Experiment 3

Zijian Zark Wang

April 23, 2024

1 Experiment 3: Causal Manipulation of Attention

1.1 Procedure

Participants are asked to complete a series of choice tasks. These tasks are divided into four parts. At each time there is only one task presented on the screen. Before each part begins, there are 2-3 example tasks to help participants get familiarized with the tasks in the corresponding part.

In Part 1-2, each task is an intertemporal choice task. Each task contains two options: a single immediate monetary reward, presented on the top (the "single" option), and a sequence of two monetary rewards, presented on the bottom (the "sequence" option). Participants are required to choose the option they prefer. When each task begins, both options are not visible. Participants have to click a "Display" button to view the options. They are forced to view the options for at least 1.8s (during this time, their mouse pointer will be hidden) before they are able to make a choice.

In Part 1, after participants submit a choice, they can directly start the next task. In Part 2, after submitting a choice, an additional question will appear on the same screen. This additional question has three options, and participants have to identify which one among the three options is the sequence option of the current task. We inform participants that

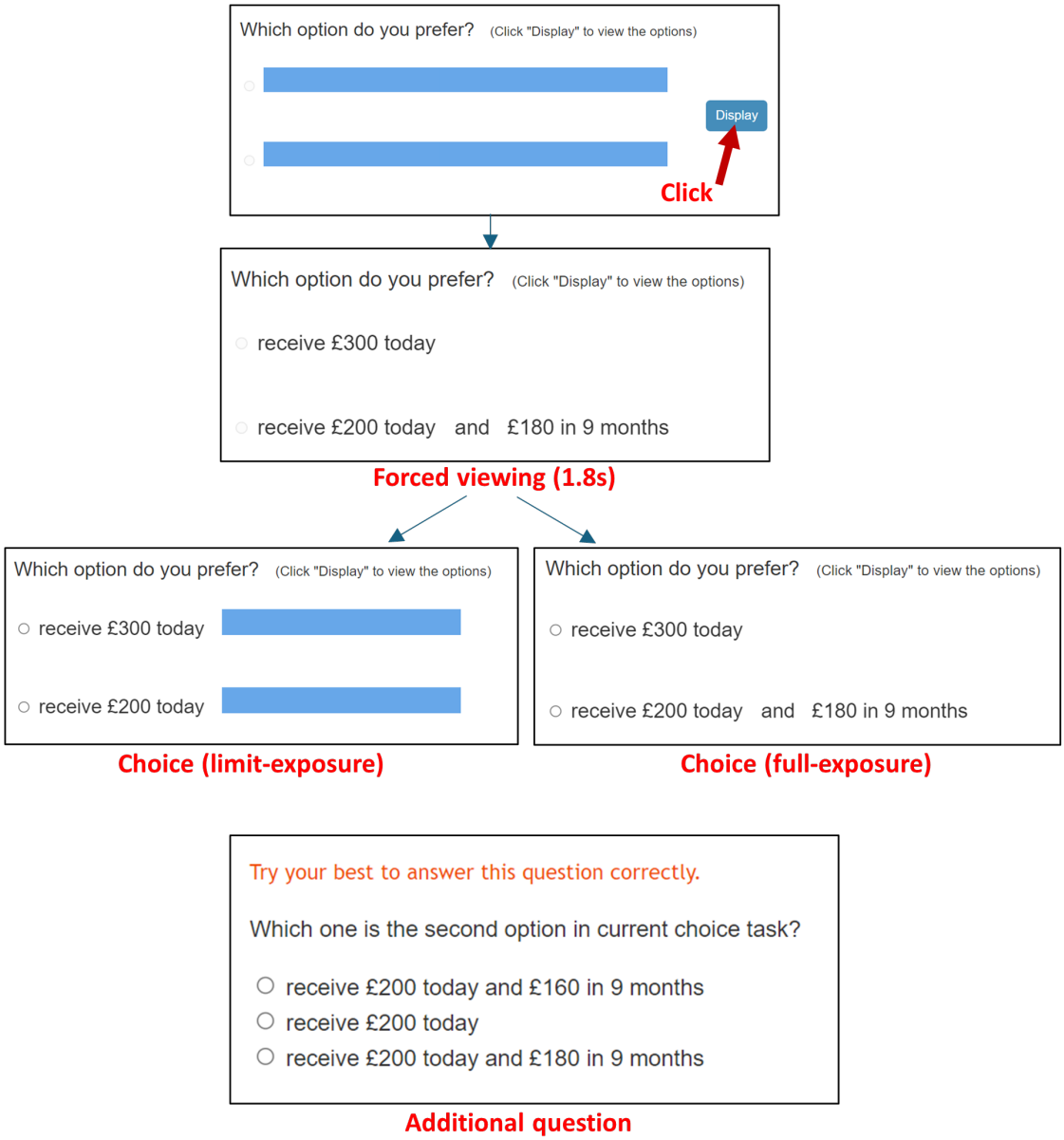
the additional question is to test their understanding and attention to the choice task, and ask them to try their best to correctly answer the question. We name a task followed by an additional question as a task within the "question" part, and a task without such a question as a task within the "no question" part. Figure 1(a) demonstrates an example intertemporal choice task.

Each task in Part 3-4 is called a count-the-rabbits task. Tasks in Part 3 follow the same format as in Part 1; tasks in Part 4 follow the same format as in Part 2. Nevertheless, in Part 3-4 we replace the monetary rewards by some rabbit symbols. In each count-the-rabbits task, there is an option containing a single bunch of rabbit symbols and the other option contains two bunches of rabbit symbols. Participants need to identify which option has more rabbit symbols. In Part 3, participants can directly move to the next task once finishing the choice; In Part 4, following each choice, there is an additional question asking them the exact number of "rabbits" in the sequence option. Figure 1(b) demonstrates an example count-the-rabbits task.[1]

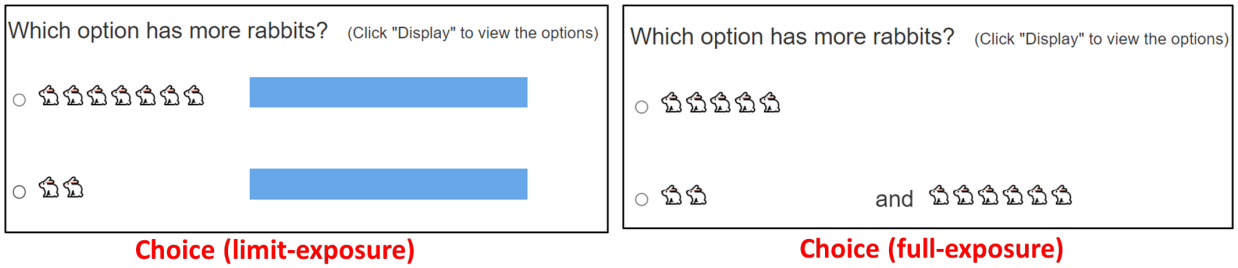
Participants are randomly assigned to two groups. In one group, in each task once both options become visible, they will remain visible until the participant moves to the next task. We term this group as the "full-exposure" group (control group). In the other group, after both options have been displayed for 1.8s, the right half of each option will be blocked out. The participant need to make choices in the case that only part of the information is visible (see Figure 1). We term the second group as the "limit-exposure" group (treatment group). Notably, since each option has a different length of content, only in the single option will a part of the information be actually blocked out. For the sequence option, we only block out a blank space. In an intertemporal choice task, the information being blocked is the delayed reward in the sequence option; in a count-the-rabbit task, the information being blocked is the second bunch of the rabbit symbols in the sequence option.

In each intertemporal choice task, the single option could be denoted by "receive s today" and the sequence option by "receive $\rho\eta$ today and $1.5(1-\rho)\eta$ in 12 months". In other words, by choosing the single option, a decision maker would immediately get an amount $(1-\rho)\eta$

[1]Given the format of count-the-rabbits tasks are similar with intertemporal choice tasks, in Figure 1(b), we only demonstrate the screen that the participants face when making the choice.



(a) Intertemporal Choice Task



(b) Count-the-Rabbits Task

Figure 1: Screenshot of Experiment 3

more than the immediate reward in the sequence option; by choosing the sequence option, the same amount $(1-\rho)\eta$ would be invested in a riskless bond and the decision maker would get an interest of 50% in one year later. The preference for the sequence option could be an indicator for patience. We select η from {£200, £240, £280, £320} and ρ from {0.1, 0.2, 0.3, 0.4, 0.5, 0.6}. The largest level for ρ is 0.6, ensuring that the delayed reward in the sequence option would be a considerable amount (at least as the same as the immediate reward). Thus, the main tasks in Part 1-2 contain 24 tasks. We randomly and evenly assign these tasks to each part.

For each count-the-rabbit task, suppose the single option contains r_1 rabbits and the sequence option contains r_2 rabbits for the first bunch and r_3 rabbits for the second bunch. We select r_1 from {7, 8}, r_2 from {1, 2, 3}, and r_3 from $\{r_1-r_2-1, r_1-r_2+1\}$. Therefore, there are 12 main tasks in Part 3-4. In half of these tasks, the sequence option has one more rabbit than the single option ($r_2 + r_3 > r_1$); for the other half, it is the single option that has one more rabbit ($r_2 + r_3 < r_1$). Similar to the intertemporal choice tasks, we randomly and evenly assign these tasks to each part.

1.2 Sample

We recruited 300 UK residents via Prolific (female: 152; mean age: 43.6). The median completion time is 10.1 minutes. Each participant was paid £1.5 (on average £8.1 per hour). In each of Part 1 and Part 2, there is one attention check task. Four participants failed the attention check. Besides, there were two participants for whom the tasks were not displayed in the correct order.[2] We drop the participants who fail the attention check and those for whom the tasks were not displayed correctly. In the end, there are 148 participants in the "full-exposure" group and 146 participants in the "limit-exposure" group. We have 7,065 observations for intertemporal choice tasks and 3,504 observations for count-the-rabbits tasks.

The accuracy rate of additional questions is high for each kind of tasks. For intertemporal

[2]For one participant, the data collected for main tasks in Part 2 ended up being example tasks. For the other participant, the data collected for the example count-the-rabbit tasks in Part 3 ended up being intertemporal choice tasks.

choice tasks in Part 2, the overall accuracy rate is 94.0%, and 208 participants correctly answered all questions. For count-the-rabbit tasks in Part 4, the overall accuracy rate is 96.7%, and 259 participants correctly answered all questions.

1.3 Theoretical Analysis

In this experiment, we aim to investigate when people evaluate a two-reward sequence, whether directing their attention to a considerable delayed reward would make them value the sequence more. We divide participants into two groups (limit-exposure / full-exposure). The difference between these groups lies in the information they were exposed to when making choices. Each participant experienced two parts (no question / question). The setup of groups and questions was designed to control participants' attention allocation during the tasks.

As is pointed out by Chun et al. (2011), a critical function of attention mechanisms is to "focus limited processing capacity on the most important information relevant to ongoing goals". In the "limit-exposure" group, to achieve the goal of correctly answering the additional questions, in each task participants have to remember the (only) information being blocked out. Thus, in an intertemporal choice task, they have to focus on the delayed reward in the sequence option during the forced viewing period, as they can never access this information after that. By contrast, in the "full-exposure" group, all relevant information is visible when participants answer the additional question, so they do not need to specifically focus on the delayed reward. We propose, given the delayed reward is a considerable amount, paying more attention to it would make participants value the sequence option more. Therefore, for intertemporal choice tasks, being asked to answer the additional question would increase the preference for the sequence option for participants in the "limit-exposure" group, and would not have much impact on the choices for participants in the "full-exposure" group.

The count-the-rabbits tasks can help us understand the mechanisms by which attention influences choices. As is pointed out by Pleskac et al. (2023), attention can alter choices by two possible processes: one is through valuation, the other is directly through perception. The latter suggests that attention increases the perceived salience of an object and people

may tend to choose the more salient option. In specific preferential and perceptual decision tasks, Pleskac et al. (2023) find evidence supporting the valuation process and contradicting the perceived salience process. Also, for our experiment, we propose that attention alter intertemporal choices through valuation rather than perception. The count-the-rabbit task (a perceptual task) help us distinguish the two processes. These tasks possess the same format as the intertemporal choice tasks, and as is indicated by Figure 2, under each group and part, the frequency with which participants choose the sequence option is similar between both kinds of tasks. If attention alters choice mainly through perception for both tasks, the groups and additional questions should influence the choices in the count-the-rabbits tasks in the same way as in the intertemporal choice tasks. Indeed, the evidence we found suggests they influence the choices in those tasks in different ways, thus supports the valuation process.

Manipulating the exposure time of a stimuli is a commonly used technique that can alter decision makers' attention and preferences in experiments. For example, in one study of Fisher (2021), participants are asked to choose between a small sooner reward and a large later reward. The author firstly presents the delay attribute and amount attribute in order. In some choice tasks, the delay attribute is exposed for 2s while the amount attribute is exposed for 0.5s. In other tasks, the exposure times are reversed. The participants are then required to make a choice. The author finds that when viewing the amount (delay) attribute, participants tend to spend more time fixating at the large amount (sooner date). When making the choices, they are more likely to choose the large later reward if the amount attribute is exposed for a longer time. Our experiment differ from Fisher (2021) in two ways. First, we direct attention to an element in a reward sequence, rather than an attribute. Second, in our experiment, longer exposure time does not necessarily mean more attention. As is suggested by Figure 4, for many participants, the intention to choose an option has already been formed by the end of the forced viewing period. That is, in the "limit-exposure" group, before we block out some information, participants may have already made a decision. Thus, we use the requirement to answer a relevant question to raise attention to certain information rather than the exposure time alone.

1.4 Choice Results

1.4.1 Intertemporal Choice Task

The choices under each group and part, are distributed as in Figure 2. In the "limit-exposure" group, the proportion of choosing the sequence option within the "question" part is 5.5% higher than that under the "no question" part; in the "full-exposure" group, the former proportion is 2.1% higher than the latter proportion. Besides, in the "limit-exposure" group, 23 participants always choose the single-amount option and 21 participants always choose the sequence option. In the "full-exposure" group, 31 participants always choose the single-amount option and 35 participants always choose the sequence option.

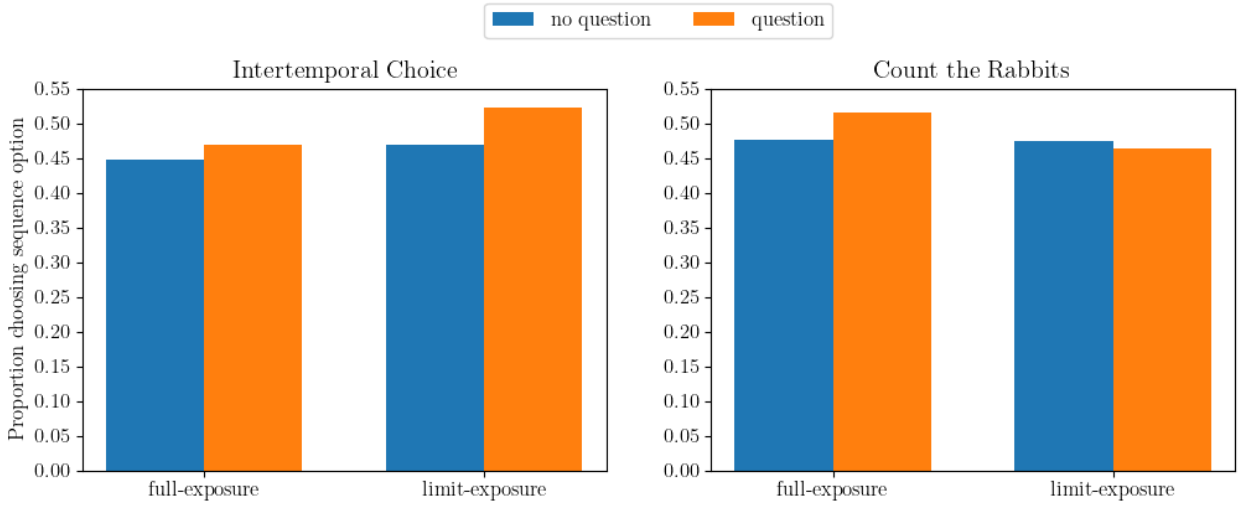


Figure 2: Mean proportion of participants choosing the sequence option

We examine the impact of groups and questions on intertemporal choices through a set of logistic linear regressions. Table 1 illustrates the key estimates in the results. The dependent variable is 1 if a participant choose the sequence option in a task and 0 otherwise. The variable Group is 1 if the participant is in the "limit-exposure" group and 0 otherwise; Question is 1 if the task is within the "question" part and 0 otherwise. Each level of ρ and η is treated as a dummy variable. Each of Model (1)-(3) in Table 1 is estimated through maximum likelihood method. Model (1) is a pooled regression. Model (2) is run upon the sample in which each participant has changed her choice at least once across all intertemporal

Table 1: Regression Results for Intertemporal Choice Tasks

	(1) Pooled	(2) FE	(3) FE
Group	0.085	0.047	-0.096
	(0.19)	(0.533)	(0.154)
Question·1{Group = 0}	0.085	0.301	0.301
	(0.059)	(0.189)	(0.187)
Question·1{Group = 1}	0.218***	0.53***	0.53***
	(0.067)	(0.164)	(0.163)
observations	7056	4416	7056
aic	9625.349	4253.529	4259.531

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$. Standard errors are clustered at the subject level and are reported in the parentheses. The p-values are calculated based on Wald tests. Model (2) includes subject-specific dummies for those having changed their choices at least once across all intertemporal choice tasks. Model (3) adds two dummies to Model (2) to capture whether a subject always chooses the sequence option, and the single option. Each model includes an intercept and task-sepcific dummies.

choice tasks, and subject-specific dummies are created for these participants.[3] Model (3) is run upon the full sample and adds two dummies to Model (2) to capture whether a subject always chooses the sequence option, and the single option.

As is consistent with our theoretical analysis, in the "limit-exposure" group (i.e. Group = 1), participants are significantly more likely to choose the sequence option within the "question" part rather than within the "no question" part (at significance level 0.5%). By contrast, in the "full-exposure" group (i.e. Group = 0), the additional questions do not increase the preference for the sequence option significantly. In addition, with η growing larger, participants are more likely to choose the sequence option, which is in line with the magnitude effect.

[3]The reason why Model (2) in Table 1 focuses on a subset of participants is, the design matrix will become singular without omitting those who keep choosing one option all the time.

1.4.2 Count-the-Rabbits Task

In count-the-rabbits tasks, 226 participants correctly choose the option with more rabbits for every task, and the overall accuracy rate is 97.0%. There are only 105 wrong choices. As is illustrated in Figure 3, the wrong choices in count-the-rabbits tasks are disproportionally biased to the single option. In all conditions except the "question" part in the "full-exposure" group, participants are more likely to choose the single option by mistake, rather than the sequence option. One explanation is that, in the "full-exposure" group, to answer the additional questions, participants need to (and they can) count the rabbits within each bunch, which helps eliminating the choice error.

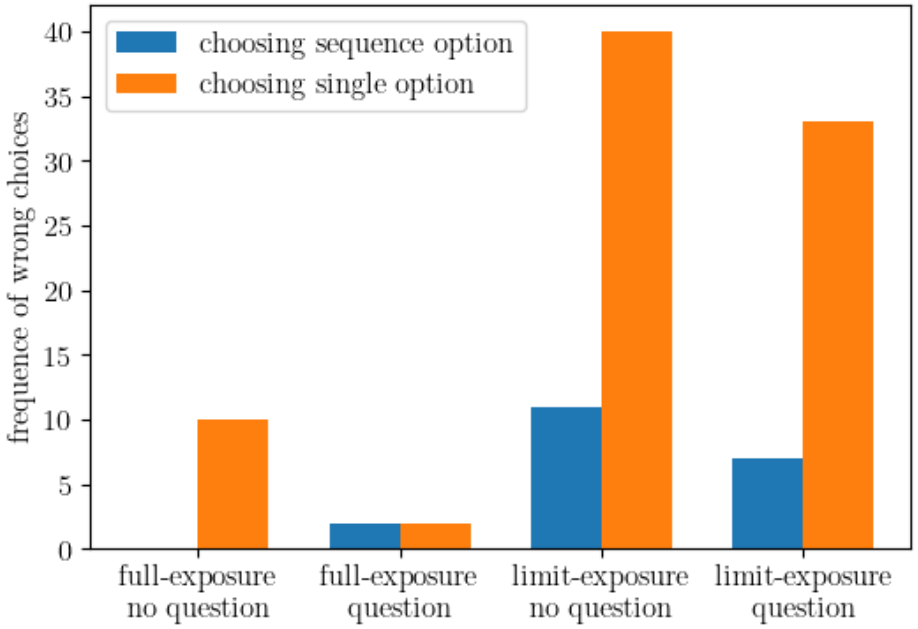


Figure 3: Frequence of wrong choices in count-the-rabbits tasks

Furthermore, we conduct a set of logistic linear regressions upon the choices in the count-the-rabbits tasks. Table 2 illustrates the key estimates. The dependent variable, and variable Group as well as Question are the same as those for the intertemporal choice tasks. Each level of r_1 and r_2 is treated as a dummy variable. We also created a dummy variable for whether the sequence option has more rabbits (i.e. $r_2 + r_3 > r_1$). Model (1)-(4) in Table 2 are all estimated through maximum likelihood method. Model (1) is a pooled regression while Model (2)-(4) include subject-specific dummies. Model (2) are run upon

Table 2: Regression Results for Count-the-Rabbits Tasks

	(1) Pooled	(2) FE	(3) FE	(4) FE
Group	-0.732*	-4.466*	-0.21	-0.964***
	(0.331)	(1.789)	(1.771)	(0.312)
Question·1{Group = 0}	0.581*	1.357*	1.618*	2.032**
	(0.228)	(0.606)	(0.681)	(0.778)
Questsion·1{Group = 1}	0.07	0.225	0.466	0.214
	(0.319)	(0.376)	(0.444)	(0.352)
observations	3504	3504	2190	810
aic	883.789	1103.793	752.785	586.582

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$. Standard errors are clustered at the subject level and are reported in the parentheses. The p-values are calculated based on Wald tests. FE denotes individual fixed-effects. Model (1)-(2) are run upon the full sample, (3) is for those having changed choices at least once in intertemporal choice tasks, (4) is for those having made wrong choices in count-the-rabbits tasks. Each model includes an intercept and task-specific dummies.

the full sample, Model (3) is run upon the sample in which each participant has changed her choice at least once across all intertemporal choice tasks, Model (4) is run upon the sample in which each participant has made at least one wrong choice in count-the-rabbits tasks. Notably, in the "limit-exposure" group, participants are significantly more likely to choose the sequence option within the "question" part, whereas in the "full-exposure" group, the additional questions have no significant impact on choices. In other words, compared with the intertemporal choice tasks, adding the additional questions to the count-the-rabbits tasks produces a reverse effect on choice for participants in each group. This result provides a supportive evidence for our argument that attention increases the preference for the sequence option in our intertemporal choice tasks through valuation rather than perception.

1.5 Decision Process

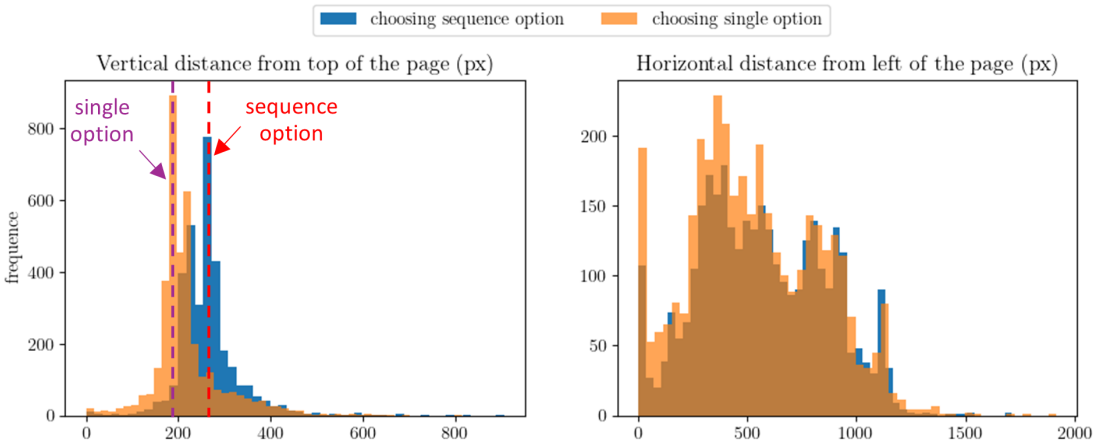
To examine the participants' decision processes, we record the participants' mouse position at the moment when they are prompted to make a choice (i.e. the end of the forced viewing

period), and their response time in each choice task.

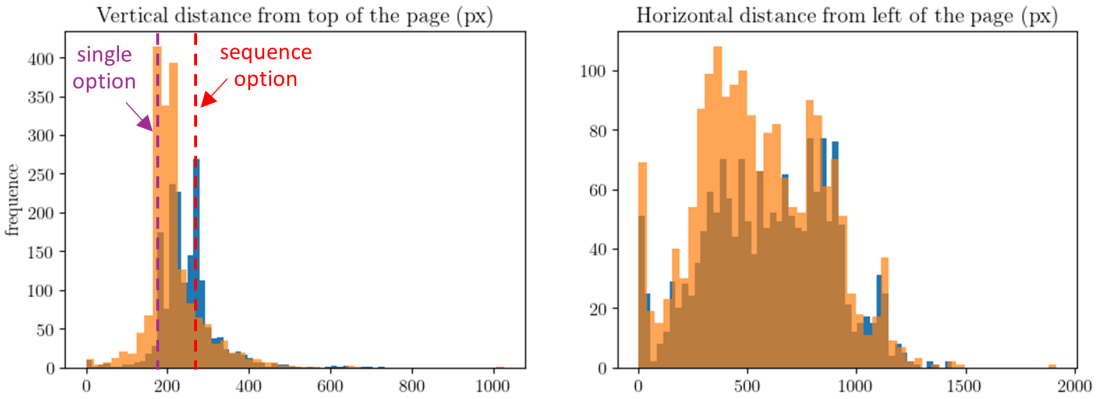
First, the mouse position data suggests, for many participants, the intention to choose an option may have already been formed at the end of the forced viewing period. As is illustrated by Figure 1, the single option lies above the sequence option in each choice task. When a participant click the "Display" button to view the content of options, her mouse pointer should lie in the middle between the two options. After that, she can move the mouse freely though the mouse pointer is invisible. Then, when the pointer appears again, she is asked to make a choice. Figure 4 shows, at the moment when participants are asked to make a choice, for those who eventually choose the sequence (single) option, the peak of the distribution of their mouses' vertical positions is exactly at the position of the option they want to choose. This indicates that, at that moment, such participants have already had a decision in mind and moved their mouses toward the option they tend to choose. For such participants, if our experimental conditions has a causal effect on their choices, it should occur in the forced viewing period.

Second, for response time, we conducted linear regressions with 2SLS method. We use data collected from those who have changed choices at least once across the intertemporal choices tasks as the sample. For first-stage regressions, we use Model (2) in Table 1 to predict choices in intertmporal choice tasks, and use Model (3) in Table 2 to predict choices in count-the-rabbits tasks. We construct a variable Choice which is 1 if the predicted choice is the sequence option and is 0 otherwise. For second-stage regressions, the dependent variable is the response time (in second). We use the variables in Table 1 and Table 2, their interactions with Choice, and subject-specific dummies as the independent variables. Given the response time data contain some outliers, we exclude the highest 0.5% response times. The key estimates are reported in Table 3.

Notably, in Table 3, the coefficients for the interaction between Choice and Group are significantly negative. This indicates that the "limit-exposure" group facilitates the choice toward the sequence option in comparison of the "full-exposure" group. However, as is illustrated by Table 1 and Table 2, Group has no impact on the choice outcome in intertemporal choice tasks. These results provides insights on how attention may affect valuation in intertemporal



(a) Intertemporal Choice Task



(b) Count-the-Rabbits Task

Figure 4: Mouse positions recorded at the end of the forced viewing period

choices. Being informed that there is some information to be blocked makes the sequence option capture participants' attention. However, this has no impact on valuation. Only when participants intentionally pay attention to learn the (semantic) information about the rewards, can the option value be increased.

Reference

Chun, M. M., Golomb, J. D., and Turk-Browne, N. B. (2011). A taxonomy of external and internal attention. *Annual review of psychology*, 62:73–101.

Fisher, G. (2021). Intertemporal choices are causally influenced by fluctuations in visual attention. *Management Science*, 67(8):4961–4981.

Pleskac, T. J., Yu, S., Grunevski, S., and Liu, T. (2023). Attention biases preferential choice by enhancing an option's value. *Journal of Experimental Psychology: General*, 152(4):993.

Table 3: The Relationship Between Response Time, Choice and Experimental Conditions

	Intertemporal Choice	Rabbit
Group	-0.684***	-0.792***
	(0.141)	(0.144)
Question·1{Group = 0}	-0.165	0.912***
	(0.174)	(0.199)
Question·1{Group = 1}	0.457***	0.849***
	(0.101)	(0.132)
Choice	0.954*	1.291***
	(0.399)	(0.456)
Choice×Group	-0.762*	-1.265***
	(0.304)	(0.229)
Choice×Question·1{Group = 0}	0.001	-0.138
	(0.257)	(0.23)
Choice×Question·1{Group = 1}	-0.12	0.263
	(0.195)	(0.175)
observations	4393	2179
aic	18560.034	8711.872
adj-R^2	0.381	0.55

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$. Both models are estimated through 2SLS method. Standard errors are clustered at the subject level and are reported in the parentheses. The p-values are calculated based on t-tests. Indepdent variables for each second-stage regression include an intercept, task-specific dummies and their interactions with the predicted choice, and subject-specific dummies.