*Figure 3*. The effect of outcome makeup was not found to be significant, $p = .89$, nor was the type of incentivization, $p = .69$. The impact of outcome position was, however, significant, $b = -.65$, $z = -3.30$, $p < .01$ (see *Figure 3* upper and lower left panels). In addition, EV-difference was found to be (marginally) significant with inattention decreasing if there was a difference in EVs, *ps* < .06; though the size of the EV-difference among non-EV-equivalent option pairs did not significantly affect the rate of inattention, $p = .44$.

We performed separate analyses for vigilance to the obtained (*Figure 3* upper and lower panels second from the right) and to the foregone outcomes (*Figure 3* upper and lower panels on the far right); which were otherwise identical to those described above. The findings closely matched the combined analyses; for brevity we only report those results which run counter to the combined analyses, and/or are different for obtained and foregone outcomes. First, frame was not a significant predictor for inattention to obtained outcomes, $p = .13$, while it was a significant predictor of increased inattention to foregone outcomes, $b = .52$, $z = 10.31$, $p < .001$. Counter to the combined results, outcome makeup significantly predicted increased vigilance to the obtained outcome, with there being less inattention to obtained outcomes involving mixed outcomes (9%) than only gains or losses (13%), $b = -.37$, $z = -6.04$, $p < .001$; outcome makeup was not a significant predictor of vigilance to foregone outcomes, $p = .76$. Interestingly, and counter to our expectations, the effect of outcome position was a significant negative predictor of inattention to obtained outcomes, $b = -.15$, $z = -2.98$, $p < .01$, with inattention decreasing when the obtained outcome was shown in the top and bottom (11%) format than when they appeared under each option's label (12%). However, this effect reversed for vigilance to the foregone outcome with greater inattention for outcomes displayed on the top and bottom of the screen (25%) than under each option's label (15%), $b = .72$, $z = 17.20$, $p < .001$. Regarding the EV-difference between options: for vigilance to the obtained outcome, only large EV-differences led to lower rates of inattention, $b = -.39$, $z = -6.18$, $p < .001$. For foregone outcomes, the effect of EV-difference was more straightforward, with both moderate, $b = -.33$, $z = -6.39$, $p < .001$, and higher, $b = -.23$, $z = -4.51$, $p < .001$, EV-differences between options decreasing inattention (relative to no difference).

Figure 3

Lastly, to examine the link between vigilance and EV-maximization, we predicted selection of the better (riskier) option (only for the six option pairs with a dominant option) by: choice number, the rate of inattention to both outcomes within the option pair, and EV-difference as in the previous study. We replicate the finding that increased experience increases the likelihood of selecting the better option (48% in the first choice to 54% in the final choice), $b = .006$, $z = 4.28$, $p < .001$. As one would expect, the rate of inattention was found to be a significant negative predictor, $b = -2.85$, $z = -4.35$, $p < .001$: as in the previous study failing to attend to outcomes reduced the likelihood of choosing the better option. The effect of EV-difference was significant with the likelihood of selecting the better option being greater when EV differences were higher (54% vs. 48%), $b =.21$, $z = 5.58$, $p < .001$, even though payoff variability increased.

Attentional Independence Assumption. As in Study 1, we tested whether attention impacts choice (*H2*$_{a\text{-}b}$) by predicting a switch from: the difference in previous outcomes, choice number, as well as PF, and its interaction with the difference in the previous outcomes. Counter to Study 1, choice number was not a significant predictor, p = .26. However, as per Study 1, the larger the obtained outcome (relative to the foregone outcome) the lower the likelihood of a switch, b = -1.31, z = -27.78, p < .001. Again, and in line with our predictions, the effect of PF was significant, b = .29, z = 4.73, p < .001, with increased focus on the foregone outcome increasing the likelihood of switching. Lastly, the interaction between the difference in previous outcomes and PF was marginally significant, b = .31, z = 1.95, p = .05. Though the effect is opposite in direction to H_{2b} and the results of the previous study, with the effect of greater obtained outcomes on the likelihood of switching being reduced when more attention was directed to the foregone outcome.

Discussion

Study 2 replicates the key effects present in Study 1, and provides further insight into factors that influence vigilance. We find that strong vigilance assumptions are not supported: often only the obtained or foregone outcome was attended to, and inattention increased with experience (i.e., as more choices were made, and outcomes observed). In addition, outcome position predicted attention: when outcomes were shown under labels instead of at the top (bottom) of the screen – thus requiring a quick eye-movement – vigilance to foregone outcomes decreased, while there was a slight increase in vigilance to obtained outcomes. We also find that EV-differences between options influenced vigilance: foregone outcomes were attended to less when options had equivalent EVs than when one option had higher EV.

As in Study 1, increased attention to the foregone outcome increased the probability of switching to a different option on the next choice, even when taking into account differences between the obtained and foregone outcome. Counter to our predictions, an increased focus on the foregone outcome actually decreased the negative impact of greater obtained outcomes on switching. This provides further evidence against this effect being due to the amplification of regret, or increasing the use of a win-stay lose-shift strategy.

General Discussion

In two eye-tracking studies, we find that decision makers are *not* consistently vigilant observers in repeated choice tasks; frequently, either the obtained or the foregone outcome is not attended to – and, occasionally, neither outcome is processed. This is an important finding since many theories of experiential choice assume that each outcome is attended to and is either integrated immediately to update the subjective value of each option or encoded in memory for later retrieval (Ashby & Rakow, 2014; Hertwig et al., 2006; Sutton & Barto, 1998; Gonzalez & Dutt, 2011). Moreover, we demonstrate that the level of vigilance varies predictably: decision makers are more likely to attend to obtained than to foregone outcomes, and attentiveness is influenced by the makeup of the options and other aspects of the choice task (e.g., the display). Furthermore, we find that attentional allocation predicts subsequent choices, with an increased focus on foregone outcomes increasing the likelihood that the other option is picked on the next choice. Together, these findings suggest that current models of repeated experiential choice would benefit from revision – and provide some insight into how to implement such revisions.[4]

Re-thinking the vigilance assumption in process models of experiential choice

The current findings, when combined with previous research in decisions-from-samples paradigms, which indicate that choices are generally made after relatively few samples (Weber et al., 2004; Hills & Hertwig, 2010), suggest that frugal information uptake

[4] Four key findings summarized in this paragraph were replicated in a third eye-tracking study (*N* = 31) using four new choice sets (not reported for the sake of brevity). Specifically, vigilance was (1) greater for obtained than for forgone outcomes, (2) decreased for either outcome type as more choices were made, and (3) was lower for loss-only choice sets; also, (4) switches were more likely following increased attention to forgone outcomes.

may be the norm in decisions-from-experience. For example, the relatively great speed at which an individual's choices become stable suggest that initial observations carry considerable weight (perhaps largely because – as found here – they are more likely to be attended to than later observations). Later choices would then usually fall in line with preferences formed from these initial observations, unless the decision maker perceives a (real or illusory) change in the environment, or believes that they have identified a pattern in the outcomes that warrants frequent switching (Gaissmaier & Schooler, 2008; Wolford, Newman, Miller & Wig, 2004). Note that because vigilance decreases over time we should expect preferences to update increasingly slowly as more information becomes available – even when such changes in preference are advantageous. This is exactly what is observed in repeated choice tasks when an unannounced change in the option payoff distributions alters which of two options is best: participants are quick to select the initially superior option, but slow to alter that preference to favor an equally superior option when the environment changes (Gaissmaier, Schooler & Rieskamp, 2006; Rakow & Miler, 2010).

Diminishing vigilance over time may also explain an intriguing finding from the decisions-from-samples literature. Recency (greater influence of later observations) is often observed when participants choose themselves how much information to collect before making a one-shot decision (e.g., Hertwig et al., 2004), but not when the experimenter determines how many pre-decisional observations are permitted (Rakow et al., 2008; Ungemach, Chater & Stewart, 2009). Presumably, reduced vigilance to outcomes is more acute when one cannot opt to stem the flow of outcomes to be viewed; therefore, if participants who are forced to sample simply reduce their vigilance to later outcomes this will counteract recency (because later outcomes are simply not attended to).

Importantly, while our participants did not maintain perfect vigilance, they attended to at least one outcome (obtained or foregone) in 95% of choices. It might, therefore, be argued that vigilance is actually quite high. However, our analyses were deliberately liberal in classifying fixations (e.g., including a 50ms fixation 5° of visual angle away from the edge of an outcome) to ensure that anything that *might* represent a fixation was included. To illustrate, had we instead used a standard cutoff for detecting fixations of 1° of visual angle in Study 1 the rate of vigilance would have been much lower (34% of the time neither outcome would have been viewed); thus, it is likely that the true rate of vigilance is substantially lower than reported here.

One reason why inattention is noteworthy is that it prompts us to re-interpret current models of repeated choice. For instance, value-updating models often include a parameter that reflects imperfect integration of new information, due to inertia or noise (e.g., Busemeyer & Townsend, 1993). While unlikely to be the full story, our data provide an explanation for imperfect value updating: updating based on prior outcomes cannot be perfect if some outcomes are not observed. Memory-based sampling models often have a parameter reflecting the probability that a given (prior) outcome is retrieved when a subsequent choice is made (e.g., Dutt & Gonzalez, 2012). Our data suggest that such parameters may be better understood to reflect *both* the probability that an outcome is attended to *and* the probability that the outcome is stored and retrieved *given* that is was observed. Additionally, our data should prompt researchers to look beyond simply re-interpreting the components of existing models along the lines discussed here. This is because our data show that vigilance is partly predictable from features of the decision task or choice environment; therefore, adding components to models that reflect variation in vigilance as a function of those features (e.g., the presence of losses) may improve those models.

The predictors, and implications, of (in)vigilance

Our data reveal multiple influences on the level of vigilance to outcomes in repeated choice. First, vigilance to foregone outcomes is lower than vigilance to obtained outcomes.

Second, losses, or combinations of losses and gains, are less frequently attended to than gains. Third, this negative effect of losses on vigilance is, on average, greater for foregone outcomes. Combined, these results might suggest that participants were attempting to minimize feelings of regret by choosing not to process outcomes that might induce such emotions. While sticking one's head in the proverbial sand might seem unwise, it could have benefits. Failing to observe that one could have earned more (or lost less) can only decrease regret as there is no input to generate it; while not attending to the foregone could help insulate against potentially maladaptive behavior such as chasing misleading wins (Barber, Odean, & Zheng, 2001; Grosskopf et al., 2006; Barraclough et al., 2004; Ert & Erev, 2007).

Formal models that allow for the differential weighting of obtained and foregone outcomes (Yechiam & Rakow, 2012; Camerer & Ho, 1999) provide one framework for modeling the decreased vigilance to foregone outcomes that we observed. However, these models implement differential weighting by discounting the weight given to foregone outcomes in the decision process, which, while it might fit the data, does not necessarily reflect the greater *inattention* to foregone outcomes that we observed. An approach more in line with our data would be to include a model parameter which provides some probability of the foregone and obtained outcomes being processed. As such, we suggest that future research should more carefully examine what is driving this diminished attention to foregone outcomes and potential losses as such investigations could provide important insight into the cognitive and affective processes involved in experiential learning and a greater understanding of robust phenomena such as loss aversion and adaptation in changing environments.

The consequences of variation in attentional allocation

In addition to identifying some influences on the degree of vigilance in decisions-from-feedback, our data also suggest that this attentional allocation plays an important role in experiential choice. Specifically, we consistently find that the greater the proportion of attention directed at the foregone outcome, the higher the likelihood that a switch is made on the following choice; an effect which was present even when the value of the outcome being observed was taken into account. This is important as it suggests that experiential choice, just like described choice (Fiedler & Glöckner, 2012) and valuation (Ashby et al., 2012), is likely influenced by attention-weighted evidence accumulation processes (Busemeyer & Townsend, 2004; Usher & McClelland, 2001). Thus, not only are outcomes weighted based on their frequency of occurrence, but also by the amount of attention they receive. Importantly, this implies that the fit, or generalizability, of models could be improved by including components that reflect attentional processes. Our studies illustrate two strategies for achieving this. First, as we have done, one can use process data from eye tracking (as a proxy for the attention allocated to each datum) as a model input. Second, one can determine what influences the allocation of attention, and use that to inform what parameters or characteristics are included in a model. For example, we observed that attention diminished as more choices were made. For a value-updating model, this implies diminishing sensitivity to new information; while, for a model of sampling from memory, it implies that, *ceteris paribus*, initial observations have an elevated probability of recall because they are more likely to be attended to.

Process models of decisions from experience – next steps

Our findings challenge some of the standard assumptions of current models by showing: that decision makers do not always maintain vigilance; that not all types of outcomes are treated the same; and that attentional allocation predicts experiential choice. However, this does not imply that the processes instantiated in current models of experiential choice, such as sequential value updating (Hertwig et al., 2004) or memory retrieval processes (Ashby & Rakow, 2014; Gonzalez, Dutt, & Lebiere, 2013) are spurious. Rather, we argue that we have identified *additional* components of information acquisition and attention that could usefully be incorporated into such models. Having shown that eye tracking can provide insights into preference construction processes, we urge cognitive researchers to utilize eye-tracking and other process data to further improve and test theory.

References

Ashby, N. J. S., Dickert, S., & Glöckner, A. (2012). Focusing on what you own: Biased information uptake due to ownership. *Judgment and Decision Making*, *7*(3), 254-267.

Barber, B. M., Odean, T., & Zheng, L. (2005). Out of Sight, Out of Mind: The Effects of Expenses on Mutual Fund Flows. *The Journal of Business*, *78*(6), 2095-2120.

Barraclough, D. J., Conroy, M. L., & Lee, D. (2004). Prefrontal cortex and decision making in a mixed-strategy game. *Nature neuroscience*, *7*(4), 404-410.

Barron, G., & Erev, I. (2003). Small feedback based decisions and their limited correspondence to description based decisions. *Journal of Behavioral Decision Making*, *16*(3), 215-233.

Barron, G., & Ursino, G. (2013). Underweighting rare events in experience based decisions: Beyond sample error. *Journal of Economic Psychology*, *39*, 278-286.

Bell, D. E. (1982). Regret in decision making under uncertainty. *Operations Research*, *30*(5), 961-981.

Biele, G., Erev, I., & Ert, E. (2009). Learning, risk attitude and hot stoves in restless bandit problems. *Journal of Mathematical Psychology*, *53*(3), 155-167.

Busemeyer, J. R., & Townsend, J. T. (1993). Decision field theory: a dynamic-cognitive approach to decision making in an uncertain environment. *Psychological Review*, *100*(3), 432-459.

Camerer, C. F., & Ho, T. -H. (1999). Experience weighted attraction learning in normal form games. *Econometrica*, *67*(4), 827-874.

Cheung, Y. W., & Friedman, D. (1997). Individual learning in normal form games: Some laboratory results. *Games and Economic Behavior*, *19*(1), 46-76.

Dutt, V., & Gonzalez, C. (2012). Making instance-based learning theory usable and understandable: The Instance-Based Learning Tool. *Computers in Human Behavior*, *28*(4), 1227-1240.

Erev, I., Ert, E., Roth, A. E., Haruvy, E., Herzog, S. M., Hau, R., ... & Lebiere, C. (2010). A choice prediction competition: Choices from experience and from description. *Journal of Behavioral Decision Making*, *23*(1), 15-47.

Ert, E., & Erev, I. (2007). Replicated alternatives and the role of confusion, chasing, and regret in decisions from experience. *Journal of Behavioral Decision Making*, *20*(3), 305-322.

Ert, E., & Erev, I. (2008). The rejection of attractive gambles, loss aversion, and the lemon avoidance heuristic. *Journal of Economic Psychology*, *29*(5), 715-723.

Fiedler, S., & Glöckner, A. (2012). The dynamics of decision making in risky choice: an eye-tracking analysis. *Frontiers in Psychology*, *3*.

Gaissmaier, W., & Schooler, L. J. (2008). The smart potential behind probability matching. *Cognition, 109*, 416-422.

Gaissmaier, W., Schooler, L. J., & Rieskamp, J. (2006). Simple predictions fueled by capacity limitations: When are they successful? *Journal of Experimental Psychology: Learning, Memory and Cognition, 32*(5), 966-982.

Glaholt, M. G., & Reingold, E. M. (2011). Eye movement monitoring as a process tracing methodology in decision making research. *Journal of Neuroscience, Psychology, and Economics*, *4*(2), 125-146.

Glöckner, A., & Herbold, A.-K. (2011). An eye-tracking study on information processing in risky decisions: Evidence for compensatory strategies based on automatic processes. *Journal of Behavioral Decision Making, 24*(1), 71-98.

Glöckner, A., Fiedler, S., Hochman, G., Ayal, S., & Hilbig, B. E. (2012). Processing differences between descriptions and experience: a comparative analysis using eye-tracking and physiological measures. *Frontiers in Psychology, 3*.

Glöckner, A., & Pachur, T. (2012). Cognitive models of risky choice: Parameter stability and predictive accuracy of prospect theory. *Cognition*, *123*(1), 21-32.

Gonzalez, C., & Dutt, V. (2011). Instance-based learning: Integrating sampling and repeated decisions from experience. *Psychological Review*, *118*(4), 523-551.

Gonzalez, R., & Wu, G. (1999). On the shape of the probability weighting function. *Cognitive Psychology*, *38*(1), 129-166.

Grosskopf, B., Erev, I., & Yechiam, E. (2006). Foregone with the wind: Indirect payoff information and its implications for choice. *International Journal of Game Theory*, *34*(2), 285-302.

Hau, R., Pleskac, T. J., Kiefer, J., & Hertwig, R. (2008). The description–experience gap in risky choice: The role of sample size and experienced probabilities. *Journal of Behavioral Decision Making*, *21*(5), 493-518.

Hertwig, R., Barron, G., Weber, E. U., & Erev, I. (2004). Decisions from experience and the effect of rare events in risky choice. *Psychological Science*, *15*(8), 534-539.

Hills, T. T., & Hertwig, R. (2010). Information search in decisions from experience do our patterns of sampling foreshadow our decisions? *Psychological Science*, *21*(12), 1787-1792.

Hills, T. T., Noguchi, T., & Gibbert, M. (2013). Information overload or search-amplified risk? Set size and order effects on decisions from experience. *Psychonomic Bulletin & Review*, *20*(5), 1-9.

Holt, C. A., & Laury, S. K. (2002). Risk aversion and incentive effects. *American Economic Review*, *92*(5), 1644-1655.

Johnson, E. J., Payne, J. W., Bettman, J. R., & Schkade, D. A. (1989). *Monitoring information processing and decisions: The mouselab system* (No. TR-89-4-ONR). Duke University, Durham NC, Center for Decision Studies.

Josephs, R. A., Larrick, R. P., Steele, C. M., & Nisbett, R. E. (1992). Protecting the self from the negative consequences of risky decisions. *Journal of Personality and Social Psychology*, *62*, 26–37.

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review*, *87*(4), 329-354.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*(2), 263-291.

Kahneman, D., & Tversky, A. (1984). Choices, values, and frames. *American Psychologist*, *39*(4), 341-350.

Krajbich, I., Armel, C., & Rangel, A. (2010). Visual fixations and the computation and comparison of value in simple choice. *Nature Neuroscience*, *13*(10), 1292-1298.

Lejarraga, T., Hertwig, R., & Gonzalez, C. (2012). How choice ecology influences search in decisions from experience. *Cognition*, *124*(3), 334–342.

Lopes, L. L., & Oden, G. C. (1999). The role of aspiration level in risky choice: A comparison of cumulative prospect theory and SP/A theory. *Journal of Mathematical Psychology*, *43*(2), 286–313.

Milosavljevic, M., Malmaud, J., Huth, A., Koch, C., & Rangel, A. (2010). The drift diffusion model can account for value-based choice response times under high and low time pressure. *Judgement and Decision Making*, *5*(6), 437-449.

Nezlek, J. B., Schroeder-Abe, M., & Schuetz, A. (2006). Multilevel analyses in psychological research. Advantages and potential of multilevel random coefficient modeling. *Psychologische Rundschau*, *57*(4), 213-223.

Orquin, J. L., Bagger, M., & Mueller Loose, S. (2013). Learning affects top down and bottom up modulation of eye movements in decision making. *Judgment and Decision Making*, *8*(6), 700-716.

Orquin, J. L., & Mueller Loose, S. (2013). Attention and choice: A review on eye movements in decision making. *Acta Psychologica*, *144*(1), 190–206.

Payne, J. W. (1976). Task complexity and contingent processing in decision making: An information search and protocol analysis. *Organizational Behavior and Human Performance*, *16*(2), 366-387.

Payne, J. W., Bettman, J. R., & Johnson, E. J. (1988). Adaptive strategy selection in decision making. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *14*(3), 534-552.

Peterson, C. R., & Beach, L. R. (1967). Man as an intuitive statistician. *Psychological Bulletin*, *68*(1), 29-46.

Prelec, D. (1998). The probability weighting function. *Econometrica*, *66*(3), 497-527.

Rakow, T., Demes, K. A., & Newell, B. R. (2008). Biased samples not mode of presentation: Re-examining the apparent underweighting of rare events in experience-based choice. *Organizational Behavior and Human Decision Processes*, *106*(2), 168-179.

Rakow, T., & Miler, K. (2009). Doomed to repeat the successes of the past: History is best forgotten for repeated choices with non-stationary payoffs. *Memory and Cognition, 37*(7), 985-1000.

Rakow, T., & Newell, B. R. (2010). Degrees of uncertainty: An overview and framework for future research on experience based choice. *Journal of Behavioral Decision Making*, *23*(1), 1-14.

Rieskamp, J. (2008). The probabilistic nature of preferential choice. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *34*(6), 1446-1465.

Roe, R. M., Busemeyer, J. R., & Townsend, J. T. (2001). Multialternative decision field theory: A dynamic connectionist model of decision making. *Psychological Review*, *108*(2), 370-392.

Russo, J. E. (2011). Eye fixations as a process trace. In M. Schulte-Mecklenbeck, A. Kühberger, & R. Ranyard (Eds.), *A handbook of process tracing methods for decision research* (pp. 43–64). New York, NY: Psychology Press.

Shimojo, S., Simion, C., Shimojo, E., & Scheier, C. (2003). Gaze bias both reflects and influences preference. *Nature Neuroscience*, *6*(12), 1317-1322.

Sutton, R. S., & Barto, A. G. (1998). *Reinforcement learning: An introduction* (Vol. 1, No. 1). Cambridge: MIT press.

Ungemach, C., Chater, N., Stewart, N. (2009). Are probabilities overweighted or underweighted when rare outcomes are experienced (rarely)? *Psychological Science, 20*, 473-479.

Usher, M., & McClelland, J. L. (2001). The time course of perceptual choice: the leaky, competing accumulator model. *Psychological Review*, *108*(3), 550-592.

Weber, E. U., Shafir, S., & Blais, A. R. (2004). Predicting risk sensitivity in humans and lower animals: risk as variance or coefficient of variation. *Psychological Review, 111*(2), 430-445.

Wolford, G., Newman, S. E., Miller, M. B., & Wig, G. S. (2004). Searching for patterns in random sequences. *Canadian Journal of Experimental Psychology, 58*(4), 221-228.

Yechiam, E., & Busemeyer, J. R. (2006). The effect of foregone payoffs on underweighting small probability events. *Journal of Behavioral Decision Making*, *19*(1), 1-16.

Yechiam, E., & Hochman, G. (2013). Losses as modulators of attention: Review and analysis of the unique effects of losses over gains. *Psychological Bulletin*, *139*(2), 497-518.

Table 1. Probabilities (P1-4) and outcomes (O1-4) for each option in each option pair (O-Pair) and their expected values (EV1-2), as well as the average maximization rates (MR) and vigilance rates (VR) in Study 1; sorted by domain: gains only (O-Pairs 1 – 6), mixed outcomes (O-Pairs 7- 10), and losses only (O-Pairs 11 – 14)

O-Pair	P1	O1	P2	O2	EV1	P3	O3	P4	O4	EV2	MR	VR
1	0.8	£2.00	0.2	£1.60	£1.92	0.8	£3.85	0.2	£0.10	£3.10	67%	96%
2	0.5	£2.00	0.5	£1.60	£1.80	0.5	£3.85	0.5	£0.10	£1.98	51%	97%
3	0.8	£2.00	0.2	£0.00	£1.60	1	£1.50	0	£0.00	£1.50	63%	94%
4	0.1	£16.00	0.9	£0.00	£1.60	1	£1.50	0	£0.00	£1.50	33%	97%
5	0.2	£2.00	0.8	£0.00	£0.40	0.25	£1.50	0.75	£0.00	£0.38	54%	95%
6	0.03	£16.00	0.97	£0.00	£0.40	0.25	£1.50	0.75	£0.00	£0.38	36%	94%
7	0.7	£1.50	0.3	£-1.50	£0.60	0.9	£1.50	0.1	£-1.50	£1.20	62%	95%
8	0.5	£1.80	0.5	£-1.80	£0.00	0.74	£1.80	0.26	£-1.80	£0.87	59%	95%
9	0.26	£1.80	0.74	£-1.80	£-0.87	0.5	£1.80	0.5	£-1.80	£0.00	58%	94%
10	0.1	£1.50	0.9	£-1.50	£-1.20	0.3	£1.50	0.7	£-1.50	£-0.60	62%	92%
11	1	£-1.50	0	£0.00	£-1.50	0.1	£-16.00	0.9	£0.00	£-1.60	27%	95%
12	1	£-1.50	0	£0.00	£-1.50	0.8	£-2.00	0.2	£0.00	£-1.60	65%	94%
13	0.5	£-2.00	0.5	£-1.60	£-1.80	0.5	£-3.85	0.5	£-0.10	£-1.98	56%	99%
14	0.8	£-2.00	0.2	£-1.60	£-1.92	0.8	£-3.85	0.2	£-0.10	£-3.10	72%	96%

Table 2. Probabilities (P1-4) and outcomes (O1-4) for each option in each option pair (O-Pair) and their expected values (EV1-2), as well as the average maximization rates (MR; - denotes when there was no EV dominant option) and vigilance rates (VR) in Study 2; sorted by domain: gains only (O-Pairs 1 – 3), mixed outcomes (O-Pairs 4- 6), and losses only (O-Pairs 7 – 9).

O-Pair	P1	O1	P2	O2	EV1	P3	O3	P4	O4	EV2	MR	VR
1	0.4	£0.10	0.6	£0.08	£0.09	0.21	£0.31	0.79	£0.03	£0.09	-	99%
2	0.4	£0.15	0.6	£0.13	£0.14	0.21	£0.70	0.79	£0.05	£0.19	42%	99%
3	0.4	£0.09	0.6	£0.17	£0.08	0.21	£0.74	0.79	£0.01	£0.16	45%	99%
4	0.4	£0.15	0.6	£-0.06	£0.02	0.21	£0.38	0.79	£-0.07	£0.02	-	99%
5	0.4	£0.13	0.6	£-0.02	£0.04	0.21	£0.69	0.79	£-0.08	£0.08	39%	99%
6	0.4	£0.11	0.6	£-0.05	£0.01	0.21	£0.85	0.79	£-0.10	£0.10	44%	99%
7	0.4	£-0.22	0.6	£-0.09	£-0.14	0.21	£-0.57	0.79	£-0.03	£-0.14	-	98%
8	0.4	£-0.39	0.6	£-0.10	£-0.22	0.21	£-0.77	0.79	£-0.01	£-0.17	67%	99%
9	0.4	£-0.44	0.6	£-0.18	£-0.28	0.21	£-0.87	0.79	£-0.02	£-0.20	74%	99%