How episodic memory influences choices from past experiences

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Abstract

Decisions-making processes are complex and integrate various sources of information. However, up until recently limited research has been dedicated to understanding the role of memory in making decisions. The current work experimentally investigates the effect of episodic memory on choices based on experience. We experimentally manipulated episodic memory in participants and had them complete a decision task from experience where they repeatedly chose between safe and risky options. Inducing episodic memory prevented participants from becoming risk-averse: instead, they developed a stronger preference for risk. Episodic processes seem to strengthen our memories of positive extreme outcomes, leading to more risk-seeking. The findings also suggest the single first consequence of a risky choice has a profound impact on how we subsequently behave.

Introduction

There are a variety of variables that can affect our decisions. We are likely to make different choices depending on whether calm and composed, late for lunch, focusing on something else, or exhausted. Decision-making researchers have for a long time tried to understand how we make decisions and how they can be altered. However, the mechanisms of decision-making are complex and not fully yet understood. It is clear decisions do not operate in isolation and interact with other processes in the brain. A new line of research at the intersection of memory and decision-making tries to understand the role and impact of memory on our decisions. It has for a long time been suggested that memory can encode and retrieve information

in a more specific (episodic) or general (semantic) way (Tulving, 1986). However, it is still unclear how such distinctions in how we remember information alter behavior. The current work investigates the way episodic memory might alter preferences for risks. We induced episodic memory in participants and examined their behavior in a gambling task learned from experience. We begin by discussing about theories in the field of decision-making and previous empirical work that has investigated how memory can affect decisions.

Decision-making

Humans are far from being perfect at making decisions; we tend to not objectively consider values in our choices and are subject to many biases. Previous literature has shown how important it is to take these biases into account and to distinguish between the objective value of rewards and the subjective value attributed to them (Kahneman & Tversky, 1984). For example, we are more likely to choose an insurance if is presented as being the default option (Kahneman, Knetsch & Thaler, 1991). This is because people are susceptible to the reference point from which a decision is being made. We consider wins or loses near the reference point to have greater subjective value, and give less weight to wins and loses far from this reference point. We also tend to fear losses more than we anticipate wins. This theory has been called Prospect theory (Kahneman & Tversky, 1984) and states that more importance is given to the difference between 0$ and 100$ is greater than to the difference between 1000$ and 1100$. Because of this, people tend to choose a gain of 10$ over a 50% to win 20$ (the subjective value of 20$ is less than double the value of 10$). In other words, people are generally risk-averse when it comes to gains (Kahneman & Tversky, 1984).

A key factor that impacts risk preferences is how we learn about the outcomes associated with each option (Hertwig, Barron & Weber, 2004). There are at least two ways in which such values can be learned. The first one is from description, where the experimenter describes the probabilities and rewards associated with each option and then asks the participant to choose between them. The second way is from experience, where participants learn the values by themselves, from repeatedly choosing between the options and receiving feedback. In tasks of decision from experience participants are not explicitly told which outcomes are associated with each option but instead have to remember what happened previously and adjust their behavior accordingly.

There are many differences in how people choose by learning from description or from experience. One flaw of earlier decision-making theories is that they did not seriously consider this distinction and mostly focused on decisions from description. For example, Prospect theory states that people should be more risk-seeking for losses than for gains; however, more recent evidence suggests that in decisions from experience, people are more risk seeking for gains than for losses (Ludvig, Madan & Spetch, 2014). Another worthy distinction is the tendency to overestimate rare events in choices from description but underestimate rare events in choices from experience (Hertwig et al., 2004). Shteingart, Neiman & Loewenstein (2013) have also shown the first outcome to be especially important in learning from experience. In a task where participants had to choose from experience between a safe option giving a fixed amount and a risky option with a fixed probability of giving high or low monetary rewards, the outcome of the first risky choice had substantial and lasting effect on behavior. This possibly can be due to the primacy effect in memory which makes us more likely to remember the first outcomes of a new sequence (Sederberg et al., 2006)

Memory and decision-making

A new line of work has looked at the link between episodic memory - the ability to learn and recall specific details – and adaptive decision-making. Murty, FeldmanHall, Hunter, Phelps and Davachi (2016) found that participants had to remember previously learned associations between lotteries and experienced rewards to choose lotteries adaptively. Wimmer and Shohamy (2012) have shown rewards associated with certain items to spread to other similar but previously unrewarded items, such that participants started choosing rewards that previously had never been rewarded. Duncan & Shohamy (2016) found that showing familiar scenes induced episodic memory use and made participants more likely to remember and chose high-valued objects they had encountered before.

Madan, Ludvig & Spetch (2014) have more specifically investigated the role of memory in learning decisions from experience. They hypothesized an extreme-outcome rule where extreme outcomes in risky choice are remembered with more salience (Talarico & Rubin, 2003) and hence are given more weight when choosing from experience. Since people value losses more than wins, heavy loses should be better remembered than heavy wins, making people more risk-seeking for wins than for loses. This theory is supported by recent findings which have found people to be more risk-seeking for wins than for loses in decisions from experience (Ludvig, Madan & Spetch, 2014).

To test their hypothesis, they designed a task where participants choose from experience between two options. Participants learn from experience to choose between a moderate gain and a 50% chance to give double the amount and a 50% chance to give nothing. They also had to learn to choose between a moderate loss or a 50% chance to lose double or nothing. At the end of the experiment they asked participants what was the first outcome that came to their mind for

each option. Consistent with the extreme-outcome rule, people who remembered the high reward from the gain choice with risk were more risk-seeking in positive choices, and people who remembered the heavy loss from the risky loss choice were less risk-seeking in loss choices. This effect did not generalize to choices from decision (Madan, Ludvig & Spetch, 2016), suggesting that memory for extreme-outcome specifically influences risk-seeking in decisions learned from experience and not for the ones learned from description.

What has not been explored is how episodic memory might influence risk preferences when the expected value between options is held constant. To investigate this, we used a technique recruiting episodic memory processes and explored the consequence of this manipulation on risk preferences during decision-making. This episodic specificity induction technique (Madore & Schacter, 2014) consists of a short interview that requires people to either recall specific or more general details. This episodic specificity induction has been shown to lead to better performance on a social problem-solving task (Madore & Schacter, 2014) and also increased the number of internal details in remembered past and future experiences (Madore, Gaesser & Schacter, 2014). After this manipulation, we administered the decision-making task from experience designed used in Madan et al. (2014). This task requires participants to choose between risk and safe options. Both options have the same expected values, and participants learn these values by themselves. At the end of the study, we asked participants what outcome first came to their mind when thinking about the risky option.

Following the extreme-outcome rule proposed by Madan et al. (2014), we hypothesized that the episodic specificity induction might strengthen the memory bias people have for extreme outcomes. Since the task we used involves gains, we hypothesized the episodic induction might make participants more risk-seeking. If the extreme-outcome rule is correct, this also implies that

people should tend to recall the extreme outcome more. We also wanted to see if the first outcome that people experience after choosing the risk option would heavily impact their risk preferences, since we hypothesize the findings from Shteingart et al. (2013) might be related to the primacy effect (Sederberg et al., 2006).

Methods

To investigate if episodic memory lead to more risk-seeking in gains, we designed an experiment where we probed participants to retrieve memories in either an episodic or general way. We then measured their behavior on the same gambling task used in Madan et al. (2014). The second experimental manipulation consisted of the first outcome that occurred when participants chose the risky option for the first time. This study was initially conducted as a 2-way mixed design with every participant undergoing the same procedure twice. However, since the results showed very strong carryover effects, we here report the results as a 2-way between-subjects design.

Participants

This study aims to recruit 48 participants. However, the current preliminary sample consists of 30 participants. This sample includes 23 females (mean age = 23.6, sd = 4.48) and 7 males (mean age = 22.8, sd = 0.98). One participant in the general condition was excluded from the analysis because she chose the safe option 98% of the time. People were recruited through McGill's classified ads system. The study lasted an hour and participants were paid 10$ for their time and received a bonus amount of approximately 2.50$ (mean = 2.48$, sd = 0.08$). This study was approved by McGill's Research Ethics Office (REB).

Episodic specificity induction

We started by inducing an episodic specificity or control induction in each participant by following the procedure of Madore et al. (2014). The episodic specificity induction is an experimental manipulation that has been inspired from the Cognitive interview, which has been shown to enhance the number of accurate details eyewitnesses can recall about events (Memon, Meissner, & Fraser, 2010). The participants first watched a 4-minutes long Mr. Bean video and were told to pay close attention to it and that questions would be asked afterward.

At the end of the video, participants were interviewed and asked different questions depending on whether they were randomly assigned to the episodic or control condition. In the episodic condition, participants were first asked to describe as many specific details as they could remember about the surroundings. They were then asked to do the same about the physical appearances of the people in the scene. Finally, they were asked to describe the actions in the video in chronological and in as much detail as they could remember. In the control condition, participants were asked more general questions about the video (e.g. to give adjectives that describe the actions, how they thought the video was made, etc.).

Choice task

The choice task used was inspired from Madan et al. (2014). On each of 100 trials, participants chose between two doors which both yielded real-monetary rewards. After choosing a door, participants were shown the reward they received from that door. Participants were not told beforehand the possible outcomes associated with each door; they had to learn the task from their own experience. One of the doors was safe and always yielded a reward of 1.25 cents, while the other door was designated as the "risky" door and had a 50% chance to give 2.5 cents and a 50% chance to yield nothing. Participants performed 100 trials of this task per session.

First outcomes manipulation

We wanted to see if we could replicate the outcome primacy effect obtained from Shteingart et al. (2013) in a setting where it is not possible for participants to get two wins or loses straight when first choosing the risk option. We manipulated the first four outcomes participants obtained when choosing the risky door: They either first received win-loss-win-loss (the "first-win" condition) or loss-win-loss-win (the "first-loss" condition). Since we suspected the second, third and fourth first outcomes might also strongly affect participants' risk preferences, the first outcome manipulation allowed us to systematically evaluate the impact of the very first outcome on risk preferences.

Memory tests

We wanted to see if our experimental manipulations might influence participants' memories of the outcomes they received in the task, and if the memory of the outcomes guided behavior. We assessed participants' memories right after the choice task by asking them what was the first outcome that came to their mind, following the procedure from Madan et al. (2014).

Results

The following results are preliminary and include 30 of the 48 participants that will compose the full sample. Due to pure chance, the number of participants in the first-win and first-loss conditions unfortunately happened to be quite unequal. There are 10 participants in the episodic and first-win condition, 5 participants in the episodic and first-loss general condition, 10 participants in the first-win and episodic condition, and 5 participants in the first-loss and general condition. This unbalance will be removed when we collect the full sample.

We conducted our analysis using a logistic mixed regression model with risky vs safe choices as the dependent variable. Conducting our statistical tests with a between-subject analysis would mean breaking the assumption of independence, since it would not consider the correlation between trials arising from the same participant. However, analyzing the average response of each participant under the linear regression framework would lead to an overestimation of the variance in our sample, since the variance would be calculated using the number of participants rather than the number of trials. A logistic mixed regression model conforms to both requirements.

To test the effects of memory and first outcome conditions on risk-taking behavior, we ran a logistic mixed regression model which revealed no main effect of trial ($p = 0.89$), no main effect of memory condition ($p = 0.45$) and a trending interaction between trial and memory condition ($p = 0.078$, see figure 2). Within the same model, we found no main effect of first-outcome condition ($p = 0.31$) and a significant interaction between first-outcome condition and trial ($p = 0.0025$, see figure 3). Within the same model, we found no main effect of first outcome

to mind ($p = 0.36$) and a significant interaction between first outcome to mind and trial ($p = 0.003$, see figure 4).

Some of these independent variables are highly correlated, and it is somewhat inappropriate to include them in the same model. For this reason, we re-ran the previous analysis with every independent variable and its interaction with trial into separate models. The only difference in significance was the interaction between memory condition and trial which changed from being trending to significant ($p = 0.0007$). This is likely due to the correlation between memory condition and the first outcome that comes to mind (see table 2 and figure 5).

Source	Estimate	Std Error	Z-score	P-value
A: trial	-0.020	0.144	-0.136	0.892
B: condition	0.126	0.168	0.757	0.449
C: First outcome condition	-0.160	0.158	-1.011	0.312
D: First outcome to mind	-0.153	0.167	-0.904	0.366
A x B (Interaction)	0.266	0.151	1.764	0.078
A x C (Interaction)	0.442	0.146	3.022	0.003
A x D (Interaction)	0.460	0.157	2.933	0.003

Table 1: Effect of different factors on the development of risk preferences

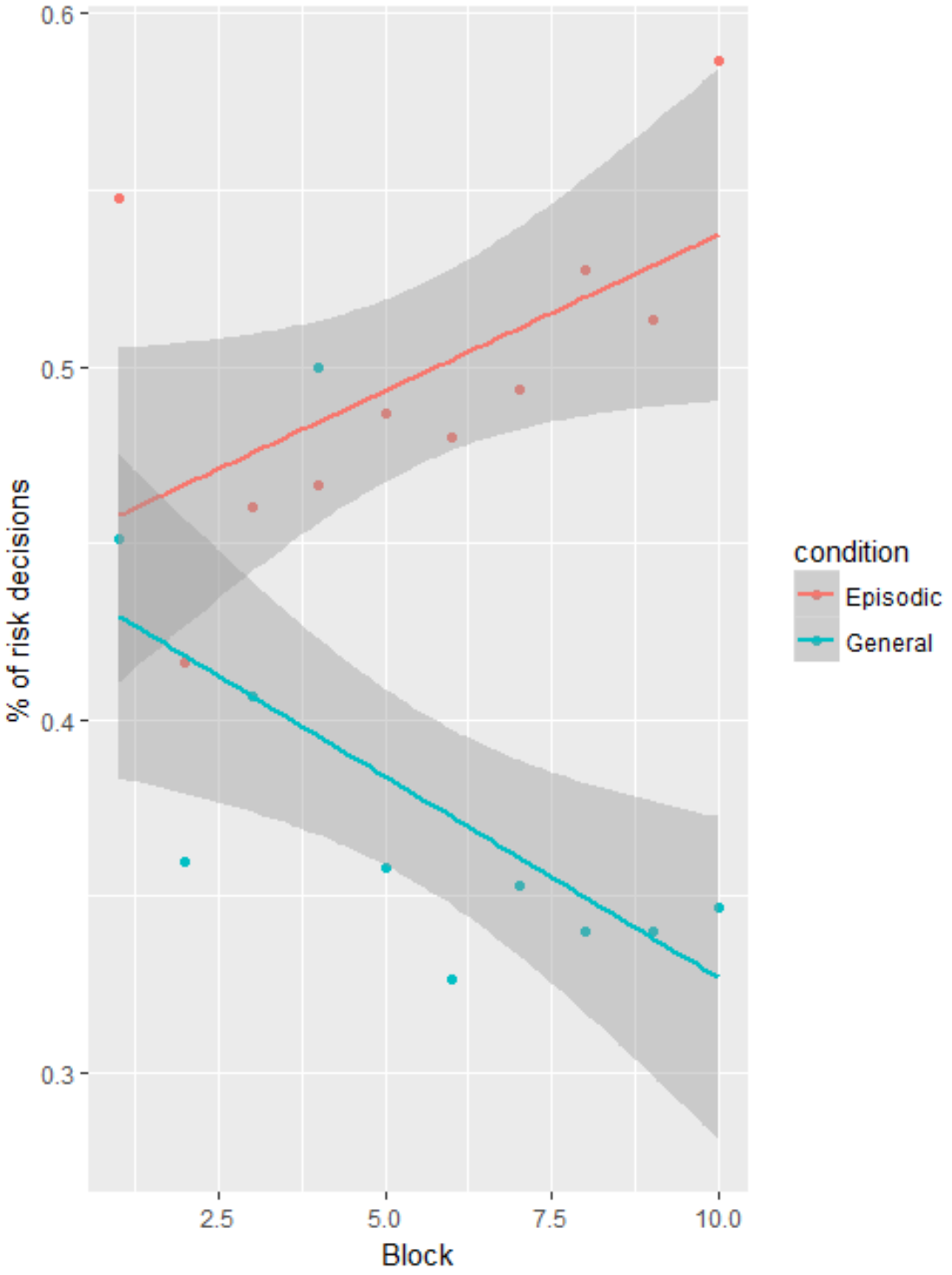

Figure 2: Risk preferences across trials in the episodic and general conditions

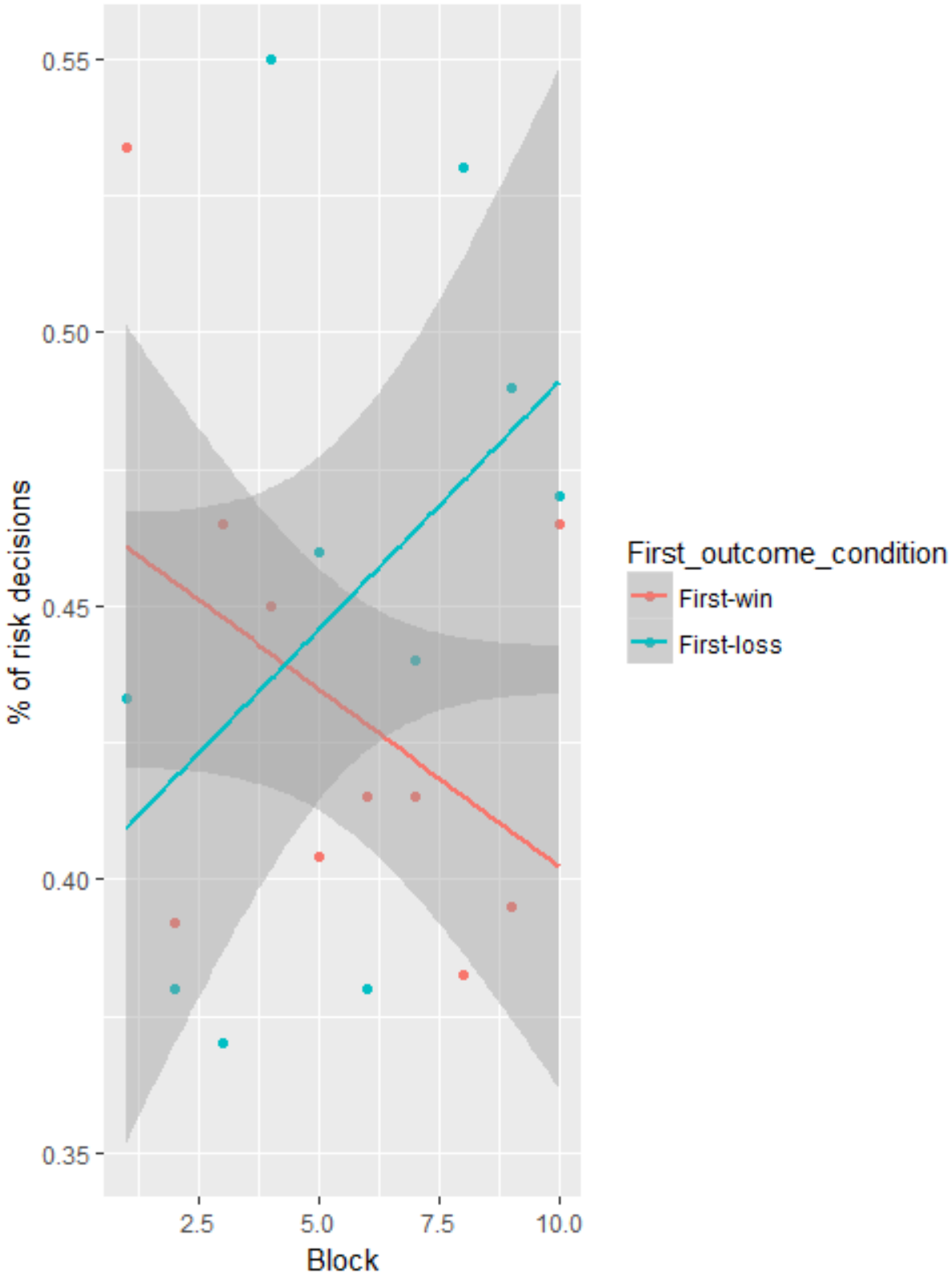

Figure 3: Risk preferences across trials in the first-win and first-loss conditions

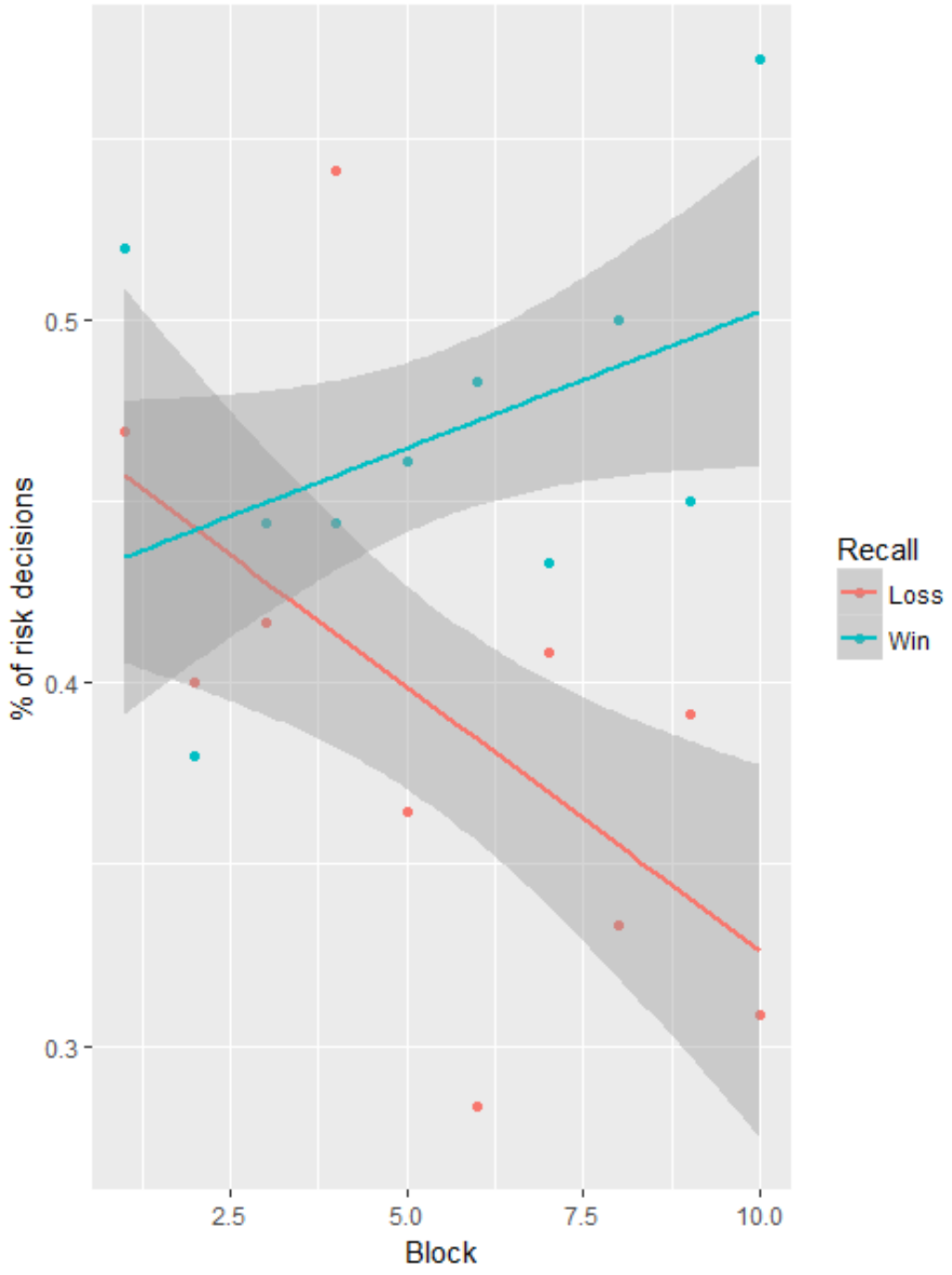

Figure 4: Risk preferences across trials when a win and a loss was the first outcome to come to mind.

We also investigated whether the episodic specificity induction influences memories of outcomes associated with the doors – that is, the outcome participants reported as being the 'first one to come to mind' when shown the risk door. We ran a logistic regression model with memory and first outcome conditions as the independent variable and the first outcome to come to mind as the dependent variable. The model revealed a trending main effect of memory condition ($p = 0.056$), but no main effect of the first outcome ($p = 0.32$) or interaction between the two ($p = 0.32$) (see figure 5 and table 2).

	Estimate	Standard Deviation	Z-score	P-value
A: Memory condition	0.853	0.447	1.91	0.056
B: First outcome condition	0.448	0.447	1.00	0.316
A x B (Interaction)	0.448	0.447	1.00	0.316

Table 2: Effect of memory and first outcome conditions on the first outcome that came to mind when seeing the risk option.

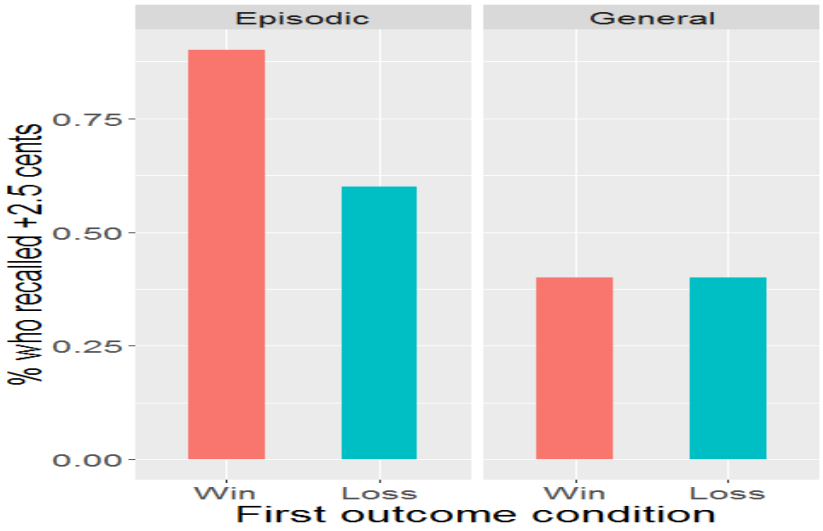

Figure 5: Number of people who recalled the positive outcome (+2.5 cents) when seeing the risky door, in different memory and first outcome conditions.

Discussion

We found that the episodic specificity manipulation changed how the participants' risk preferences evolved during the experiment. The two groups initially had approximately the same levels of risk preferences. However, people in the general condition tended to become more risk-averse as the experiment progressed, and participants who underwent the episodic specificity induction showed the opposite pattern: They became more risk-seeking. This suggests that episodic memory may play a role in the extreme-outcome rule: episodic memory seems to strengthen the memory bias we have for extreme outcomes, which here made people more risk-seeking over time. We obtained support for this theory by showing that participants in the episodic condition also tended to recall winning more when thinking about the risky option (even though this effect is currently trending, we expect to reach significance in the full sample). This suggests a mediation model, where the episodic specificity induction leads to more risk-taking in decisions between gains due to a bias in memory for remembering past extreme positive outcomes associated with risk. Such a model is supported by the fact that the effect of memory condition on the development of risk-taking preferences went from very significant to trending when both memory condition and recall where included in the same model. However, more specific statistical analyses and collection of the full sample will be needed to confirm this hypothesis.

We were also able to replicate the first-impression effect found by Shteingart et al. (2013). However, we found a somewhat different pattern: in their findings, participants start with high or low risk preferences depending on the first outcome they experienced. In our sample, people started at around the same point and became risk-seeking or risk-aversion depending on the first outcome. However, due to the imbalance in our sample, these results (and others as well)

should not be taken as definitive. The unbalance makes it possible for some of the effect due to the memory induction to be attributed to the first outcome, and vice-versa. We will have to wait for the full sample before drawing definitive conclusions. Even so, it is encouraging to see that the first-impression effect might still apply even in a more controlled setting where everyone receives the same amount of rewards in their first risky decisions, in a different order.

There are also other theories that could potentially explain how episodic memory might enhances risk-seeking. Previous research has found an association between improved episodic memory and well-being. In (Jing, Madore & Schacter, 2016), an episodic specificity induction enhanced positive affect, lowered negative affect and decreased the perceived likelihood of a bad outcome occuring. Training people's autobiographical episodic memory also has been shown to help with depression and anxiety disorders (Hitchcock, Werner-Seidler, Blackwell, & Dalgleish, 2016). Episodic memory could therefore enhance risk-taking through positive mood, since mood has been shown to increase risk-taking (Schulreich et al., 2014; Otto, Fleming & Glimcher, 2016). A possible mechanism for this has to do with findings from Wimmer and Shohamy (2012), who have found that the hippocampus seems responsible in spreading rewards to other similar memories to the one associated with the reward. This would mean that for people under the episodic induction, memories of losing from the risk option might progressively get contaminated by memories of winning. Such a hypothesis could be investigated further by measuring mood and affect throughout the study.

A limitation of the current findings is the amount of risk-taking in the episodic condition (49.8% across first outcome conditions) which is closer to previous results from Madan et al. (2014) (45%, with N = 114) than the general condition (37.8%). They did not use a memory

manipulation, hence risk preferences in our condition should be closer to their results than risk preferences in the episodic condition. The general condition is meant to be a control condition with most of the aspects of the episodic specificity induction, but without asking participants to recall specific memories. However, this raises the question of whether the differences observed can be attributed not to the episodic condition, but instead to the general one. To investigate this, it would be possible to replicate the current study without using any experimental manipulation task for memory.

In conclusion, we have demonstrated that the use of episodic memory makes people more risk-seeking. This might possibly by explained by the participants' enhanced recall of positive outcomes in the episodic condition. We also replicated the first-impression effect from Shteingart et al. (2013) in a more controlled setting. However, we will have to wait until we collect the full sample before drawing definitive conclusions. If the current results still hold, it would be very interesting to re-run the same experiment with losses. This could potentially distinguish between the two theories proposed here as to how episodic memory influences risk preferences.

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Statement of contribution

I wrote the ethics application to the REB committee to get it approved. I programmed the decision task used in the experiment in python (using previous code for another task). I implemented the design into an experiment and wrote the scripts for it. I tested all 30 participants in the study so far. All data extraction and formatting was done by me using R. All the data analyses were done by me. The study was mainly designed by Ross Otto and Signy Sheldon, but I also took part in the design of the study. The final paper was written by me. The structure for the introduction was suggested by Signy Sheldon and the paper was previously reviewed by Ross Otto.