Abstract

Whether it is to stay on the same course of action or to shift to another, explorations are important to justify the choices made. Choice ecology plays a major role in the different searching behaviours of people. In this study, the searching patterns of people are considered when subjected to losses or gains sampled from continuous distributions, and this difference is explored for particular decision making tasks and tasks that follow. It was noted that the attention payed to the tasks are also based on the choice ecology where participants payed more attention to tasks involving losses and when they are switching between options. While participants in this study are asked to complete various decision making tasks involving losses and gains without prior knowledge, it is seen that the searching patterns differ in the loss and gain domains. The delayed effect of losses on over exploration in tasks following losses sampled from discrete distributions were not seen when the payoffs were sampled from continuous distributions.

1 Introduction

1.1 The description-experience gap

Decisions from description are those decision making problems or tasks which involve *priori probabilities* (Knight, 2013) where the participants are provided with a complete and abstract set of instructions (Weiss-Cohen, Konstantinidis, Speekenbrink, & Harvey, 2018) regarding the distribution of the possible outcomes of all the choices before the decision is made in order to help the participants to make an informed choice. However, in the normal day-to-day routine, people rarely read, understand and apply these descriptions of probability distributions. They rely on information gained from previous experiences with the available options in most decision making scenarios. Hence, they make *decisions from experience* rather than decisions from description.

Decisions from experience are those decision making problems or tasks which involve careful considerations of *statistical probabilities* (Knight, 2013). They do not provide any prior information about the choices to the participants and the participants are forced to rely only on their own insights about the distribution of the possible choices using the feedback they receive from the previous trials (Weiss-Cohen et al., 2018).

While comparing final decisions in the same decision making task where there are explicit descriptions for each option and where participants have to make their own conclusions about the options, a systematic gap between the two choices is seen (Hertwig & Erev, 2009). In the study conducted by Hertwig and

Erev in (2009), participants were given a choice between a risky option with two outcomes and a safe option. This was tested in 3 different experiential paradigms namely, *sampling, partial feedback* and *full feedback paradigms*.

In the *sampling paradigm*, participants are allowed to sample the options as many times as they want to gain insight about the distribution of the options. They are then asked to make a final decision between the options based on their insights. In the *partial feedback paradigm*, each choice made by the participants contribute to their final earnings and they receive information about the chosen option after each trial. The *full feedback paradigm* is similar to the partial feedback paradigm. Here, the participants receive information about all options after every trial. In the above three paradigms, participants were inclined to select the risky option when the advantageous outcome had a high probability and the safe option when the advantageous outcome had a low probability. In other words, people tend to *underweight* rare events (Lejarraga, Hertwig, & Gonzalez, 2012). They are more risk seeking in gains than in losses (Weiss-Cohen et al., 2018). In decisions from description, however, this tendency is reversed. People tend to *overweight* rare events (Lejarraga et al., 2012) and are more risk seeking in the loss domain (Weiss-Cohen et al., 2018).

1.2 Exploratory search in decisions from experience

Choosing among options without prior knowledge or information regarding the options leads to exploration of the given options. Exploration of options plays a vital part in making decisions from experience. When you walk into an ice cream shop, the fancy names of all the flavours can be overwhelming. Usually, you are given a chance to explore the flavours first by tasting small spoonfuls of various options before you are asked to make a final choice. Similarly, trying out the fit of different clothing apparels before choosing the final one, reading the blurbs on the back of various available books before buying one that catches your eye, to name a few involves exploration. The *cost-less exploration* is often followed by the final costly decision, in this case, buying your favourite flavour of ice cream, a clothing apparel that fits and buying a book that interests you. All the examples above follow the sampling paradigm. This paradigm helps to understand the *"behaviour, processes and strategies"* (Gonzalez & Dutt, 2016) of exploration.

However, this is not always the case. The feedback paradigm is categorised by *costly exploration*. Consider the scenario where you have to move to a new city. You need to find a new doctor, restaurants and cafes you like, a new hairdresser or parlour, a quite place to work or take a walk, a library or a

bookstore, cinema theatres or bowling alleys, a bar or a club, and countless other decisions. You have a whole city wide spread options to choose from. It takes time (and sometimes, money) to explore and find places that interest you. These examples constitute *costly explorations*. These explorations made in the experiential decision making process provide outcomes along with information (Hills & Hertwig, 2012). This causes the dilemma of *exploration vs exploitation*: *"The agent has to exploit what it already knows in order to obtain reward, but it also has to explore in order to make better action selections in the future"* (Sutton & Barto, 2018). Once you find a good restaurant, you can choose to continue eating there or you could try the new cafe across the street. You could take a walk in the quiet and peaceful park in front of your apartment or you could walk across the bridge on the other side of the city.

Many decisions in life are categorised by the balance between exploring options for information and exploiting the corresponding rewards (Mehlhorn et al., 2015). While the properties of choice ecology and the cognitive abilities of the decision maker explain search in decisions from experience (Lejarraga et al., 2012), an affinity towards these properties are caused by the unequal exploration of a payoff distribution (Lejarraga & Hertwig, 2017). While considering negative and positive experiences, negative experiences seem to have more impact on people's lives than positive experiences (Rozin & Royzman, 2001; Vaish, Grossmann, & Woodward, 2008). The question that arises here is: *Do losses invoke more search than gains?*

Considering exploration in terms of the *ecology of choice* i.e. choices involving losses and gains, it is seen that people usually tend to explore the options more when faced with the threat of losses than the promise of gains (Lejarraga et al., 2012). This causes a *loss-gain asymmetry* in search exploration. However, the search was not incentivised. The experiment followed the *sampling paradigm* which constitutes *cost-free exploration*. This asymmetry was later generalised to also include situations where explorations were *costly* (Yechiam, Zahavi, & Arditi, 2015). The question that remains is: *Why does asymmetry in exploration emerge?*

Loss Aversion (Tversky & Kahneman, 1992) states that people are more sensitive when faced with the chance of losing something than the chance of gaining something of similar value. The *Endowment Effect* (Kahneman, Knetsch, & Thaler, 1990) is a behavioural phenomenon where people tend to value a particular commodity already in their possession more than a similar commodity of similar value that they can purchase. The *Status Quo Bias* (Samuelson & Zeckhauser, 1988) shows people's disproportionate preference to maintain the status quo in the fear of losing it. In cases of decisions under certainty, the threat of losing shows a greater difference in performance than gaining a reward of similar value (Costantini & Hoving, 1973). Psychologically, losses tend to trigger increased arousal than similar

gains (Gonzalez, Dana, Koshino, & Just, 2005; Löw, Lang, Smith, & Bradley, 2008). *"Losses lead to heightened autonomic responses, compared to equivalent gains (as indicated by pupil dilation and increased heart rate) even in situations where the average decision maker exhibits no loss aversion"* (Hochman & Yechiam, 2011).

Lejarraga and Hertwig (2017) states that *"the loss–gain exploration asymmetry does not predict or translate into loss aversion in choice." Loss Aversion* (Tversky & Kahneman, 1992), a basic assumption in psychological and cognitive behaviour of people when faced with losses, was demonstrated in risky decisions. The concept that losses have more subjective weight than gains with similar values drives people to avoid losses. However, situations with feedback were found to be inconsistent with the above assumption (Ert & Erev, 2013).

Yechiam and Hochman (2013b) conducted 13 studies to examine decisions from experience. No evidence of loss aversion was found in any of the studies. An alternative idea that was presented in Yechiam and Hochman (2013a) was that the prospect of losses increases attention than the prospect of equal gains, termed as *Loss Attention*. Losses capture the attention of people as they are wary of more losses. This difference creates the *attention-aversion gap* where loss attention shows a general awareness and caution towards the threat of a loss, which is a *"necessary but not sufficient condition"* (Yechiam & Hochman, 2013a) for loss aversion.

When faced with losses, people are more attentive to avoid further losses and thereby, react slower. They take time to deliberate whether to stay on the same course of action or to switch between options in order to minimise losses. The threat of loss encourages people to search for other possibilities, either to avoid losses or to minimise the losses. This inevitably, leads to more switching between choice options (Yechiam et al., 2015). Hence, it begs the question: *Can loss attention explain the asymmetry in the experiential exploration?*

1.3 Loss restlessness and gain calmness

Recently, losses are seen to have effects that are not consistent with loss aversion but arise due to the impact of loss attention (Yechiam & Hochman, 2013b). Two opposite effects of losses on searching behaviour have been outlined in Yechiam et al. (2015). Boredom can be the cause of increased exploratory search between options (Aston-Jones & Cohen, 2005). Since losses increase arousal and attention (Gonzalez et al., 2005; Löw et al., 2008; Yechiam & Hochman, 2013a), the levels of boredom can be decreased. Hence, losses invoke decreased searching behaviour. However, the increased arousal and attention caused

due to the presence of losses, would encourage the behaviour of exploring other possibilities (Yechiam et al., 2015). Schneider (1992) argued that when faced with losses, people tend to be conflicted since the expected outcomes of any given option does not satisfy their own aspirations. Hence, there should be increased searching behaviour in the loss domain.

The attentional model for losses show that the effect of losses is not confined to the particular problem (Yechiam & Hochman, 2013b). It was observed that there was a delayed effect of losses on the switching behaviour amidst choices in tasks and problems that followed. Yechiam et al. (2015) first identified *Loss Restlessness* as *"increased tendency to switch choices following prior tasks with losses."* The exploratory search behaviour among options that did not contain losses however, seemed to have an opposite *calming* effect. *Gain Calmness* was identified as *"decreased choice switching following prior tasks producing gains"* (Yechiam et al., 2015).

Building on the study conducted by Lejarraga et al. (2012) which outlined the positive effect of losses on search behaviour in the sampling paradigm, Yechiam et al. (2015) extended it to include costly explorations using the feedback paradigm. Additionally, the delayed effect of losses on subsequent tasks were also considered. The first experiment conducted in the paper consisted of 4 decision tasks with two choice alternatives (risky and safe options) each where 2 involved possible outcomes of gains and 2 involved possible outcomes of losses, each with 100 trials. The order of the tasks were randomised. The outcomes were randomly sampled from discrete distributions consisting of either low payoffs or high payoffs. Each participant completed all 4 tasks with gain and loss outcomes. The main dependent variable was the switching between options which was represented by calculating the mean run size, the number of consecutive selections of the same option, for each task. The results showed that the run sizes were smaller in tasks consisting of losses showing the increased switching behaviour when faced with losses. Compared to the participants who performed a loss task first, those who performed it after the two gain tasks had larger run sizes.

This project aims to replicate Experiment 1 in Yechiam et al. (2015) with a few extensions to include the attentiveness of participants when faced with losses or gains. From past research, it was expected that participants would explore the options more when they are faced with losses rather than gains. As seen in Yechiam et al. (2015), it was expected that tasks with losses would be seen to have shorter run sizes. It was also expected that if participants were presented with gambles involving losses before gambles involving gains, the tendency of over-exploration in the loss domain would carry over to subsequent choices between gambles that involved gains i.e. shorter runs would be seen in tasks with no losses when they are followed by tasks involving losses. This study aims to replicate these results.

In addition to the above, an extension regarding loss attention is also explored. Loss attention can be measured using the response times of participants to the tasks. Here, it is predicted that the deliberation lengths (i.e., response times) differ between gambles with losses and gambles with gains. Participants are expected to have shorter response times when exploring gambles with gains than gambles with losses. In the original paper, each option only led to no more than two possible monetary outcomes. In this study, the payoff distributions will be changed to continuous distributions to investigate if the original results generalise.

2 Method

2.1 Participants

One hundred and fourty-nine participants (49 identified as females, 97 identified as males, 1 identified as non-binary, 2 preferred not to reveal their gender) with a mean age of 31.7 ± 9.45 years participated in the study conducted on a paid experimental multiple-block choice game online. Participants were recruited through Prolific (*Prolific*, 2014), an online research platform that employs diverse participants from all over the world to various experiments and studies. Each participant is paid £2 for their participation along with additional payments up to £2 depending on the final number of tokens they have collected through the game. If the number of tokens are negative, the participants will not receive any additional payments. Multiple responses from participants were eliminated. The responses recorded when the consent of participants were not explicitly given were also eliminated. While no participant was eliminated due to their responses, there were outliers found during the analysis. Corresponding to the respective analysis, the outliers were eliminated promptly.

2.2 Procedure

In this study, which lasted for a median time of about 9 minutes, participants were asked to complete a multiple-block choice game. Participants started the game with zero tokens. They were presented with two choice gambles with no prior information about the choices. They were expected to choose between the options for 50 trials with a risky and a safe alternative in each trial. After each trial, the participants earned or lost a certain number of tokens. These tokens contributed to the final number of tokens. There were 4 such blocks to be completed one after the other. 2 blocks consisted of possible outcomes involving gains and 2 blocks consisted of possible outcomes involving losses.

Table 1

Payoff Distributions for the Loss and Gain Choice Alternatives with Low and High Payoffs

Condition	Safe Option	Risky Option
Gain-Low	Win 15-25	50% get 0, 50% win 35-45
Gain-High	Win 95-105	50% get 0, 50% win 195-205
Loss-Low	Lose 15-25	50% get 0, 50% lose 35-45
Loss-High	Lose 95-105	50% get 0, 50% lose 195-205

Participants either completed the gain tasks first followed by the loss tasks or vice versa. The order of the tasks were randomised for which the participants did not have prior knowledge. The options containing the risky and safe outcomes were randomised for each participant and each block. When the participants chose between the safe or risky option, the outcomes were then sampled from predetermined continuous uniform payoff distributions as given in Table 1. The payoffs were rounded off to the nearest whole numbers as people usually tend to ignore decimal places. They consisted of either low monetary payoffs or high monetary payoffs in the loss and gain domains. The order of the low and high payoffs were also randomised for each participant and each block. Since the payoffs were continuous, the possible outcomes were not a single value for the safe option and one of two values for the risky option. The outcomes were within a given range.

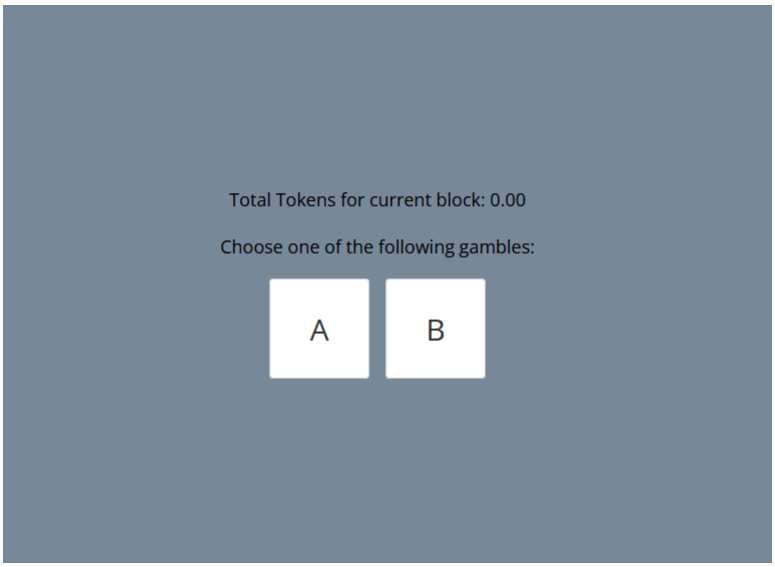
The complete instructions for the game and the additional payment structure are given in Appendix A. An image of the game screen is shown in Figure 1. The development of the game was done in JS-Psych (De Leeuw, 2015) and the data collected was stored in the Pavlovia (*Pavlovia*, 2002) server. The data was then downloaded and cleaned using Python while all the analysis was done in R Studio.

3 Results

While all participants completed all four tasks with gains and losses, 54% of the participants completed the gain tasks first followed by the loss tasks and 46% completed loss tasks first followed by the gain tasks. Throughout the experiment, it was seen that 62% of choices made by the participants corresponded with the safe option and 38% of the choices corresponded with the risky option.

Figure 1

The Screen Setup for the Experiential Choice Game in the First Trial of the First Block

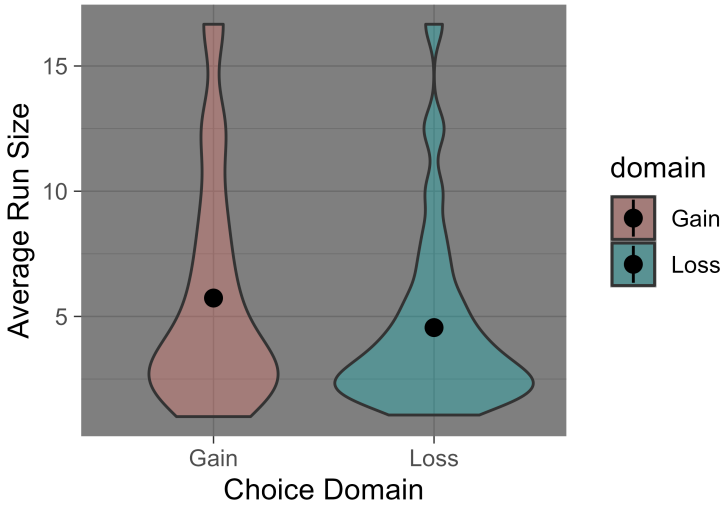


3.1 Do participants explore the options more if the gambles involved losses rather than gains?

Firstly, to understand the exploratory searching behaviour of participants when faced with losses and gains, the average run sizes for each participant within each block were calculated. These values were visualised to find the presence of outliers. Once the outliers were eliminated by ignoring values above and below the third and first quartile of the data respectively, it was seen that average run size in the gain domain (approx 5.73) was slightly higher than that of loss domain (approx 4.55). Figure 2 visualises the differences in a violin plot with the mean run size for each domain.

Figure 2

Mean and Distribution of the Average Run Sizes in the Gain and the Loss Domain



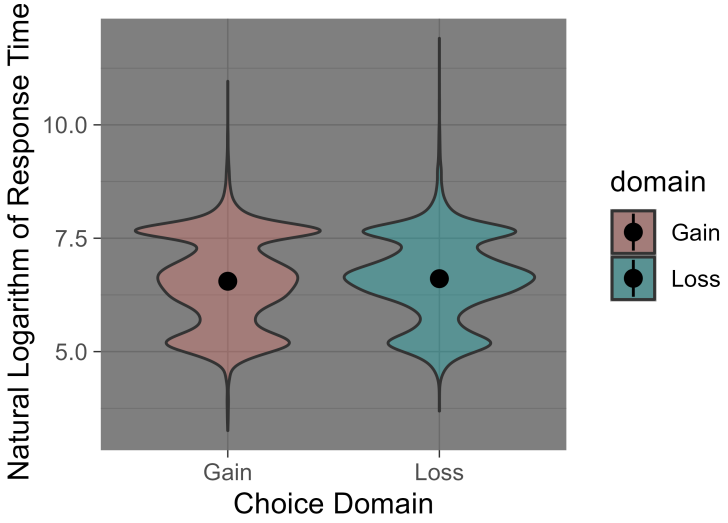
Secondly, to test the significance of the mean difference between the average run sizes of the two domains, a linear fixed effects model was also used on the data. It shows a statistical significant (diff = -1.2932, SE = 0.2712, df = 404.8207, t = -4.769, p = 2.59e-06) effect of domain on the average run size which indicates that participants have shorter average run sizes when they are faced with losses. Greater lengths of run sizes indicate lesser switching between options. Hence, we can conclude that *there is an increased exploratory searching behaviour in the loss domain as compared to the gain domain.*

3.2 Do participants deliberate more when exploring gambles involving losses compared to gambles involving gains?

Analysing the response times of participants for the two different domains can show the levels of attentiveness the participants pay to the losses and gains they face. The average response time in the gain domain (approx 1103.702 milliseconds) were slightly lesser that that in the loss domain (approx 1147.209 milliseconds). Taking the natural logarithm of the response times helps to bring linearity in the data. Figure 3 visualises this difference using a violin plot with the mean response time for each domain.

Figure 3

Mean and Distribution of the Natural Logarithm of Response Times in the Gain and the Loss Domain

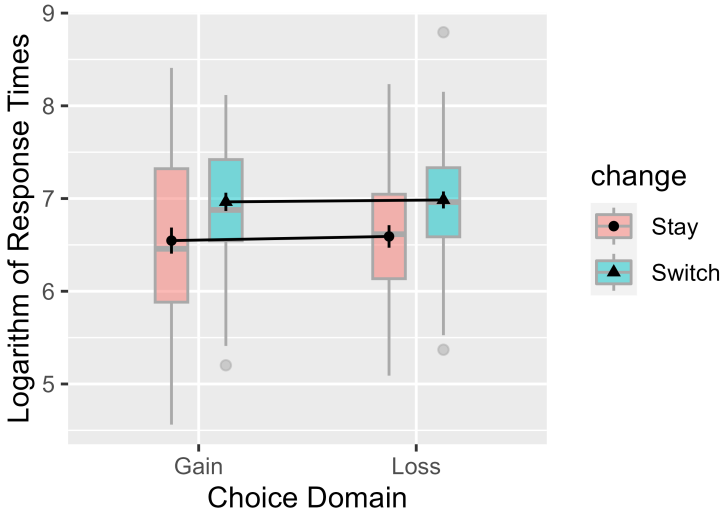


Since the variances of the two groups are not assumed to be equal, a Welch Two Sample t-test is performed. It is seen that there is a significant (t = -5.11, df = 29682, p = 3.324e-07) difference between the log of the response times of the loss and gain domains. Participants take more time to respond to gambles involving losses. Hence, we can conclude that *participants deliberate more when they are faced with losses than gains.*

Further, the response times can also be assessed according to when the participants decide to stay with the same option or switch to the other. For conducting this analysis, for each participant in each block, it was noted whether they decided to Switch or Stay according to their responses. The first choice in every block was considered as Stay. An mixed ANOVA was performed where the choice domain and the change in option were considered as within subjects variables. The logarithm of the response times was chosen as the variable for the participant's attention. Figure 4 shows the representation of the participant's attention as a function of the choice domains and the change in the domains

Figure 4

Response Times as an Effect of the Choice Domain and the Change in the Domain



Here, it is seen that while change in the domain has a significant ($F(1,140) = 89.91$, $p < .001$) effect on the response times, the domain ($F(1,140) = 0.61$, $p = .436$) and interaction ($F(1,140) = 0.35$, $p = .558$) effect do not have a significant effect on the response times. From Figure 4, it is seen that in the gain and loss domain the participants pay more attention when they are switching options as compared to when they stay on the same option.

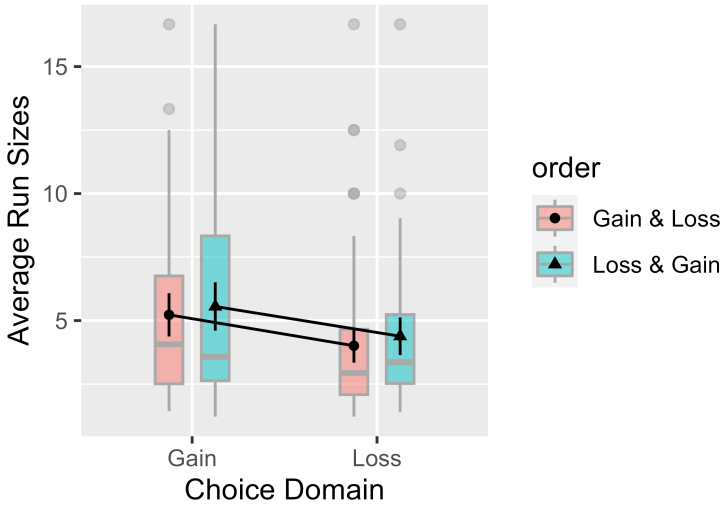
3.3 Does the tendency of over-exploration in the loss domain carry over to subsequent choices between gambles that involved gains?

Loss is often accompanied by increased searching behaviour as stated in Sections 1.2 & 1.3. To find if these effects carry over to the subsequent tasks, after eliminating outliers, a mixed ANOVA was performed where the order of the tasks is considered as a between subjects variable and the choice domain (loss or gain) as a within subject variable using the average run sizes as a variable for the choice switching

behaviour. Out of the 149 participants, 81 of them started the experiment with the gain tasks followed by the loss tasks and 68 of them started with the loss tasks followed by the gain tasks. Figure 5 shows the representation of the exploratory switching behaviour as a function of the choice domains and the order of the domains.

Figure 5

Average Run Sizes as an Effect of the Choice Domain and the Order of the Domain



The results show that domain alone has a significant ($F(1,135) = 0.50$, $p = .48$) impact on the average run sizes. The order showed no significant ($F(1,135) = 15.8$, $p < .01$) impact. The interaction between order and domain also did not show a significant ($F(1,135) = 0.01$, $p = .94$) impact on the average run sizes. From Figure 5 it is seen that under the gain domain, the average run size is slightly higher (diff = -0.327, SE = 0.646, $p = 0.6132$) when it is followed by losses. This shows that compared to participants who performed a gain task first, those who performed it after the loss tasks had larger run sizes indicating more calmness among the switching between options in the gain tasks following the loss tasks. Under the loss domain, the average run size is slightly lower (diff = 0.375, SE = 0.504, $p = 0.4581$) when it is followed by gains. This shows that compared to participants who performed a loss task first, those who performed it after the gain tasks had smaller run sizes indicating more restlessness among loss tasks following the gain tasks. However, these results are not significant as seen by the p-values. Hence, the conclusions and inferences are not supported by the data.

4 Discussion

4.1 Key Findings

The exploratory search behaviour within each choice domain for the respective tasks as shown in Yechiam et al. (2015) has been replicated in this paper when the possible outcomes are samples from continuous distributions unlike the payoff distributions in other papers (Lejarraga et al., 2012; Yechiam et al., 2015). Many reasons can explain the increased search behaviour of losses such as increased arousal (Löw et al., 2008; Gonzalez et al., 2005) and the effects to the autonomic nervous system that control involuntary processes (Hochman & Yechiam, 2011).

The ideas presented in Yechiam and Hochman (2013b) can be collaborated with through the above analysis and results (Sections 3.2). It can also be concluded that attention to the gambles, recorded by the response times, are varied in the choice domains. Participants do seem to pay more attention and deliberate more when they are faced with losses. Increased arousal can also be the reason behind loss attention (Yechiam & Hochman, 2013a, 2013b). It can also be seen that people deliberate more when they are expected to deviate from their current course of action.

Yechiam et al. (2015) outlines Loss Restlessness and Gain Calmness in costly explorations when the possible outcomes are sampled from discrete distribution. The results obtained after conducting a mixed ANOVA does not show this effect when the possible outcomes are sampled from continuous distributions. A possible reason for this difference could be the confusion of the risky and safe options. Since the participants did not receive a single definitive value in the safe option and two in the risky option, it may not have been clear to the participants that there was a risky and a safe option. In cases of decisions from experience, people are more risk seeking in gains than in losses (Weiss-Cohen et al., 2018). Hence the proportion of participants who chose the risky option in gains should be higher than in losses. However, as seen in Table 2, the proportion of risky options in the gains domain is lower than in the loss domain. Aside from the effect of losses on the rapid switching between options, clarity could play a role in the searching behaviour. The mean age of participants of this study is slightly higher than the mean age of participants in the study conducted by Yechiam et al. (2015). This could also be a factor in the differences in conclusions inferred regarding loss restlessness and gain calmness.

Table 2

Proportions of Risky and Safe Choices made by Participants within each Choice Domain

		Choices	
		$Risky$	$Safe$
Domain	$Gain$	0.16	0.33
	$Loss$	0.22	0.27

4.2 Limitations

While using Prolific was an easy and reliable method of recruiting participants, due to some technical difficulties and other related problems, some participants have attempted the experiment more than once. While incomplete experiments were not recorded to the server, the responses from participants with multiple entries were reduced to one response each where the first response recorded was considered for the study. If the participant did not have a Prolific ID, the response was not included. This, however, does not affect the study.

A few participant's reaction time was either shorter or longer than the majority. While none of these responses were eliminated before the start of the analysis of the study, they were eliminated as outliers when reaction time was analysed. There were many outliers seen in the average run sizes as well, which were promptly eliminated as outliers when the analysis was conducted. The association between the response times and the searching behaviour of participants were not explored in this study. This aspect could be explored further to explain the over exploration in losses with increased attention to losses.

4.3 Future Studies

Other robust and powerful methods of measuring loss attention are eye-tracking and measuring arousal through increased heart rates. These measurements of attentiveness may give a clearer picture about loss attention than response times as some participants may be either slow or fast reader which could have affected the response times.

Loss restlessness and Gain calmness can be further explored with continuous distributions. With larger difference between the safe and risky options, the distinction between the two can be made clearer. This avenue has not been explored much. Hence, the effect of various distributions on the behaviour towards loss and gain gambles can be an interesting direction to pursue.

Appendix A Task instruction

After the participants consented to taking part in the study, the following instructions were given:

This experiment should not take more than 15-20 minutes. On the screen you will see two options, A and B. You are required to choose between these options for 50 times(trials) without any prior information. This constitutes one block. You will have 4 such blocks. You will start the experiment with 0 tokens. Each option will correspond to some loss or gain of tokens. Each block has different token values for each option.

When you click on an option, the colour of the option will change to green. The tokens gained or lost will be shown under the choices after each trial. The tokens will accumulate within each block and are shown on the screen. After each block, the total tokens will be shown on the screen before the start of the next block. At the end of all 4 blocks, the accumulated tokens for all blocks will be shown. These tokens will convert to bonus payments you will receive at the end of the experiment.

You will receive £2.00 as a base payment for 15-20 minutes of your time along with additional bonus payments. The additional bonus payments are as follows:

For 0 - 100 tokens, you will receive £0.50

For 100 - 200 tokens, you will receive £1.00

For 200 - 300 tokens, you will receive £1.50

If you get 300 tokens or above, you will receive £2.00

However, if the final accumulated tokens are negative, you will not receive any additional bonus payments over the base payment.

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