How does choice architecture influence attention and decision making?

by

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How does choice architecture influence attention and decision making?

submitted by Chaoyi Shi in partial fulfillment of the requirements for the degree of Master of Arts in Psychology

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Abstract

Choice architecture has a profound influence on human decision making, but the underlying cognitive mechanisms remain unclear. We propose that choice architecture guides visual attention to shape decision making. In a pre-registered experiment (N=646), participants were presented with two credit cards under different choice architecture conditions and were asked to choose the better card for themselves given their financial situation. We used a factorial between-subjects design with eight conditions: default (better card vs. worse card was pre-selected) x instructions (pre-selection was described as intentional vs. random) x presentation order (better card vs. worse card was presented on the left). Pre-registered analyses showed that participants paid more attention to the card when it was pre-selected than when not, and more likely to choose the pre-selected card. Participants also paid more attention to the better card and were more likely to choose it when it was presented on the left than on the right. However, instructions about the pre-selection had a limited impact on attention or choice. Exploratory analyses showed that attention mediated the effect of default and presentation order on choice, and choice also mediated the effect of default and presentation order on attention. These findings suggest that choice architecture guides visual attention to shape decision making. The current study provides new insights on the attentional mechanism of choice architecture, with implications for practitioners and policymakers on designing optimal choice architecture to aid decision making for consumers.
Lay Summary

Choice architecture influences human behavior in everyday life, but we still don't fully understand why. To answer the question, we presented participants with two credit cards with different choice architecture conditions: default (better card vs. worse card was pre-selected) x instructions (pre-selection was described as intentional vs. random) x presentation order (better card vs. worse card was presented on the left) and asked them to choose the better card for themselves given their financial situation. Results showed that participants paid more attention to the card when it was pre-selected than when not and were more likely to choose the pre-selected card. Participants also paid more attention to the better card and were more likely to choose it when it was presented on the left than on the right. However, instructions about the pre-selection had a limited impact on attention or choice.
Preface

I am the primary author of this thesis. Chaoyi Shi completed the experimental design and data analysis for this thesis under the supervision of Dr. Jiaying Zhao. The BubbleView task was adapted from Luo & Zhao (2019). Chaoyi Shi wrote the manuscript with review and revision from Dr. Jiaying Zhao, the supervisor on this project.

The Behavioural Research Ethics Board at the University of British Columbia approved the experiment (H21-03696), with the project title “Decision-making on everyday products.”
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For my late mother, Chunxia Huang, for all your love and support. I miss you more than life
Introduction

Choice architecture is the context in which choices are presented to individuals (Thaler & Sunstein, 2008). From a product display at a store to the settings on a device, choice architecture influences human decision making both explicitly and implicitly (Johnson & Goldstein, 2003). The underlying principle of choice architecture is that by manipulating the manner in which decisions are made, individuals can be nudged towards particular decisions without restricting their freedom of choice (Thaler & Sunstein, 2008; Tversky & Kahneman, 1974; Ariely, 2009; Halpern, 2015). Briefly, nudge refers to a subtle change in the choice architecture that can steer individuals towards one of the available options without imposing any mandates or incentives (Thaler & Sunstein, 2008).

Default has been well-established in literature as a significant nudge in influencing individual decision making in various contexts (Thaler & Sunstein, 2008; Johnson & Goldstein, 2003; Egebark & Ekström, 2016). For example, when participants were told to assume that they had just moved to a new state where the default was to be an organ donor, their revealed donation rates were about twice as high compared to when they were informed that the default was not to be an organ donor (Johnson & Goldstein, 2003). In addition, when the default printer option was replaced from single-sided to double-sided printing, there was a 15% reduction in paper consumption (Egebark & Ekström, 2016). Defaults have been revealed as more effective when operating through endorsement as defaults are perceived as conveying what the choice architect suggests the decision-makers should do (Jachimowicz et al., 2019). On the opposite, when individuals don’t trust the choice architect because they believe that the choice architecture is designed based on intentions differing from their own, defaults could become less effective (Tannenbaum et al., 2017). Familiar position is another nudge that facilitates individuals’ choice
(Dayan & Bar-Hillel, 2011; Andersson & Nelander, 2021). People often allocate more attention to the displayed items on the left side rather than on the right side, a phenomenon known as pseudoneglect (Jewell & McCourt, 2000; Mesulam, 1981). When a healthy item was displayed to the left (vs. right) of an unhealthy item, preference for healthy options was enhanced and consumption volume of a healthy item (vs. an unhealthy item) was higher (Romero & Biswas, 2016).

While the elements of choice architecture, grounded in principles of psychology, behavioral economics, and cognitive science, are universally applicable, their outcomes can vary dramatically across populations (Mrkva et al., 2021). The assumption that a singular intervention or choice presentation would resonate equally across diverse groups is a simplification that fails to account for the multifaceted realities of human lives. Income often plays a subtle yet profound role in shaping personal beliefs, perceptions, and evaluations (Manstead, 2018). An individual’s financial standing can influence their risk appetite, their trust in institutions, and even their perspectives on societal norms and values (Cook & Sadeghein, 2018; Spadaro et al., 2020; Agneman et al., 2022). In the realm of choice architecture, these income-induced variances in experience and perception could carry significance in decision making behavior. For people living in financial abundance, with a reservoir of resources and experiences, an intervention may align seamlessly with their life context. In contrast, those living in financial scarcity may find the same intervention misaligned, irrelevant, or counterproductive. Therefore, it’s also critical to consider and understand the interplay between income and choice architecture.

A recent meta-analysis explored the cognitive mechanisms underlying the nudge interventions and found that, among a plethora of behavioral interventions developed so far, attention-grabbing or effort-reducing interventions tend to have the largest effect sizes (Luo et
Researchers proposed a novel cognitive framework by studying interventions along six cognitive processes: attention, perception, memory, effort, intrinsic motivation, and extrinsic motivation. An attention intervention was defined as “an intervention that increases or decreases the salience of an option by manipulating the features of stimulus” (Luo et al., 2021). Drawing people’s attention to a target helps facilitate their subsequent actions (Castelo et al., 2015; Egelman & Schechter, 2013). An effort intervention was defined as “an intervention that changes cognitive or physical ease required by an option” (Luo et al., 2021). Individuals tend to exhibit a preference for maintaining the status quo rather than switching to an alternative choice (Kahneman et al., 1991; Samuelson & Zeckhauser, 1988; Shah & Oppenheimer, 2008). For example, by making the more expensive “green” energy option the default choice, which requires consumers to actively opt out if they prefer a cheaper option, the purchases of the “green” energy increased almost tenfold (Ebeling & Lotz, 2015).

Attention is a fundamental aspect of human cognition and also a critical factor of the decision-making process as it determines what information is selected, processed, and ultimately used to make a decision (Vriens et al., 2020; Orquin & Mueller-Loose, 2013). Eye-tracking has been widely recognized as a reliable and valid technique for measuring attention in various contexts (Kim & Lee, 2021; Ojstersek & Topolsek, 2019; Frutos-Pascual & Garcia-Zapirain, 2015). Shimojo and colleagues (2003) asked participants to choose between two faces based on their attractiveness while their eye movements were tracked. They found that participants spent more time looking at the face they eventually chose, indicating that attentional processes drive in decision making (Shimojo et al., 2003). Another study by Orquin and Mueller-Loose (2013) investigated the role of eye movements and attention in consumer decision making. They found that people who made quicker decisions had shorter fixations and saccades (rapid eye
movements) and made fewer fixations overall, suggesting that attentional processes and eye
movements are an integral part of decision making (Orquin & Mueller-Loose, 2013).

Bottom-up attention operates on raw sensory input, rapidly and involuntarily shifting
attention to salient visual features of stimulus (Connor et al., 2004). Nudges that influence
behavior by leveraging bottom-up attention are called behavioral nudging (Papies & Lindenberg,
2019). Visually salient options that capture bottom-up attention are more likely to be chosen (Itti
& Koch, 2000; Milosavljevic et al., 2012). For example, the salience of snack foods’ visual
features affected people’s choice by biasing their location and duration of attention (Towal et al.,
2013). According to Li and Camerer (2022), in a game of Hide and Seek, both the hiders and
seekers tend to select locations with relatively higher salience. The advantage of the seekers
mostly comes from the fact that they tend to win more frequently when both players choose
locations within the top 10% of salience. Top-down attention refers to the deliberate allocation of
attention based on goals, requiring higher-level cognitive strategies, biasing attention toward
goal-relevant stimuli (Connor et al., 2004). Nudges that activate top-down attention by priming
people to think about certain behaviors or goals are called goal nudging (Papies & Lindenberg,
2019). Goal-relevant stimuli which activates top-down attention are more likely to be chosen
(Jovancevic & Hayhoe, 2009; Hayhoe, 2000; Pieters & Warlop, 1999). Participants primed with
a pleasure-seeking (hedonic) goal tended to perform impulsive behaviour, as impulsivity is
featured by generalized reward sensitivity (Ramanathan & Menon, 2006).

Previous research has primarily focused on how choice architecture influences decision-
making, with attention being identified as a key facilitator of this process (Papies & Lindenberg,
2019; Towal et al., 2013; Papies & Lindenberg, 2019). However, it remains unclear whether how
choice architecture influences attention, and whether attention plays a mediating role in the relationship between choice architecture and decision-making.

Thus, the present study seeks to address this gap by examining the cognitive mechanisms through which choice architecture impacts decision-making. The goal is to understand how three commonly studied choice architecture (that is, default, instructions about the default, and presentation order) influence visual attention and decision making. Specifically, we proposed that default, instructions about the default, and presentation order can draw attention, therefore biasing choice.

Our pre-registered hypotheses were that: 1) participants will pay more attention to the card when it’s pre-selected than when it’s not pre-selected; 2) participants will pay more attention to the pre-selected card in the intentional pre-selection condition than in the random pre-selection condition; 3) participants will pay more attention to the card when it’s presented on the left than when it’s presented on the right; 4) participants are more likely to choose the card when it’s pre-selected than when it’s not pre-selected; 5) participants are more likely to choose the pre-selected card in the intentional pre-selection condition than in the random pre-selection condition; 6) participants are more likely to choose the card when it’s presented on the left than when it’s presented on the right.

A road map to the current study

We conducted six pilot studies to establish the current study design (see Appendix F). Pilot study 1 provided initial insights into the attention and choice patterns across different pre-selection conditions. There was no significant difference in attention or choice, but the findings influenced our decision to include pre-selection as a factor in the future experiments with a larger sample size. In pilot study 2, with a slightly larger sample size, we still did not find significant effects of
attention or choice across the three pre-selection conditions, but this motivated us to recruit a larger sample. In pilot study 3, with a much larger sample size, we found that lower-income participants paid less attention to both cards and to the signature (worse) card, compared to higher-income participants. There was no difference in memory performance between lower-income participants and higher-income participants. Regarding choice, both lower-income and higher-income participants were influenced by signature card pre-selected condition but not infinite card pre-selected condition compared to no pre-selection condition. In pilot study 4, we redesigned the two credit cards used in the study by removing the insurance values and adjusting the values of annual fee, cashback rates, purchase interest rates and default interest rates based on the 25 credit cards from the five banks in the U.S. (JPMorgan Chase, Bank of America, Wells Fargo, Citigroup, and U.S. Bank). We found that lower-income group significantly spent less attention to the key features on both cards compared to higher-income group. Specifically, for irrelevant features, there was no difference in attention between lower- and higher-income participants; for relevant features, lower-income participants paid less attention than higher-income participants. The lower-income group showed significantly lower memory accuracy of card features compared to the higher-income group. Memory was driven by attention for both income groups. In terms of choice: for the lower-income group, good default didn’t benefit them, but the bad default hurt them; for the higher-income group, the good default benefited them but the bad default didn’t hurt them. Choice seemed to be driven more by attention than by numeracy and financial literacy. These findings encouraged us to pre-register our study (pilot study 5) and recruit a larger sample size to have adequate power. We didn’t replicate the findings from pilot study 4. In pilot study 5, the lower-income participants paid less attention to the features of the cards than higher-income participants. For lower-income participants, attention
predicts choice, but financial literacy and numeracy did not predict choice. The lower-income participants were not less likely to choose the better card for themselves compared to the higher-income participants, and both lower-income and higher-income participants showed the similar pattern in choice (they were both more likely to choose the worse card in the bad default condition than in the control condition and more likely to choose the better card in the good default condition than in the control condition). There was no difference in memory performance between the lower-income and higher-income participants. We then reflected on the findings and discussed the efficacy of using self-reported income in the analyses. We modified the study design by including a manipulation of financial scarcity at the beginning of the study (participants were randomly assigned to a 20% pay cut condition or a 2% pay cut condition) and adding presentation order as a primary variable. There was no main effect of financial scarcity or presentation order on attention, nor an interaction effect. However, we found that presentation order, but not financial scarcity, predicted choice. Participants were more likely to choose the card presented on the left, and they had higher memory performance when the better card was presented on the left. Since the manipulation of financial scarcity did not work, we decided to continue using the self-reported income variable for future studies. The findings above inspired us to design a study having default, instruction and presentation order as the primary variables to see how these three choice architectures together could influence attention, choice and memory.
Methods

The current study was pre-registered on Open Science Framework at: https://osf.io/z5ch9. Data can be accessed at: https://osf.io/kyx63/. The study was approved by the University of British Columbia’s Behavioral Research Ethics Board (ID Number: H21-03696) and all participants provided informed consent prior to beginning the study.

Participants

We conducted a power analysis in G*Power with an assumed minimum effect size $f=.157$, $a=.05$, and power=0.95, which showed that a minimum number of 536 participants were needed. Thus, we initially recruited a large sample of 1720 participants from the U.S. on Amazon Mechanical Turk (MTurk) who received $1 for participating in the study. To ensure data quality, participants were excluded according to the pre-registered exclusion criteria: 1. if they failed the attention checks (n=522); 2. if they completed the study survey in less than 100 seconds or more than 2000 seconds (n=9); 3. if they reported total monthly spending $\leq$ $100 or $\geq$ $20,000 (n=105); 4. if they spent over 20 seconds per fixation which indicates mouse idling in the BubbleView task (n=192); 5. if they had $\leq$ 20 fixations which indicates insufficient mouse movements in the BubbleView task (n=35); 6. if their responses were incomplete (n=37); and 7. if they had duplicated subject IDs (n=174). As a result, 1074 participants were excluded, leaving a final sample of N=646 ($M_{age}$=37.64, $SD=12.36$; 55.66% male, 43.57% female; 78.79% Caucasian, 12.54% Asian; 43.15% liberal, 45.83% conservative; 86.58% with at least a bachelor’s degree; mean household income=$58,915, median=$54,999).

Materials

We designed two credit cards (infinite card and signature card) and participants were asked to choose the better card for themselves based on their financial situation. Each card
contained seven features: name, card, cash back reward for groceries, dining, and travel, cash back reward for gas and other purchases, annual fee, purchase interest rate, and default interest rate (see Appendix A). To determine the realistic values of cash back rewards, interest rates, and annual fees of the cards, we examined 25 credit cards from the five banks in the U.S. (JPMorgan Chase, Bank of America, Wells Fargo, Citigroup, and U.S. Bank), and selected the minimum values of interest rates, annual fees, and cashback rewards from the 25 credit cards for the infinite card, and the maximum values for the signature card. During the study we asked participants to report their average monthly spending and payment to determine which card was better for them. We then calculated the net benefit of each card by comparing the total costs of the card (i.e., annual fee and interests) to the total benefits of the card (i.e., cash back values), and found that for all participants in our study, the infinite card was the better card, and the signature card was the worse card.

Procedure

Participants were randomly assigned to one of the eight conditions from a 2 (pre-selection: better card vs. worse card pre-selected) × 2 (instruction: pre-selection described as intentional vs. random) × 2 (presentation order: better card vs. worse card presented on the left) between-subjects factorial design. Across the eight conditions (see Appendix B), the better vs. the worse card was pre-selected by checking the button above the card, and the pre-selection was described as either intentional (i.e., “A credit card has been pre-selected for you. We believe that it is the better option for you. You will get this option unless you switch to the other option.”) or random (i.e., “A credit card has been pre-selected for you. This pre-selection is randomly determined based on a coin flip. You will get this option unless you switch to the other option.”). The better card was presented on the left or the right side of the screen.
In each condition, participants first completed a BubbleView task (adapted from Luo & Zhao, 2019), where the two cards were covered by an opaque black mask and only a small circular area around the mouse was transparent where participants could see the underlying cards by moving their mouse on the screen. We tracked participants’ mouse location as a proxy for visual attention. The mouse always started in the middle of the screen for all participants. Their goal was to choose the better card for themselves given their financial situation (view demo here: https://www.youtube.com/watch?v=UBAGUJZZW4Y). After viewing the cards, participants chose the card by clicking on the button above each card. The task instruction and the pre-selection remained visible to participants at all times. There was no time limit in this task. There was a brief training session before the BubbleView task to make sure participants knew how to view the content covered by the mask using their mouse.

After the BubbleView task, participants in all conditions completed a survey on Qualtrics that contained several sections (see Appendix C). First, participants completed an attention check to select the card that was previously presented on the left. Second, they completed a surprise memory task to test their memory of the card features. Third, they answered questions on monthly spending so we could determine which card was better for them. Fourth, they were asked which piece of information of the card was the most important to them when deciding which card to choose. Fifth, they answered a series of questions that measured their financial literacy and numeracy. Finally, they answered demographic questions.

**Measures**

Since each card contained seven features, each feature was an area of interest (AOI, see Appendix A). As a pre-registered measure, attention was quantified as proportional dwell time on each card (i.e., total dwell time on the seven AOIs of each card divided by the total dwell time
on the black mask) and proportional fixation on each card (i.e., total fixations on the seven AOIs of each card divided by the total fixations on the black mask). Dwell time was the amount of time the mouse stayed in a given region, and fixations were the number of mouse landings in a given region (see Appendix D for heatmaps). As another pre-registered measure, choice was binary (1=participants chose the better card, 0=participants chose the worse card). Memory was assessed in the surprise memory test as an accuracy score (the number of correctly answered questions divided by the total number of questions). Demographic measures included financial literacy (Fernandes et al., 2014), numeracy (Schwartz et al., 1997), age, gender, ethnicity, political orientation, income, education, and financial stress.
Results

Pre-registered analyses

To examine how choice architecture influences attention, we conducted a two-way mixed-design ANOVA on proportional dwell time and found a main effect of pre-selection \(F(1)=7.88, p=.005, \eta^2_p=.008\], suggesting that participants paid more attention to the pre-selected card than the non-selected one. There was no interaction between instruction and pre-selection \(F(1,1)=1.75, p=.187, \eta^2_p=.002\], suggesting that participants paid equal amounts of attention to the pre-selected card in the intentional condition than the random condition. We also conducted a one-way repeated measures ANOVA to compare attention to the left card and the right card and found main effect of presentation order \(F(1)=51.96, p<.001, \eta^2_p=.049\], suggesting that participants paid more attention to the card presented on the left than on the right.

The results on proportional fixations showed the same pattern, with main effects of pre-selection \(F(1)=9.02, p=.003, \eta^2_p=.010\] and presentation order \(F(1)=63.71, p<.001, \eta^2_p=.063\], but no interaction between instruction and pre-selection \(F(1,1)=.86, p=.354, \eta^2_p=.001\]. Figure 1 presents proportional dwell time and fixations on each card by condition. These results confirmed our pre-registered hypotheses that participants will pay more attention to the card when it’s pre-selected than not pre-selected, and participants will pay more attention to the card when it’s presented on the left than on the right, but not the hypothesis that participants will pay more attention to the pre-selected card in the intentional condition than in the random condition.
To examine how choice architecture influences card choice, we conducted a logistic regression and found that pre-selection ($B=-1.88$, $SE=.26$, $p<.001$, OR=.15) and presentation order ($B=-.57$, $SE=.18$, $p=.001$, OR=.56) were significant predictors of choice, suggesting that participants were more likely to choose the better card when it was pre-selected than when not, and when the card was presented on the left than on the right. There was no interaction between instruction and pre-selection ($B=.26$, $SE=.35$, $p=.469$, OR=1.29), suggesting that participants were equally likely to choose the pre-selected card in the intentional or the random condition.

Table 1 presents the card choice by condition. These results confirmed our pre-registered hypotheses that participants are more likely to choose the card when it’s pre-selected, and more likely to choose the card when it’s presented on the left than on the right, but not the hypothesis that they are more likely to choose the pre-selected card in the intentional or random condition.

Table 1. Card choice by condition.
<table>
<thead>
<tr>
<th>Conditions</th>
<th>N choosing the better card</th>
<th>N choosing the worse card</th>
<th>% choosing the better card</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better card pre-selected, better card left, intentional</td>
<td>74</td>
<td>18</td>
<td>80.43%</td>
</tr>
<tr>
<td>Better card pre-selected, worse card left, intentional</td>
<td>50</td>
<td>17</td>
<td>74.63%</td>
</tr>
<tr>
<td>Better card pre-selected, better card left, random</td>
<td>70</td>
<td>11</td>
<td>86.42%</td>
</tr>
<tr>
<td>Better card pre-selected, worse card left, random</td>
<td>57</td>
<td>34</td>
<td>62.64%</td>
</tr>
<tr>
<td>Worse card pre-selected, better card left, intentional</td>
<td>25</td>
<td>42</td>
<td>37.31%</td>
</tr>
<tr>
<td>Worse card pre-selected, worse card left, intentional</td>
<td>29</td>
<td>64</td>
<td>31.18%</td>
</tr>
<tr>
<td>Worse card pre-selected, better card left, random</td>
<td>29</td>
<td>41</td>
<td>41.43%</td>
</tr>
<tr>
<td>Worse card pre-selected, worse card left, random</td>
<td>27</td>
<td>58</td>
<td>31.76%</td>
</tr>
</tbody>
</table>

**Exploratory analyses**

As exploratory analyses to demonstrate the robustness of our results, we repeated the ANOVAs and regressions while controlling for financial literacy, numeracy, income, financial stress, age, education, and political orientation. These analyses showed partially similar results as the pre-registered ones, that participants were more likely to choose the pre-selected card than the non-selected one, paid more attention to and were more likely to choose the card presented on the left than on the right, but participants did not pay more attention to the pre-selected card than the non-selected one, and there was no effect of instruction on attention to or choice of the pre-selected card (see Tables E1, E2 & E3 in Appendix E).

To investigate the relationship between attention and choice, we employed two-way ANOVAs (Figure 2). Our attentional analyses revealed significant interactions across all four situations (Figure 2. a-d). When the better card was pre-selected, we found significant interactions both when assessing attention as proportional dwell time \(F(1,1)=33.07, p<.001,\)
\[ \eta^2 = .047 \] and as proportional fixations \([F(1,1)=32.66, p<.001, \eta^2 = .047]\). The pattern persisted when the worse card was pre-selected: significant interactions were shown when attention was measured as proportional dwell time \([F(1,1)=14.09, p<.001, \eta^2 = .022]\) and as proportional fixations \([F(1,1)=19.33, p<.001, \eta^2 = .029]\). To further explore the directionality, we conducted paired-sample \(t\)-tests. On one hand, the findings provided evidence for choice driving attention. Specifically, when participants were presented with the better card being pre-selected, those opting for the better card consistently paid greater attention to the better card compared to the worse card when attention was measured as proportional dwell time \([t(250)=3.90, p<.001, d=.25]\) and as proportional fixations \([t(250)=3.63, p<.001, d=.25]\). A similar trend was observed when the worse card was pre-selected: participants who chose the worse card paid more attention towards the worse card relative to the better card when attention was measured as proportional dwell time \([t(204)=-3.40, p<.001, d=-.24]\) and as proportional fixations \([t(204)=-4.20, p<.001, d=-.24]\). On the other hand, there is tentative evidence suggesting that attention drives choice. This was evident when the better card was pre-selected: participants who chose the worse card paid more attention to the worse card compared to the better card when attention was measured as proportional dwell time \([t(79)=-4.18, p<.001, d=-.47]\) and as proportional fixations \([t(79)=-3.72, p<.001, d=-.47]\). However, this trend was not consistent. When the worse card was pre-selected, participants who chose the better card demonstrated no difference in attention between the two cards when attention was measured as proportional dwell time \([t(109)=1.69, p=.094, d=.16]\) and as proportional fixations \([t(109)=1.57, p=.119, d=.16]\).
To examine whether attention mediated the effect of pre-selection and presentation order on choice, we conducted mediation analyses (Figure 3), which showed proportional dwell time on the better card partially mediated the effect of pre-selection on choice of the better card ($p = .069$, bootstrap estimate = .02, 95% CI = [.00, .03]), but proportional fixations fully mediated the effect ($p = .046$, bootstrap estimate = .02, 95% CI = [.00, .04]). Proportional dwell time on the better card mediated the effect of presentation order on choice of the better card ($p < .001$, bootstrap estimate = .05, 95% CI = [.03, .08]), and proportional fixations also mediated the effect ($p < .001$, ...
These results suggest that attention mediates the effect of pre-selection and presentation order on choice.

Figure 3. Mediation analyses of attention: (a) proportional dwell time and (b) proportional fixations mediating the effect of pre-selection on choice, (c) proportional dwell time and (d) proportional fixations mediating the effect of presentation order on choice.

To examine whether choice mediated the effect of pre-selection and presentation order on attention, we conducted reverse mediation analyses (Figure 4), which showed choice of the better card mediated the effect of pre-selection on proportional dwell time on the better card ($p<.001$, bootstrap estimate=$.03$, 95%CI=[.02, .05]), and also mediated the effect on proportional fixations ($p<.001$, bootstrap estimate=$.04$, 95%CI=[.02, .05]). Choice mediated the effect of presentation order on proportional dwell time on the better card ($p<.001$, bootstrap estimate=$.01$, 95%CI=[.00, .02]), and also mediated the effect on proportional fixations ($p<.001$, bootstrap
estimate=.01, 95%CI=[.00, .02]). These results suggest that choice mediates the effect of pre-selection and presentation order on attention.

Figure 4. Mediation analyses of choice: choice mediating the effect of pre-selection on (a) proportional dwell time and (b) proportional fixations, choice mediating the effect of presentation order on (c) proportional dwell time and (d) proportional fixations.

To examine how choice architecture influences memory, we conducted a 3-way ANOVA on the accuracy score in the surprise memory test (Figure E1), and found a main effect of presentation order [$F(1)=7.17, p=.008, \eta^2=.011$], suggesting that participants showed better memory of the card features when the better card was presented on the left than on the right. There was no main effect of pre-selection [$F(1)=.04, p=.845, \eta^2<.001$], or interaction between instruction and pre-selection [$F(1,1)=.47, p=.493, \eta^2=.001$], showing limited impact of pre-selection or instruction on memory performance.

To examine if people with different income were differentially impacted by the choice architecture, we conducted a logistic regression on choice taking income into account, which
showed a significant interaction between income and pre-selection on card choice ($B=.50, SE=.19, p=.009, OR=1.65$): When the better card was pre-selected, lower- and higher-income participants were equally likely to choose the better card, but when the worse card was pre-selected, higher income was associated with a greater likelihood of choosing the better card. There was also a significant interaction between income and presentation order on card choice ($B=.45, SE=.19, p=.019, OR=1.56$): When the better card was presented on the left, lower- and higher-income participants were equally likely to choose the better card, but when the worse card was presented on the left, higher income was associated with a greater likelihood of choosing the better card.
General Discussion

The current study examined the impact of choice architecture, specifically default, instructions about the default and presentation order, on human financial decision making. We found that participants demonstrated a greater level of attention towards the pre-selected card compared to the non-pre-selected card, as well as to the card presented on the left compared to the right. In line with these results, participants were more inclined to select the pre-selected card and the card presented on the left as opposed to the non-pre-selected card and the card presented on the right, respectively. Notably, while both factors were found to be significant, the presentation order in which the cards were presented had a stronger influence on participants’ attention than default, and default had a stronger influence on choice than presentation order. Attention mediated the effects of default and presentation order on choice: the default option or the left option drew more attention, therefore increased choice. Choice also mediated the effects of default and presentation order on attention: the default option or the left option increased choice, therefore drew more attention. Both default and presentation order had differential impacts on lower- and higher-income participants: there was no difference across income when the better card was pre-selected or presented on the left; however, when the worse card was pre-selected or presented on the left, higher income was correlated with a greater likelihood of choosing the better card, disadvantaging lower-income participants. Interestingly, higher income correlated with more attention to the worse option, suggesting an attentional blindness to the worse option among lower-income participants.

An important finding in the current study was that default and presentation order can guide attention which mediated decision making, but whether the default is described as intentional or random doesn’t matter. This could suggest that attention was primarily driven by
the salience and order of the presented options, rather than the specific intentions behind the design of the default. It’s also possible that our participants didn’t pay close attention to the instructions while they were viewing the information, which might have impacted their subsequent attention allocation and decision making. Additionally, we asked spending questions after the BubbleView task, in which participants were informed that the pre-selected card was either a better option for them or randomly determined. It is possible that participants were skeptical of the validity of the instruction provided. To overcome this, spending questions could be asked prior to the BubbleView task so that the instruction later could be more credible. Finally, in the instruction provided, we didn’t specify who are “we”, which was another potential reason why the instruction didn’t convince participants.

A strong left bias in reading direction could explain why presentation order had a stronger influence on attention than default, with left-sided stimuli typically receiving more attention compared to right-sided stimuli (Jewell & McCourt, 2000). Such a leftward bias may be due to the neural organization of the visual system, which processes information from left to right in the environment (Mesulam, 1981). Thus, the presentation order of the options may be a more salient and influential factor in guiding attention than default, given that presentation order is more likely to align with the leftward bias in reading direction.

We found that default had a stronger influence on choice than presentation order. This suggested that the default option might reduce decision effort more than presentation order and might be a more powerful heuristic for influencing decision-making. Such a greater influence of default on decision-making behavior is consistent with previous research, which has shown that defaults can significantly influence decision-making, often without careful consideration of alternative options (Kahneman et al., 1991; Samuelson & Zeckhauser, 1988; Shah &
Oppenheimer, 2008). This phenomenon can be attributed to the idea that defaults may serve as a cognitive shortcut, reducing the effort required to make a decision by providing a pre-selected option that does not require additional cognitive processing.

It's interesting to note that higher-income participants paid more attention to the worse card and were more likely to choose the better card. This could stem from several factors: Firstly, higher-income individuals might have a better understanding of financial products and can discern the relative advantages of the “better” card even when another card is pre-selected or presented on the left. Secondly, higher-income individuals might be more willing to diverge from defaults due to a higher risk tolerance or confidence in their financial decisions. Thirdly, past interactions with financial products might have trained higher-income individuals to scrutinize options more carefully, making them less susceptible to default and presentation order biases.

Our study presents several limitations: Firstly, we only studied two credit cards, while in real-world bank websites, there are usually more than two cards presented at the same time. Secondly, we presented the two credit cards in a horizontal order from left to right. The findings could be different if the credit cards were presented top-down. Thirdly, in our study, the median age of our study participants was 35.00 years old and that 43.57% were female. The majority of participants identified as white, accounting for 78.79% of the sample. 86.58% of the sample reported holding a bachelor's degree. The median household income was $54,999 USD. According to the most recent data from the United States Census Bureau, in 2021, the national median age was 38.50 years, with females accounting for 50.50% of the population (U.S. Census Bureau, 2021). The largest ethnic group in the US was white, comprising 75.8% of the population, and 22.60% of the population held a bachelor's degree (U.S. Census Bureau, 2021).
The median household income in US dollars was $69,021 USD (U.S. Census Bureau, 2021). The discrepancies between our sample and the US national data in education and income level are noteworthy and suggest that the sample may not be representative of the broader population.

Fourthly, although previous studies validated BubbleView in tracking attention, demonstrating its results to be closely correlated with those from the SMI RED-250 Mobile Eyetracking System, the technique was still limited as it was not very realistic in daily free-viewing scenarios (Tomm & Zhao, 2016; Luo & Zhao, 2019). Fifthly, we did not measure implicit attention in the current study. Therefore, while we have insights into the explicit attention driven by choice architecture, the interplay between explicit and implicit attention in the context of choice architecture remains unknown and needs future exploration. Finally, the BubbleView paradigm in the current research predominantly emphasizes the participant’s focal point of attention, simulating where one would typically gaze. While it inherently captures central vision, it sidelines the broader scope of peripheral vision. A recent study examining the role of peripheral visual information on the attentional choice biases found that removing the non-fixated option approximately doubled the magnitude of the attentional biases, suggesting that peripheral visual information facilitates attention in the context of choice-architecture (Eum et al., 2023). Within our study, short-term memory becomes especially vital, aiding participants in piecing together fragmented visual insights as they traverse the BubbleView task. They could rely on this memory to recall and compare previously viewed sections. In contrast, the role of peripheral vision, which naturally detects objects and changes outside one’s direct sight, is limited in this paradigm. Instead of leveraging peripheral cues, BubbleView compels participants to actively explore, revealing areas based on prior cues or memory. Thus, while both short-term memory
and peripheral vision are essential in visual exploration, the BubbleView technique in our study places a heightened reliance on the former.

The current study is significant in several ways. Initially, it provides an attentional mechanism to understand financial decision making. We presented empirical evidence of how three commonly studied choice architecture techniques (default, instructions about the default, and presentation order) influenced attention and decision-making. Furthermore, our findings shed light on the reciprocal relationship between attention and choice. Secondly, we utilized a novel tool, BubbleView, to track attention online, which is more cost-effective compared to conventional eye-tracking techniques. Thirdly, the results of the study highlighted the potential impact of choice architecture on vulnerable populations, such as lower-income individuals. Its critical to guide consumers to make better decisions for themselves and avoid disproportionate impact on lower-income individuals by setting regulations to forbid harmful practices from financial institutions to prey on these individuals. Specifically, government agencies have a pivotal role in safeguarding consumers in the financial sector. For example, the Financial Consumer Agency of Canada (FCAC), responsible for consumer protection, can establish regulations promoting ethical choice architectures in financial institutions, encompassing guidelines on option presentation and default settings. Similarly, in jurisdictions with a Consumer Protection Bureau, this body can vigilantly monitor financial products and services, ensuring the absence of manipulative designs and penalizing institutions employing misleading elements of choice architecture.
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https://doi.org/10.2139/ssrn.3308886


https://doi.org/10.1016/j.actpsy.2013.06.003


Appendices

Appendix A: The two credit cards

![Credit Card Image]

**Infinite**
- Earn 1.5% in cash back dollars on grocery purchases, dining at restaurants and travel purchases
- Earn 1.5% in cash back dollars on gas purchases and all other purchases
- Annual fee $0
- Purchase interest rate 14.99%
- Default interest rate 20.74%

**Signature**
- Earn 3% in cash back dollars on grocery purchases, dining at restaurants and travel purchases
- Earn 1.5% in cash back dollars on gas purchases and all other purchases
- Annual fee $95
- Purchase interest rate 25.24%
- Default interest rate 29.98%

Figure A1. The two credit cards used in the experiment. Each card contained 7 features/areas of interest (AOIs), including card name, card, cashback dollars, annual fee, purchase interest rate and default interest rate. An AOI is outlined by a black box which is not visible to the participants.
### Appendix B: Eight conditions

<table>
<thead>
<tr>
<th>Condition 1. Better card pre-selected on the left with the intentional instruction</th>
<th>Condition 2. Better card pre-selected on the left with the random instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagine you are applying for a credit card at a local bank. Here are two card options. Which card is better for you given your financial situation? (A credit card has been pre-selected for you. We believe that it is the better option for you. You will get this option unless you switch to the other option.) The two cards are covered by a black mask. You can move our mouse to see the cards and their information below. Please view the cards carefully and make a decision on which card is better for you. You can select the card by clicking on the button below. After you have made your choice, click on Next to proceed.</td>
<td>Imagine you are applying for a credit card at a local bank. Here are two card options. Which card is better for you given your financial situation? (A credit card has been pre-selected for you. This pre-selection is randomly determined based on a coin flip. You will get this option unless you switch to the other option.) The two cards are covered by a black mask. You can move our mouse to see the cards and their information below. Please view the cards carefully and make a decision on which card is better for you. You can select the card by clicking on the button below. After you have made your choice, click on Next to proceed.</td>
</tr>
<tr>
<td><strong>Infinite</strong></td>
<td><strong>Signature</strong></td>
</tr>
<tr>
<td>Earn 1.5% in cash back dollars on gas purchases, dining at restaurants and travel purchases</td>
<td>Earn 1% in cash back dollars on grocery purchases, dining at restaurants and travel purchases</td>
</tr>
<tr>
<td>Earn 1.5% in cash back dollars on gas purchases and all other purchases</td>
<td>Earn 1% in cash back dollars on gas purchases and all other purchases</td>
</tr>
<tr>
<td>Annual fee: NO</td>
<td>Annual fee: $99</td>
</tr>
<tr>
<td>Purchase interest rate: 14.99%</td>
<td>Purchase interest rate: 29.99%</td>
</tr>
<tr>
<td>Default interest rate: 28.74%</td>
<td>Default interest rate: 28.74%</td>
</tr>
<tr>
<td>Condition 3. Worse card pre-selected, better card on the left, with the intentional instruction</td>
<td>Condition 4. Worse card pre-selected, better card on the left, with the random instruction</td>
</tr>
<tr>
<td>Imagine you are applying for a credit card at a local bank. Here are two card options. Which card is better for you given your financial situation? (A credit card has been pre-selected for you. We believe that it is the better option for you. You will get this option unless you switch to the other option.) The two cards are covered by a black mask. You can move our mouse to see the cards and their information below. Please view the cards carefully and make a decision on which card is better for you. You can select the card by clicking on the button below. After you have made your choice, click on Next to proceed.</td>
<td>Imagine you are applying for a credit card at a local bank. Here are two card options. Which card is better for you given your financial situation? (A credit card has been pre-selected for you. This pre-selection is randomly determined based on a coin flip. You will get this option unless you switch to the other option.) The two cards are covered by a black mask. You can move our mouse to see the cards and their information below. Please view the cards carefully and make a decision on which card is better for you. You can select the card by clicking on the button below. After you have made your choice, click on Next to proceed.</td>
</tr>
</tbody>
</table>
Condition 5. Better card pre-selected, worse card on the left, with the intentional instruction

Imagine you are applying for a credit card at a local bank. Here are two card options. Which card is better for you given your financial situation? (A credit card has been pre-selected for you. We believe that it is the better option for you. You will get this option unless you switch to the other option.)

The two cards are covered by a black mask. You can move our mouse to see the cards and their information below. Please view the cards carefully and make a decision on which card is better for you.

You can select the card by clicking on the button below.

**Infinite**

- Earn 1.5% in cash-back dollars on gas purchases, dining at restaurants and travel purchases
- Earn 1.5% in cash-back dollars on grocery purchases, dining at restaurants and travel purchases
- Annual fee: $80
- Purchase interest rate: 19.99%
- Default interest rate: 29.99%

**Signature**

- Earn 0.5% in cash-back dollars on gas purchases, dining at restaurants and travel purchases
- Earn 0.5% in cash-back dollars on grocery purchases, dining at restaurants and travel purchases
- Annual fee: $0
- Purchase interest rate: 14.99%
- Default interest rate: 29.99%

After you have made your choice, click on Next to proceed.

Condition 6. Better card pre-selected, worse card on the left, with the random instruction

Imagine you are applying for a credit card at a local bank. Here are two card options. Which card is better for you given your financial situation? (A credit card has been pre-selected for you. This pre-selection is randomly determined based on a coin flip. You will get this option unless you switch to the other option.)

The two cards are covered by a black mask. You can move our mouse to see the cards and their information below. Please view the cards carefully and make a decision on which card is better for you.

You can select the card by clicking on the button below.

**Signature**

- Earn 1.5% in cash-back dollars on gas purchases, dining at restaurants and travel purchases
- Earn 1.5% in cash-back dollars on grocery purchases, dining at restaurants and travel purchases
- Annual fee: $80
- Purchase interest rate: 19.99%
- Default interest rate: 29.99%

**Infinite**

- Earn 1.5% in cash-back dollars on gas purchases, dining at restaurants and travel purchases
- Earn 1.5% in cash-back dollars on grocery purchases, dining at restaurants and travel purchases
- Annual fee: $0
- Purchase interest rate: 14.99%
- Default interest rate: 29.99%

After you have made your choice, click on Next to proceed.

Condition 7. Worse card pre-selected on the left, with the intentional instruction

Condition 8. Worse card pre-selected on the left, with the random instruction
Figure B1. Eight conditions in the experiment.
Appendix C: Qualtrics survey

Infinite_left

Which card was previously presented on the left? (This is an attention check.)

Signature_left

Which card was previously presented on the left? (This is an attention check.)

A surprising memory test

Here are some questions for you about the cards you just saw.

Which card has a HIGHER annual fee?

- Infinite
- Signature
Which card provides a HIGHER purchase interest rate?

- Infinite
- Signature

Which card provides a LOWER default interest rate?

- Infinite
- Signature

Which credit card provides FEWER cash back dollars on grocery purchases, gas purchases and regularly recurring bill payments?

- Infinite
- Signature

Default Question Block

Here are some questions about your monthly spending in general.

How much do you usually spend per month on gas (in USD)? If you don’t spend any money on gas, you can put 0.

How much do you usually spend per month on groceries (in USD)?

How much do you usually spend per month on recurring bills (in USD)?

How much do you usually spend per month in total (in USD)?

Do you currently use a credit card?

- Yes
- No

https:// ubic.yu1.qualtrics.com/Q/EdtSection/Blocks/Ajax/GetSurveyPrintPreview?ContxtSurveyID=SV_eA96PDQxK7x46e8k&ContxtLibraryID=UR_... 2/11
If you use a credit card, what is your average monthly balance to carry forward (in USD)?

Have you ever missed a payment on your credit card for two consecutive months?

- Yes
- No
- Don't know

If you have missed a payment on your credit card for two consecutive months, what is your average monthly balance to carry forward (in USD)?

Card info

When you were deciding which card to choose, what information did you consider the most important?

- The name of the card
- The color of the card
- Annual fee
- Purchase interest rate
- Default interest rate
- Cash back dollars

Financial Literacy

Here are some questions on financial literacy. Please provide your best guess on these questions.

Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, would you be able to buy:

- More than today with the money in this account
- Exactly the same as today with the money in this account
- Less than today with the money in this account
- Don't know
- Refuse to answer
Do you think that the following statement is true or false? “Bonds are normally riskier than stocks.”

- True
- False
- Don’t know
- Refuse to answer

Considering a long time period (for example, 10 or 20 years), which asset described below normally gives the highest return?

- Savings accounts
- Stocks
- Bonds
- Don’t know
- Refuse to answer

Normally, which asset described below displays the highest fluctuations over time?

- Savings accounts
- Stocks
- Bonds
- Don’t know
- Refuse to answer

When an investor spreads his money among different assets, does the risk of losing a lot of money:

- Increase
- Decrease
- Stay the same
- Don’t know
- Refuse to answer

It is important to read the questions correctly. To make sure you are paying attention, please select “True” for this question. This is an attention check.

- True
- False
- Don’t know
- Refuse to answer
Do you think that the following statement is true or false? “If you were to invest $1,000 in a stock mutual fund, it would be possible to have less than $1,000 when you withdraw your money.”

- True
- False
- Don’t know
- Refuse to answer

Do you think that the following statement is true or false? “A stock mutual fund combines the money of many investors to buy a variety of stocks.”

- True
- False
- Don’t know
- Refuse to answer

Do you think that the following statement is true or false? “After age 70 1/2, you have to withdraw at least some money from your 401(k) plan or IRA.”

- True
- False
- It depends on the type of IRA and/or 401(k) plan
- Don’t know
- Refuse to answer

Do you think that the following statement is true or false? “A 15-year mortgage typically requires higher monthly payments than a 30-year mortgage, but the total interest paid over the life of the loan will be less.”

- True
- False
- Don’t know
- Refuse to answer

Suppose you have $100 in a savings account and the interest rate is 20% per year and you never withdraw money or interest payments. After 5 years, how much would you have in this account in total?

- More than $200
- Exactly $200
- Less than $200
- Don’t know
Which of the following statements is correct?

- Once one invests in a mutual fund, one cannot withdraw the money in the first year
- Mutual funds can invest in several assets, for example in both stocks and bonds
- Mutual funds pay a guaranteed rate of return which depends on their past performance
- None of the above
- Don’t know
- Refuse to answer

Which of the following statements is correct? If somebody buys a bond of firm B:

- He owns a part of firm of B
- He has lent money to firm B
- He is liable for firm B’s debts
- None of the above
- Don’t know
- Refuse to answer

Suppose you owe $3,000 on your credit card. You pay a minimum payment of $30 each month. At an annual percentage rate of 12% (or 1% per month), how many years would it take to eliminate your credit card debt if you made no additional new charges?

- Less than 5 years
- Between 5 and 10 years
- Between 10 and 15 years
- Never
- Don’t know
- Refuse to answer

Numeracy

Here are some questions on numeracy. Please provide your best guess on these questions.

Imagine that we flip a fair coin 1,000 times. What is your best guess about how many times the coin would come up heads in 1,000 flips?
In the BIG BUCKS LOTTERY, the chance of winning a $10 price is 1%. What is your best guess about how many people would win a $10 price if 1000 people each buy a single ticket to BIG BUCKS?


In ACME PUBLISHING SWEEPSTAKES, the chance of winning a car is 1 in 1,000. What percent of tickets to ACME PUBLISHING SWEEPSTAKES win a car? _____

Which of the following numbers represents the biggest risk of getting a disease?

- 1 in 100
- 1 in 1000
- 1 in 10

It is important to read the questions. This is an attention check that we use to make sure that participants are paying attention to the questions we ask. Please select 5% for this question.

- 1%
- 5%
- 10%

Which of the following numbers represents the biggest risk of getting a disease?

- 1%
- 10%
- 5%

If Person A's risk of getting a disease is 1% in 10 years, and person B's risk is double that of A's, what is B's risk?

_____% in 10 years

If Person A's chance of getting a disease is 1 in 100 in 10 years, and person B's risk is double that of A's, what is B's risk?

_____ in 100 in 10 years

If the chance of getting a disease is 10%, how many people would be expected to get the disease?
Out of 100?
Out of 1000?

If the chance of getting a disease is 20 out of 100, this would be the same as having a ___% chance of getting the disease?

The chance of getting a viral infection is .0005. Out of 10,000 people, about how many of them are expected to get infected?

Demographic questions

Here are some final questions on demographics.

Which gender do you identify with?

- Woman
- Man
- Non-binary
- Transgender
- Two spirited
- Other
- Prefer not to say

What is your age (in years)?

With which of the following do you identify? (select all that apply)

- White
- Black
- Indigenous peoples of North America
- Arab
- Latin, Central or South American
☐ Asian
☐ None of the above or other
☐ Prefer not to say

Which of the following best describes your political views?

☐ Strongly liberal
☐ Liberal
☐ Slightly liberal
☐ Middle of the road
☐ Slightly conservative
☐ Conservative
☐ Strongly conservative
☐ None of the above

What is your total annual household income before tax (in USD)?

☐ Less than $10,000
☐ $10,000 - $19,999
☐ $20,000 - $29,999
☐ $30,000 - $39,999
☐ $40,000 - $49,999
☐ $50,000 - $59,999
☐ $60,000 - $69,999
☐ $70,000 - $79,999
☐ $80,000 - $89,999
☐ $90,000 - $99,999
☐ $100,000 - $109,999
☐ $109,999 - $119,999
☐ $119,999 - $129,999
☐ $129,999 - $139,999
☐ $139,999 - $149,999
☐ More than $150,000

How many people are there in your household (including yourself)?

[Blank field]
What is the highest level of education you have completed?

- Less than high school
- High school
- Diploma/certificate
- Some college/university
- Bachelor's degree
- Graduate degree

How much financial stress have you experienced lately to handle daily expenses?

- No stress at all
- Somewhat stress
- Mild stress
- Moderate stress
- A lot of stress
- A great deal of stress
- Overwhelming stress

Random ID

Thank you for participating in this survey!
Please copy and paste the following code to mturk:
$[e://Field/Random%20ID]$
Click the button to complete the survey.

Powered by Qualtrics
Appendix D: Heatmap of mouse location in each condition

**Condition 1.** Better card pre-selected on the left with the intentional instruction

**Condition 2.** Better card pre-selected on the left with the random instruction

**Condition 3.** Worse card pre-selected, better card on the left, with the intentional instruction

**Condition 4.** Worse card pre-selected, better card on the left, with the random instruction

**Condition 5.** Better card pre-selected, worse card on the left, with the intentional instruction

**Condition 6.** Better card pre-selected, worse card on the left, with the random instruction

**Condition 7.** Worse card pre-selected on the left, with the intentional instruction

**Condition 8.** Worse card pre-selected on the left, with the random instruction
Figure D1. Heatmap of mouse location in each condition. Warmer colors represent a greater density of mouse locations.
Appendix E: Exploratory analyses

ANOVAs and regressions controlling for demographic variables

When controlling for demographic variables (financial literacy, numeracy, income, financial stress, age, education, and political orientation), the two-way mixed-design ANOVA showed no main effect of pre-selection \( [F(1)=3.25, \ p=.072, \ \eta^2_G=.004] \) on proportional dwell time, nor interaction between instruction and pre-selection \( [F(1,1)=2.34, \ p=.127, \ \eta^2_G=.003] \) (see Table E1). The one-way repeated measures ANOVA showed a main effect of presentation order \( [F(1)=4.19, \ p=.041, \ \eta^2_G=.005] \) (see Table E2). For proportional fixations, there was no main effect of pre-selection \( [F(1)=2.07, \ p=.150, \ \eta^2_G=.003] \) nor interaction between instruction and pre-selection \( [F(1,1)=.82, \ p=.367, \ \eta^2_G=.001] \) (see Table E1). There was also no main effect of presentation order \( [F(1)=3.50, \ p=.062, \ \eta^2_G=.004] \) (see Table E2).

Table E1. Two-way ANOVAs on proportional dwell time and proportional fixations controlling for demographic variables.

<table>
<thead>
<tr>
<th></th>
<th>Proportional dwell time</th>
<th>Proportional fixations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( F )</td>
<td>( p )</td>
</tr>
<tr>
<td>Pre-selection</td>
<td>3.25</td>
<td>.072</td>
</tr>
<tr>
<td>Instruction</td>
<td>.36</td>
<td>.550</td>
</tr>
<tr>
<td>Instruction x pre-selection</td>
<td>2.34</td>
<td>.127</td>
</tr>
<tr>
<td>Age</td>
<td>3.68</td>
<td>.056</td>
</tr>
<tr>
<td>Political orientation</td>
<td>.01</td>
<td>.933</td>
</tr>
<tr>
<td>Education</td>
<td>.68</td>
<td>.411</td>
</tr>
<tr>
<td>Financial stress</td>
<td>.01</td>
<td>.925</td>
</tr>
<tr>
<td>Personal income*</td>
<td>.77</td>
<td>.380</td>
</tr>
<tr>
<td>Financial literacy</td>
<td>2.09</td>
<td>.149</td>
</tr>
<tr>
<td>Numeracy</td>
<td>37.62</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

*Personal income was calculated as household income divided by the square root of the number of people in the household.

Table E2. One-way ANOVAs on proportional dwell time and proportional fixations controlling for demographic variables.

<table>
<thead>
<tr>
<th></th>
<th>Proportional dwell time</th>
<th>Proportional fixations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( F )</td>
<td>( p )</td>
</tr>
<tr>
<td>Presentation order</td>
<td>4.19</td>
<td>.041</td>
</tr>
<tr>
<td>Age</td>
<td>3.66</td>
<td>.056</td>
</tr>
<tr>
<td>Political orientation</td>
<td>.01</td>
<td>.928</td>
</tr>
<tr>
<td>Education</td>
<td>.65</td>
<td>.422</td>
</tr>
<tr>
<td>Financial stress</td>
<td>.01</td>
<td>.921</td>
</tr>
</tbody>
</table>
Personal income* | .82 | .365 | .000 | .16 | .694 | .000
Financial literacy | 2.01 | .157 | .001 | 3.10 | .079 | .001
Numeracy | 38.49 | <.001 | .020 | 73.29 | <.001 | .031

*Personal income was calculated as household income divided by the square root of the number of people in the household.

Logistic regressions controlling for the demographic variables showed that pre-selection ($B=-2.12$, $SE=.28$, $p<.001$, OR=.12) and presentation order ($B=-.67$, $SE=.19$, $p<.001$, OR=.51) were significant predictors of choice, but not the interaction between instruction and pre-selection ($B=.29$, $SE=.38$, $p=.442$, OR=1.34, see Table E3).

Table E3. Logistic regressions on choice of the better card.

<table>
<thead>
<tr>
<th></th>
<th>$b$</th>
<th>$se$</th>
<th>$p$</th>
<th>odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-selection</td>
<td>-.212</td>
<td>.28</td>
<td>&lt;.001</td>
<td>.12</td>
</tr>
<tr>
<td>Instruction</td>
<td>-.20</td>
<td>.28</td>
<td>.474</td>
<td>.82</td>
</tr>
<tr>
<td>Presentation order</td>
<td>-.67</td>
<td>.19</td>
<td>&lt;.001</td>
<td>.51</td>
</tr>
<tr>
<td>Instruction x pre-selection</td>
<td>.29</td>
<td>.38</td>
<td>.442</td>
<td>1.34</td>
</tr>
<tr>
<td>Age</td>
<td>.01</td>
<td>.01</td>
<td>.511</td>
<td>1.01</td>
</tr>
<tr>
<td>Political orientation</td>
<td>-.04</td>
<td>.05</td>
<td>.429</td>
<td>.96</td>
</tr>
<tr>
<td>Education</td>
<td>-.17</td>
<td>.13</td>
<td>.190</td>
<td>.85</td>
</tr>
<tr>
<td>Financial stress</td>
<td>.02</td>
<td>.07</td>
<td>.712</td>
<td>1.03</td>
</tr>
<tr>
<td>Personal income*</td>
<td>.00</td>
<td>.00</td>
<td>.012</td>
<td>1.00</td>
</tr>
<tr>
<td>Financial literacy</td>
<td>.07</td>
<td>.05</td>
<td>.129</td>
<td>1.07</td>
</tr>
<tr>
<td>Numeracy</td>
<td>.06</td>
<td>.03</td>
<td>.091</td>
<td>1.06</td>
</tr>
</tbody>
</table>

*Personal income was calculated as household income divided by the square root of the number of people in the household.

**Memory performance**

Figure E1. Memory performance across the eight conditions. Error bars = $1 \pm$ standard error.
Correlation matrix
Table E4. A correlation matrix of attention, memory, choice, financial literacy, numeracy, and personal income for all participants (N=646).

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Proportional dwell time on the better card</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Proportional dwell time on the worse card</td>
<td>-.32***</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Proportional fixations on the better card</td>
<td>.89***</td>
<td>-.36***</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Proportional fixations on the worse card</td>
<td>-.36***</td>
<td>.87***</td>
<td>-.40***</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Memory</td>
<td>.09</td>
<td>.12</td>
<td>.10</td>
<td>.14*</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Choice</td>
<td>.25***</td>
<td>-.15**</td>
<td>.26***</td>
<td>-.17***</td>
<td>.13</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Financial literacy</td>
<td>.11</td>
<td>.15**</td>
<td>.16**</td>
<td>.16**</td>
<td>.18***</td>
<td>.13</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Numeracy</td>
<td>.21***</td>
<td>.18***</td>
<td>.26***</td>
<td>.25***</td>
<td>.32***</td>
<td>.15**</td>
<td>.53***</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>9. Personal income</td>
<td>.03</td>
<td>.08</td>
<td>.07</td>
<td>.11</td>
<td>.07</td>
<td>.12</td>
<td>.29***</td>
<td>.34***</td>
<td>–</td>
</tr>
</tbody>
</table>

*p < .05, ** p < .01, *** p < .001

As Table E4 shows, after Bonferroni correction, proportional dwell time was correlated with proportional fixations (on the better card: \( r=.89, p<.001 \); on the worse card: \( r=.87, p<.001 \)).

Attention to the better card was negatively correlated to attention to the worse card (proportional dwell time: \( r=-.32, p<.001 \); proportional fixations: \( r=-.40, p<.001 \)). Memory was only correlated with attention (proportional fixations) to the worse card (\( r=.14, p=.041 \)). This suggests that the more attention participants paid to the worse card, the better memory they had of the worse card.

Choice was a binary variable (0=choosing the worse card, 1=choosing the better card). The more attention participants paid to the better card, the more likely they were to choose the better card (proportional dwell time on the better card: \( r=.25, p<.001 \); proportional fixations on the better card: \( r=.26, p<.001 \)). The less attention participants paid to the worse card, the more likely they were to choose the better card (proportional dwell time on the worse card: \( r=-.15, p=.006 \);
proportional fixations on the worse card: \( r = -0.17, p < 0.001 \). There was no correlation between memory and choice \( (r = 0.13, p = 0.061) \). Financial literacy correlated with numeracy \( (r = 0.53, p < 0.001) \), and both were correlated with attention and memory, suggesting that the higher financial literacy or numeracy, the more attention they paid to the better card, and the better memory they had. Numeracy was correlated with choice \( (r = 0.15, p = 0.006) \), suggesting that the higher numeracy, the more likely participants were to choose the better card.

**Perceived importance of card features**

We plotted a graph of the overall frequency of perceived card feature that was considered most important for choosing the better card (see Figure E2). The features that were considered most important were annual fee and purchase interest rate. To examine if participants paid greatest attention to the card feature that they considered the most important, we compared the feature that received the most attention to the feature that was considered most important in the choice for each participant. If both features matched, we counted it as a yes; if not, we counted it as a no. In all conditions, the most important card feature did not receive the most attention (Figure E3). There was no difference among the eight conditions \( \chi^2(7, N=646)=3.098, p = 0.876 \).
Figure E2. Frequency of perceived card feature that was considered most important for choosing the better card.

Figure E3. Consistency between the most important card feature and attention.
### Appendix F: Summary of pilot studies

Table F1. A summary table of pilot studies.

<table>
<thead>
<tr>
<th></th>
<th>Number of participants</th>
<th>Conditions</th>
<th>Measures</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot 1</td>
<td>N=44</td>
<td>infinite card pre-selected (N=13) signature card pre-selected (N=20) no card pre-selected (N=11)</td>
<td>Attention Choice</td>
<td>There’s no difference in attention (both proportional dwell time and proportional fixations) to each AOI across the three conditions. There’s no difference in choice across the three conditions.</td>
</tr>
<tr>
<td>Pilot 2</td>
<td>N=60</td>
<td>infinite card pre-selected (N=21) signature card pre-selected (N=22) no card pre-selected (N=17)</td>
<td>Attention Choice</td>
<td>There’s no difference in attention (both proportional dwell time and proportional fixations) for each AOI across the three conditions. There’s no difference in choice between infinite/signature card pre-selected condition and no card pre-selected condition.</td>
</tr>
</tbody>
</table>
| Pilot 3 | N=706 | infinite card pre-selected (N=248) signature card pre-selected (N=239) no card pre-selected (N=219) | Attention Choice Memory | Lower-income participants paid less attention (both proportional dwell time and proportional fixations) to both cards compared to higher-income participants. Lower-income participants paid less attention (both proportional dwell time and proportional fixations) to the signature (worse) card compared to higher-income participants. Lower-income and higher-income participants paid equal amount of attention (both proportional dwell time and proportional fixations) to the infinite (better) card. There was no difference in memory performance between the lower-income group and higher-income group. Lower-income and higher-income participants showed the same choice pattern:  
  - They were both influenced by signature card pre-selected condition but not infinite card pre-selected condition compared to no pre-selection condition. |
| Pilot 4 | N=374 | infinite card pre-selected (N=124) signature card pre-selected (N=125) no card pre-selected (N=125) | Attention Choice Memory | Lower-income group significantly spent less attention to the key features on both cards compared to higher-income group.  
  - For irrelevant features, no difference in attention between lower- and higher-income participants  
  - For relevant features, lower-income participants paid less attention than higher-income participants |
Lower-income group showed significantly lower memory accuracy of card features compared to higher-income group. Memory was driven by attention for both income groups.

In terms of choice:
- For the lower-income group, good default didn’t benefit them but the bad default hurt them
- For the higher-income group, the good default benefited them but the bad default didn’t hurt them
- Choice seemed to be driven more by attention than by numeracy and financial literacy

<table>
<thead>
<tr>
<th>Pilot 5</th>
<th>N=887</th>
<th>infinite card pre-selected (N=274)</th>
<th>Attention</th>
<th>Choice</th>
<th>Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>signature card pre-selected (N=310)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>no card pre-selected (N=303)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lower-income participants paid less attention to the features of the cards than higher-income participants. For lower-income participants, attention predicts choice, but financial literacy and numeracy did not predict choice. Lower-income and higher-income participants showed the similar pattern in choice (they were both more likely to choose the worse card in the bad default condition than in the control condition and more likely to choose the better card in the good default condition than in the control condition). There was no difference in memory performance between the lower-income and higher-income participants.

<table>
<thead>
<tr>
<th>Pilot 6</th>
<th>N=610</th>
<th>Paycut 2%, infinite card on the left (N=145)</th>
<th>Attention</th>
<th>Choice</th>
<th>Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Paycut 2%, signature card on the left (N=144)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paycut 20%, infinite card on the left (N=148)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paycut 20%, signature card on the left (N=173)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There’s no main effect of financial scarcity or presentation order on attention, nor interaction effect. Presentation order, but not financial scarcity, predicted choice.
- Participants were more likely to choose the card presented on the left.
Participants had higher memory performance when the better card was presented on the left.