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Choosing One at a Time? Presenting Options Simultaneously Helps People make more Optimal Decisions than Presenting Options Sequentially

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Abstract

This research examines an element of choice architecture that has received little attention—whether options are presented simultaneously or sequentially. Participants were more likely to choose dominating options when the options were presented simultaneously rather than sequentially, both when the dominance relationship was transparent (Experiment 1) and when it was not (Experiments 2-3). Depth of cognitive processing mediated the effect of option presentation on optimal choice (Experiment 4). Memory load was unlikely to be the underlying mechanism, as individual differences in working memory span did not predict optimal choice in the sequential condition (which places a greater memory load; Experiment 5), and manipulations of memory load did not reduce the benefits of simultaneous presentation (Experiments 6a-6c). Instead, participants' working memory span predicted optimal choice in the simultaneous condition (which allows for more in-depth processing; Experiment 5), and a manipulation of processing load eliminated the benefits of simultaneous presentation (Experiment 7).

Keywords: choice architecture; cognitive load; option presentation; processing load; sequential; simultaneous

Choosing One at a Time? Presenting Options Simultaneously Helps People make more Optimal Decisions than Presenting Options Sequentially

Imagine Susan, a 23 year old woman, who quit her job and opened a start-up in 2012. Upon losing her employer-provided insurance, she visited the websites of numerous insurance providers, one at a time, viewed the plans that they offered, and then finally chose a health insurance plan. Now imagine Sarah, a 23 year old woman who quit her job to open a start-up in 2014. Instead of visiting the website of each and every insurance provider, Sarah went to www.healthcare.gov, entered her information, and saw a big table listing all the health insurance plans that she was eligible for, along with their values on various attributes. Assuming that the plans that Susan and Sarah were eligible for were identical, who would be more likely to choose the plan that best met her needs?

Both types of choices described above are common in people's everyday lives. In many cases, decision makers make a choice after considering options one at a time. For example, hiring managers typically interview one candidate at a time before selecting one for the position. Journal editors typically receive and consider one manuscript at a time. Other times, decision makers make a choice with all options laid out at the same time. For example, for journal special issues, guest editors typically consider multiple manuscripts submitted at the same time and then select a subset. Often times, people have a choice of whether to consider multiple options sequentially or simultaneously. For example, when buying electronic products online, people can view the specifications of each product at a time by going to the product's webpage, or by using a "compare products" function to view multiple options simultaneously.

Similarly, investors choosing a mutual fund may study one fund at a time, or compare multiple mutual funds all laid out together. Could viewing options all together rather than one at a time help or hurt managers hire better job candidates, journals select more high quality papers, consumers buy better products, and investors choose more profitable mutual funds? We investigate this possibility in the present research.

To assess the extent to which people encounter options that are presented sequentially vs. simultaneously in real life, we explored websites of the top 10 car manufacturers (Statista, 2016) and the top 10 life insurance providers (National Association of Insurance Commissioners, 2016) in the US, in terms of market share. All car manufacturers' and life insurance providers' websites had individual web pages for each of their products, allowing customers to view options one at a time. However, they differed in the extent to which customers could view multiple products simultaneously. Four car manufacturers allowed consumers to view multiple cars together but showed only two attributes—price and mileage—instead of more than 20 attributes that are used to describe cars. All car manufacturers featured a compare products tool. However, reaching this tool was not straightforward. Compared to the webpages for individual products, which could be accessed by 1.1 clicks (SD = .3) after landing on the homepage, a visitor would have to make 2.7 clicks (SD = .46) to reach the comparison tool. Furthermore, people could compare only 3.5 cars (SD = .67) at a time. On the other hand, six insurance providers featured a comparative table listing all their products, and one company provided a comparison tool that required five clicks from the home page and could be used to compare three of six available policies. Three insurance providers exclusively displayed their products on individual pages. These analyses suggest that the default format in which consumers acquire information about products varies both across and within different purchase domains. Further, when given the option, people can typically compare only a few options on a few attributes simultaneously, but have to sequentially view one product at a time if they want detailed information.

The decision of whether to present options sequentially or simultaneously is a key element of choice architecture (Thaler & Sunstein, 2008), which refers to the fact that "there are many ways to present a choice to the decision-maker, and that what is chosen often depends upon how the choice is presented" (Johnson et al., 2012, p. 488). Researchers have investigated numerous elements of choice architecture that influence decisions, such as the number of alternatives (Cronqvist & Thaler, 2004), the presence of defaults (Johnson & Goldstein, 2003), the categories in which the options are grouped (Fox, Ratner, & Lieb, 2005), and the units used to describe attributes (Larrick & Soll, 2008). We investigate an element of choice architecture that has received little attention in past research—whether options are presented simultaneously or sequentially (see Mogilner, Shiv, & Iyengar, 2013; Bohnet, Van Geen, & Bazerman, 2015, for exceptions).

Our key hypothesis is that when people choose among simultaneously presented options, they would make more optimal decisions than when they choose among sequentially presented options. The rationale behind this prediction is that when individuals consider options simultaneously, the key attributes on which the options differ from one another are easier to compare, thus allowing them to engage in more in-depth cognitive processing about the options. In other words, we predict that viewing options simultaneously would lead decision makers to process the options more comprehensively and analytically, such as by examining the relative advantages and disadvantages of the options and integrating the relevant information (Maheswaran & Chaiken, 1991; Maheswaran & Meyers-Levy, 1990). This more comprehensive, extensive, and in-depth processing, in turn, would help them identify the optimal option. Although past research has not examined this question, we review the extant literature on sequential vs. simultaneous option presentation.

Simultaneous versus Sequential Option Presentation

Strategic Decision Making.

Although research has not explicitly tested whether people make better decisions when they consider options sequentially vs. simultaneously, some research on strategic decision making is consistent with this idea. Gemünden and Hauschildt (1985) obtained detailed minutes of 83 decisions that the executive board of a mid-size German company made over an 18-month period. They noted the number of options that each decision involved: 40% were whether-or-not decisions involving single options considered individually, and 55% were decisions involving two options considered simultaneously. Eight years later, the executive board was asked to evaluate the quality of each of the 83 decisions. Strikingly, executives rated the initial decision as being "very good" 43% of the time when it involved two options, but only 6% of the time when it involved a single option. Although this study was not a controlled experiment, this finding suggests the intriguing possibility that when people consider multiple options simultaneously, they might make better decisions than when they consider options one at a time (see Heath & Heath, 2013 for an additional discussion).

Consumer Decision Making.

Recent research has more specifically investigated people's choices among sequentially versus simultaneously presented options. Mogilner et al. (2013) found that when consumers chose among sequentially presented hedonic options (e.g., chocolate, wine), they were less satisfied with their chosen option than when they chose among simultaneously presented options. For example, individuals presented with descriptions of five chocolates and asked to choose one were subsequently happier with their choice and less likely to change their choice compared to those who were presented with the descriptions one at a time. The rationale for this finding was that when presented with options sequentially, individuals hope that they would encounter an even better option subsequently, which makes them dissatisfied with their chosen option. However, when options are presented simultaneously, the question of hoping for a better option does not even arise, and thus people are more satisfied with their chosen option.

Our research differs from this work in important ways. Mogilner et al. (2013) examined choice among hedonic stimuli that cannot be broken down into attributes (e.g., chocolate, wine), and are thus holistically perceived and judged based on their subjective properties as perceived by the chooser. Instead, we study choice among quantifiable stimuli that are specified in terms of numerically represented attributes and judged based on their objective attributes. Further, among hedonic options, people are entitled to choose whatever they fancy, so there is no optimal option. Instead, we investigate cases in which there is a normatively correct option that should not be influenced by people's idiosyncratic preferences. Finally, Mogilner et al.'s key outcome was choice satisfaction and choice commitment, whereas our key outcome is whether people choose the optimal option. Thus, the present research studies choice stimuli (attribute-based vs. holistic), mechanisms (cognitive processing vs. hope), and decision outcomes (optimal choice vs. post-choice satisfaction) that are distinct from those studied by Mogilner et al. (2013).

An extensive body of research has examined a related phenomenon—how presenting a single option versus multiple options influences people's evaluations of the options (Hsee & Zhang, 2010). The typical paradigm in this stream of research is to show some participants either one of two different options (e.g., either one of two different test scores; the separate evaluation conditions), and to show a third group of participants both the options (e.g., two test scores presented together; the joint evaluation condition; Hsee, 1996). This research has found that people's evaluation of options violate basic economic principles in single evaluation but not in joint evaluation (Hsee & Zhang 2010, but see Sher & McKenzie, 2014, for arguments on why such an inconsistency might be rational). Our research differs from the literature on single vs. joint evaluation in two key ways. First, both sequential and simultaneous presentations are joint evaluations—all participants are presented with all options (unlike single evaluation, in which participants are presented with only one option). Second, our outcome variable is the choice of the best option. However, research on single vs. joint evaluation cannot even investigate this outcome because in the single evaluation condition, participants do not have multiple options to choose from.

Potential benefits of considering options simultaneously

Comparing options is a key element of making a choice (Medin, Goldstone, & Markman, 1995). Eye-tracking research reveals that when people have to choose among visually presented options, they initially scan each option to form an overview; then, they narrow down the choice set to the options in which they are interested, and selectively compare individual attributes of those options while ignoring the other options; finally, they conclude with a scan of previously ignored options before deciding on one of the options (Russo & Leclerc, 1994, see also Pieters & Warlop, 1999; Reutskaja, Nagel, Camerer, & Rangel, 2011; Willemsen & Johnson, 2011). Even when the choice is between choosing an option or not, people compare the available option with ones that they might have previously encountered, or compare the value of the available option with their internal reference value for similar options (Simonson, Bettman, Kramer, & Payne, 2013). Therefore, it is not a stretch to claim that comparisons form the basis of choice.

We submit that when people are deciding between options that are all laid out together, the differences between the options would become salient and help people compare the options with each other. Some research in the way people acquire information from visually displayed options suggest that this may be the case. After viewing details of various options presented together rather than one at a time, people acquire a better understanding of the differences among the options (Goldstone, 1996; McKenzie, 1998). For example, compared to participants who learned about both common and unique symptoms of two illnesses sequentially, participants who were presented with the symptoms of both illnesses simultaneously were more likely to use diagnostic symptoms in a subsequent diagnosis task (Klayman & Brown, 1993). Similarly, viewing simultaneously presented options helps people realize the weaknesses of individual options. For example, compared to participants who viewed the predictions of two experts sequentially, participants who were presented with both experts’ predictions simultaneously were more likely to average the two experts’ predictions, which is the normative strategy as each expert could independently over- or under-predict the true value, rather than relying on either one of the two experts’ predictions (Larrick & Soll, 2006).

These findings suggest that when options are presented simultaneously, it becomes easier for the decision maker to compare options and understand the ways in which the options differ from each other, and to assess their relative advantages and disadvantages. If viewing options simultaneously helps the decision maker engage in more in-depth information processing about the options, then they would have a higher chance of identifying the optimal option. In contrast, when options are presented sequentially, while viewing any particular option, the decision maker would not be able to readily compare all the options with each other. This may inhibit the decision maker’s ability to process the information about the various options, and therefore, reduce their likelihood of identifying the optimal option.

To illustrate the hypothesis, consider how Susan would choose among the various health insurance plans in the absence of a comparative tool such as www.healthcare.gov. Susan would visit the webpage of each of the health insurance plans that she is interested in, one at a time. She would probably form a subjective evaluation of each plan on important attributes and then move on to the next plan. After she has viewed all available plans, she can create a table listing the important attributes of each plan, but most likely, she would try to mentally compare the leading options and then choose one. However, with a comparative tool that allows Sarah to view all options simultaneously, she can directly assess which option is the best on the attributes that she cares most about, make judgments about the relative advantages and disadvantages of each plan, and choose the option that best meets her preferences. In other words, viewing options simultaneously is likely to help Sarah engage in more in-depth information processing, which would help her make an optimal choice.

Potential benefits of considering options sequentially

The arguments laid out above suggest that people would make better decisions when they consider options all together. However, research on consumer choice suggests that in certain cases, people might make better decisions when they consider options one at a time. When evaluating multiple options, a person can compare the options in two different ways, using either alternative-based comparisons or attribute-based comparisons (Bettman, Luce, & Payne, 1998; Payne, Bettman, & Johnson, 1993). In the alternative-based comparison strategy, the decision maker evaluates one alternative in its entirety, across all attributes, and then moves on to the next alternative. In the attribute-based comparison strategy, the decision maker compares all alternatives on one attribute, and then moves on to the next attribute. An alternative-based strategy called the weighted additive strategy is often considered the best strategy for making choices (Payne, Bettman, & Johnson, 1988; Zakay & Wooler, 1984). A decision maker following this strategy would take an alternative, assign a value to each of its attributes, multiply each attribute value with the subjective importance or weight of that attribute, and then sum these across all attributes for that alternative. The decision maker would then repeat this procedure for all alternatives, and then choose the alternative with the highest weighted sum.

When considering options sequentially, the decision maker might be more likely to engage in alternative-based comparisons, as they only see one option at a time. When considering options simultaneously, the decision maker might be more likely to engage in attribute-based comparisons, as they see all options and their attributes laid out all together. To the extent that a highly effective decision strategy is alternative-based, this line of reasoning would predict that people would make better decisions when choosing among sequentially presented options. However, people can engage in either alternative-based or attribute-based comparisons with either sequentially or simultaneously presented options. For example, a decision maker considering options one at a time can employ an attribute-based comparison strategy by going back and forth among options. Similarly, a decision maker considering options all together can employ an alternative-based comparison strategy by focusing on one option at a time rather than focusing on one attribute at a time. Further, people are unlikely to have pre-assigned weights for different attributes in mind unless they have carefully thought about the choice in advance. Thus, we did not consider it likely that people would make better choices when choosing among sequentially rather than simultaneously presented options.

Overview of Studies

We first conducted a pilot study to examine whether people choose among both sequentially and simultaneously presented options in their everyday lives. We then tested our hypotheses across seven experiments. In each experiment, we asked people to choose among options that were defined in terms of quantitative attributes, such as consumer products differing on multiple attributes (the types of decisions most studied in the consumer behavior literature; Wright, 1975), and gambles varying in payoffs and probabilities (the types of decisions most studied in the judgment and decision making literature; Slovic & Lichtenstein, 1968). Experiment 1 tested our main hypothesis that individuals presented with consumer items varying on five different attributes would be more likely to choose the dominating option that had the highest value on each attribute when the options are displayed simultaneously rather than sequentially. Experiment 2 sought to conceptually replicate this finding with more complex stimuli in which the dominance relationship was not obvious but had to be inferred based on one latent parameter—price per unit quantity. Experiment 3 aimed to further replicate the findings with stimuli in which the dominance relationship had to be inferred based on two latent parameters—expected value and variance.

Experiment 4 investigated the underlying mechanism, that simultaneously presentation helps people engage in more in-depth cognitive processing than sequential presentation, using an open-ended thought protocol analysis. Experiment 5 tested two competing explanations for the observed effect—between-condition differences in the depth of cognitive processing rather than between-condition differences in memory load. We did so by assessing the role of individual differences in working memory span. Corroborating this finding with experimental evidence, Experiments 6a-6c found that manipulations of working memory load did not reduce the extent to which simultaneous presentation helped people make better choices over sequential presentation, indicating that between-condition difference in working memory load is not the key mechanism. However, Experiment 7 found that when people's cognitive processing resources were restricted in a dual-task paradigm, the advantage offered by simultaneous presentation attenuated, strengthening our argument for the underlying role of more in-depth cognitive processing.

No participants were dropped from the analyses in any experiment unless reported. All conditions and choice measures are reported. In each experiment, data were analyzed only after the target sample size was met.

Pilot Study

Before testing our hypothesis, we wanted to establish the relevance of the problem in the real world. If people consider options sequentially in a significant proportion of their choices, then presenting the options all together can nudge them to make better choices. We provided participants with a description of sequential and simultaneous option presentation and gave them an example of each. Next, we asked participants to estimate how frequently they considered options sequentially vs. simultaneously when making their everyday choices.

Method

Participants. We recruited 211 participants (M_{age} = 36.75 years; 104 women, 105 men, 2 unreported) from the US using Amazon Mechanical Turk.

Procedure. Participants were first presented with a brief description of the two option consideration strategies:

> When people shop for a product, they often consider multiple options before making a choice.
>
> There are two different ways in which people can go about this process: They can either consider options one at a time (sequentially) or consider them all together (simultaneously).
>
> Many times, people consider options one at a time. They view one option, consider the pros and cons of that option, and then move on to the next option.

> They repeat this process until they have considered all the options. Once they have done so, they make a choice.
>
> At other times, people view all the options together. They view all the relevant options together, such as by putting all options side by side in a store or viewing all options on a single page when shopping online. They consider the pros and cons of all the options. Once they have done so, they make their choice.

Next, to provide participants with a concrete example, we asked them to imagine that they were buying a laptop and considering four options. To illustrate sequential option consideration, we showed participants each option one at a time on different screens. Next, to illustrate simultaneous option consideration, we showed participants all the options together on a single screen.

Thereafter, participants were asked “What percentage of time in the past did you view options one at a time vs. all together before making the final choice?” Participants had to indicate the percent of time they viewed options sequentially and simultaneously, with the total adding up to 100%.

Results

Participants indicated that they considered options sequentially in 42.85% of choices and simultaneously in 57.15% of choices in the past. The data from the pilot study indicates that in nearly half of their everyday choices, people consider options sequentially. Thus, if considering options simultaneously helps people make better decisions, then switching from sequential option consideration to simultaneous option consideration would have a significant impact on the quality of nearly half the decisions that people make.[1]

Experiment 1

The goal of Experiment 1 was to test whether people choosing from simultaneously presented consumer products would be more likely to pick the dominating option compared to those choosing from sequentially presented options. Across five trials, we showed participants multiple products varying on different attributes. One of these options had the highest value across all attributes, and thus was the dominating option. We hypothesized that participants who view the options simultaneously would be more likely to choose the dominating option than those who view the options sequentially.

Method

Participants. As we did not have any prior data for conducting a power analysis, we decided on a target sample size of 100 participants per cell at the outset, given that a sample size of 100 per cell would provide 80% power to detect a medium effect size (Cohen's d = .40) with $\alpha = .05$ (two-tailed). A survey seeking 200 US residents was posted on Amazon Mechanical Turk. In response, 201 participants ($M_{age} = 32.76$ years; 116 women, 85 men) completed the survey. We randomly assigned participants to the sequential or the simultaneous option presentation conditions.

Procedure. We presented participants with five trials in which they had to choose one of six different options for a consumer product. In each trial, we asked participants to imagine that they were planning to buy an electronic product (e.g., a laptop) and had shortlisted six options differing across five attributes (e.g., battery, processor, RAM, storage, and warranty). We designed the stimuli such that each attribute took one of two values across all six options. We ensured that one of the options dominated all others by assigning it the higher of the two values on each attribute—this option was thus the optimal option in the choice set. The dominating option appeared in different locations in each of the five trials. We randomized the order of the five trials for each participant (see Appendix A for complete stimuli).

In the simultaneous presentation condition, in each trial, participants were presented with all six options together on a single screen, and asked to “Choose one and indicate your choice in the next page.” Once participants clicked on the continue button, they were presented with the same options again and asked, “Which of the following 6 models would you choose?” Participants indicated their choice by clicking on a button next to their preferred option. Participants moved on to the next trial after making their choice.

In the sequential presentation condition, in each trial, participants were only presented with one option at a time. They could view the next option by clicking the continue button and go back to the previous options by clicking the back button. Once they had viewed all the options, they were instructed, “That was the last option for this question. Now you will see the options once again. This time, locate the option that you would choose using the continue and back buttons.” They then saw the six options again presented one at a time with a “Yes, I want to choose this option” button below each option. They could navigate to the desired option, and upon making a choice, moved to the next trial.

Results

The dependent variable was the percentage of trials in which the participants chose the optimal option. An independent samples t-test revealed that participants who considered the options simultaneously were more likely to choose the dominating option than those who considered options sequentially, $M_{simultaneous}$ = 84.42%, 95% CI [79.94%, 88.90%], SD = 21.03%, $M_{sequential}$ = 75.46%, 95% CI [70.83%, 80.10%], SD = 25.25%, $t(199) = 2.72$, $p = .007$, Cohen's d =.39.[2]

Discussion

We know from the literature (e.g., Mogilner et al., 2013) that when choosing among simultaneously presented options, people are more satisfied with their choices than when choosing among sequentially presented options. Experiment 1 shows for the first time that although a priori, people might be more likely to use more optimal alternative-based comparisons when choosing among sequentially presented options (Payne et al., 1988), they make better choices when choosing among simultaneously presented options. When participants chose among simultaneously presented consumer products, they were more likely to choose the option that had the highest level of each attribute, the dominating option, compared to when they chose among sequentially presented options. It appears that simultaneous option presentation made it easier for the participants to compare the options, thereby helping them identify the best one.

Experiment 2

Experiment 2 aimed to assess the generalizability of Experiment 1's findings in two ways. Although the type of choice that participants made in Experiment 1 is similar to common consumer choices, it can be argued that the dominance relationship may be transparent in simultaneous presentation but obscured in sequential presentation given the difficulty that people faced processing the various options. Experiment 2 tested whether simultaneous presentation helps people identify dominating options even when the dominance relationship is not transparent but instead needs to be inferred from the presented attributes.

In this experiment, we asked participants to choose between different suppliers offering different quantities of the same product at different prices. We varied the options such that one supplier provided the product at the lowest price per unit quantity, which was the optimal option. Unlike in Experiment 1, participants did not see the price per unit quantity—instead, this was a latent parameter that they had to infer. We hypothesized that participants would be more likely to choose the option with the lowest price per unit quantity when choosing among simultaneously presented options than when choosing among sequentially presented options.

Participants. A power analysis based on Cohen's d = .39 (from Experiment 1), α = .05 (two-tailed), and power = 80% indicated that we would need to recruit 105 participants per cell. To ensure that we have high power, we decided on a larger target sample size of 250 participants per cell, which would give us 99% power. A survey seeking 500 US residents was posted on Amazon Mechanical Turk. In response, 472 participants (M_{age} = 36.18 years; 250 women, 187 men, 35 unreported) completed the survey. We randomly assigned participants to either the sequential or the simultaneous option presentation conditions.

Procedure. Participants were asked to imagine that they owned a large restaurant that bought weekly supplies of different products. They were asked to make purchase decisions for five products (e.g., ketchup, ground cloves), and for each product, they could choose from five suppliers, each of whom offered different quantities of the product for different prices. We designed the stimuli such that for each product, the five suppliers varied in the price per unit quantity, with one supplier offering the lowest price per unit, which would be the optimal choice. We ensured that the optimal option occurred at different positions across the five products (i.e., whether it was listed first, second, third, fourth, or fifth), and we randomized the order of the five products (see Appendix B for the complete stimuli).

We manipulated option presentation in the same manner as in Experiment 1. In the simultaneous condition, we first presented participants with all the options together and then asked to choose one of the five options, which were again presented together. In the sequential condition, we first presented participants with the options one at a time, and then asked to choose one of the five options, which were again presented one at a time.

Results.

The dependent variable was the percentage of trials in which the participants chose the supplier offering the lowest price per unit quantity. An independent samples t-test found that participants in the simultaneous presentation condition chose the optimal option in a greater percentage of the trials compared with those in the sequential presentation condition, $M_{simultaneous}$ = 61.34%, 95% CI [57.50%, 65.19%], SD = 31.42%, $M_{sequential}$ = 54.87%, 95% CI [51.00%, 58.75%], SD = 28.84%, t(470) = 2.33, p = .02, Cohen's d = .21.[3]

Discussion.

Experiment 2 provided further support for our hypothesis that when people choose from simultaneously presented options, they are more likely to make more optimal decisions than when they choose from sequentially presented options, even when the relevant parameters that define the optimal option are implicit and need to be inferred from the attribute values. Participants making purchase decisions among five suppliers were more likely to pick the supplier offering the lowest price per unit quantity when the options were presented together as compared to when they were presented one at a time. It appears that simultaneous presentation made it easier for participants to assess and compare the options even on latent parameters, thereby increasing their chances of choosing the optimal option compared to sequential presentation.

Experiment 3

Experiment 3 sought to further generalize the findings of the previous studies using even more complex choices—risk decisions. In the context of risky options with relatively small stakes, the optimal decision is to select an option with the highest expected value (given that rational agents should not exhibit small stakes risk aversion; Rabin, 2000), but with lower variance when expected value is held constant (given the assumption of risk aversion captured by the idea “never take additional risk without additional returns;” Markowitz, 1959). This idea is consistent with the notion of stochastic dominance, which suggests that for two options with the same expected value, the less risky option dominates the riskier one (second-order stochastic dominance; Hadar & Russel, 1969; Hanoch & Levy, 1969).

In Experiment 3, we presented participants with risky options that varied on expected value. Two of these options had the highest expected value. Among these two options, there was a second-order stochastic dominance relationship such that, for the same expected value, one option had a lower variance. Thus, the optimal choice was based on two latent parameters (i.e., expected value and variance), both of which were not obvious but had to be inferred from the payoffs. We hypothesized that participants would be more likely to choose the option with the highest expected value and lower variance when choosing from simultaneously presented options than when choosing from sequentially presented options.

Method

Participants. A power analysis based on Cohen's d = .39 (from Experiment 1[4]), α = .05 (two-tailed), and power = 80% indicated that we would need to recruit 105 participants per cell. To ensure that we have high power, we decided on a larger target sample size of 150 participants per cell, which would give us 92% power. A survey seeking 300 US residents was posted on Amazon Mechanical Turk. In response, 294 participants (M_{age} = 35.28 years; 145 women, 147 men, 2 undisclosed) completed the survey. We randomly assigned participants to the sequential or the simultaneous option presentation conditions.

Procedure. We presented participants with ten trials in which they had to choose one of five different risky options, each of which would give one of two payoffs with equal probability (see Appendix C for complete stimuli). In each trial, two options had the highest expected value but differed in the variance of their outcomes (e.g., "Option 1: Heads $10, Tails: $20", "Option 2: Heads $8, Tails: $22"). We ensured that the dominating option (e.g., "Option 1: Heads $10, Tails: $20") occurred in each of the five possible positions in the choice set exactly twice across the ten trials, thus counterbalancing for order effects.

We manipulated option presentation in the same manner as in the previous experiments. In the simultaneous condition, we first presented participants with all the options together and then asked to choose one of the five options, which were again presented together. In the sequential condition, we first presented participants with the options one at a time, and then asked them to choose one of the five options, which were again presented one at a time.

Results.

The dependent variable was the percentage of trials in which the participants chose the optimal option—the option with the highest expected value and lower variance. An independent samples t-test found that participants in the simultaneous presentation condition chose the optimal option on a greater percentage of trials compared with those in the sequential presentation condition, $M_{simultaneous}$ = 62.66%, 95% CI [57.64%, 67.69%], SD = 33.10%, $M_{sequential}$ = 46.29%, 95% CI [41.02%, 51.56%], SD = 30.04%, $t(292) = 4.45$, $p < .0001$, Cohen's d = .52.[5]

Discussion.

Experiment 3 provided further support for our hypothesis that when people choose from simultaneously presented options, they are more likely to make more optimal decisions than when they choose from sequentially presented options. This occurred not only when the optimal option was based solely on a single latent parameter, as in Experiment 2, but also on multiple latent parameters, as in the current experiment. Participants presented with five lotteries simultaneously were more likely to pick the lottery with the highest expected value and lower variance, two parameters that they had to infer from the payoffs, than those presented with the same lotteries sequentially. It appears that simultaneous presentation made it easier for participants to assess and compare the options even when making these relatively complex decisions, thereby increasing their chances of choosing the best option compared to sequential presentation.

Experiment 4

Experiments 1 through 3 indicate that viewing options simultaneously increases people's likelihood of choosing the optimal option from a choice set. Our assumption has been that simultaneous presentation increases optimal decision making compared to sequential presentation because it allows participants to easily compare the options across different attributes, helping them engage in more in-depth cognitive processing about the options, and thereby, identifying the best option. Experiment 4 aimed to directly test this idea by assessing whether people engage in more in-depth cognitive processing when presented with simultaneously rather than sequentially presented options.

In this study, we asked participants to make choices among sequentially and simultaneously presented risky options across five trials, as in Experiment 3. Participants were asked to list their thoughts after each decision that they made. We analyzed the content of participants' thoughts to test whether the depth of cognitive processing differed across conditions (Chen & Berger, 2013; He & Bond, 2013; Iliev & Axelrod, 2016; Kuhnen & Niessen, 2012). To assess the specificity of the mechanism, we further tested whether the two conditions would differ in affective processing. Although affective processing is often taken as a counterpart to cognitive processing (Pham, Cohen, Pracejus, & Hughes, 2001; Zhao, Hoeffler, & Zauberman, 2011), we did not have any a priori reasons for expecting between-condition differences in affective processing.

Method

Participants. A power analysis based on Cohen's d = .52 (from Experiment 3, which used a superset of the current stimuli), α = .05 (two-tailed), and power = 80% indicated that we would need to recruit 60 participants per cell. To ensure that we have high power, we decided on a larger target sample size of 100 participants per cell, which would give us 95% power. A survey seeking 200 US residents was posted on Amazon Mechanical Turk. In response, 214 participants (M_{age} = 34.80 years; 85 women, 129 men) completed the survey.

Procedure. We presented participants with five trials in which they had to choose one of five lotteries varying in expected value and variance, which was a subset of lotteries used in Experiment 3 (see Appendix C for the stimuli). There was, however, one crucial difference. In each trial, after participants chose an option, we asked them, "Please write down what thoughts you had while choosing one of the five options on the previous screen. Please tell us anything you thought or felt while making the choice." We provided them with five separate text boxes to list their thoughts.

Results

Choice. As in the previous experiments, the dependent variable was the percentage of trials in which the participants chose the optimal option. An independent samples t-test found that participants in the simultaneous presentation condition chose the optimal option (i.e., the option with the highest expected value and lower variance) on a greater percentage of trials compared to those in the sequential presentation condition, $M_{simultaneous}$ = 52.57%, 95% CI [46.37%, 58.78%], SD = 31.41%, $M_{sequential}$ = 39.82%, 95% CI [33.73%, 45.91%], SD = 33.05%, t(212) = 2.89, p =.004, Cohen's d = .40.[6]

Depth of cognitive processing. We next used the Linguistic Inquiry and Word Count program (LIWC; Pennebaker, Booth, & Francis, 2007) to analyse the content of participants' thoughts during the decision making process. We submitted each participant's responses across all five trials to the LIWC program. The program provided numeric scores indicating the extent to which each participant's responses referred to a number of different constructs. The key constructs of interest were the percentage of words that indicated cognitive thought process and those that indicated affective thought process. As LIWC has five sub-categories under affective processes and eight under cognitive processes, we created each participant's cognitive and affective processing score by adding their scores across the various sub-categories within each of these two larger categories. Compared to participants in the sequential condition, those in the simultaneous condition described thoughts that scored higher on cognitive processing, $M_{simultaneous}$ = 24.79, 95% CI [23.66, 25.92], SD = 5.96, $M_{sequential}$ = 22.56, 95% CI [21.45, 23.68], SD = 5.82, t(212) = 2.76, p =.006, Cohen's d = .38, but not on affective processing, $M_{simultaneous}$ = 10.20, 95% CI [9.06, 11.34], SD = 4.21, $M_{sequential}$ = 11.41, 95% CI [10.29, 12.53], SD = 7.19, t(212) = -1.51, p =.13, Cohen's d = .20.[7]

Mediation. Next, we conducted a mediation analysis using Model 4 of the PROCESS macro (Preacher & Hayes, 2008) to test whether between-condition differences in the extent of cognitive processing mediated between-condition difference in choice. This non-parametric bootstrapping analysis with 5000 iterations revealed that the effect of option presentation condition on the percentage of trials on which participants chose the optimal option was mediated by participants' cognitive processing scores, indirect effect = 1.73, 95% CI [.23, 4.57].

Discussion

Experiment 4 replicated the previous experiments' findings and provided converging support for the underlying mechanism. Compared to participants who viewed the options sequentially, those who viewed the options simultaneously were more likely to choose the optimal option and to use words related to cognitive processing while describing their thoughts during the choice process. Between-condition differences in choice was explained by the depth of cognitive processing that participants engaged in while making the decision. The effect was specific to depth of cognitive processing and did not emerge for depth of affective processing.

Experiment 5

Experiment 4 provided support for the argument that simultaneous presentation increases optimal decision making compared to sequential presentation because it allows participants to engage in more in-depth cognitive processing about the options. However, an alternative explanation is that sequential presentation decreases optimal decision making compared to simultaneous presentation because sequential presentation increases working memory load, as participants in the sequential condition have to keep multiple options in memory whereas those in the simultaneous condition do not. The goal of Experiment 5 was to tease apart these two potential explanations. We did so by examining an individual difference variable—working memory span.

Multiple studies have found that individual differences in working memory capacity predict the quality of people's judgments and decisions (Bara, Bucciarelli, & Lombardo, 2001; Kyllonen & Christal, 1990; Stanovich & West, 2000). The beneficial effect of higher working memory capacity on judgments and decisions could work through two routes: the ability to store more information, and the ability to process more information (Baddeley & Hitch, 1974; Barrouillet, Portrat, & Camos, 2011; Daneman & Carpenter, 1980; Turner & Engle, 1989). These two functions of working memory help tease apart the two competing mechanisms for why simultaneous option presentation helps people make better decisions than sequential presentation. If sequential presentation is driving the effect, reducing people's ability to make optimal decisions because they have to hold information in memory, then sequential presentation should have a stronger negative effect on people with lower working memory capacity. On the other hand, if simultaneous presentation is driving the effect, increasing people's ability to make optimal decisions because it makes it easier for them to process information, then simultaneous presentation should have a stronger positive effect on people with higher working capacity.

We tested these competing hypotheses by first administering a task measuring individual differences in working memory load, in which participants had to actively store some information in memory while simultaneously processing other information online, and recalling the stored information at the end of the task (Conway, 1996; Daneman & Carpenter, 1980). We then presented participants with lotteries, as in Experiment 3, and tested the relationship between working memory and optimal lottery choice across the sequential and simultaneous conditions.

Method

Participants. A power analysis based on Cohen's d = .52 (from Experiment 3, which used a superset of the current stimuli), α = .05 (two-tailed), and power = 80% indicated that we would need to recruit 60 participants per cell. To ensure that we have high power, we decided on a larger target sample size of 100 participants per cell, which would give us 95% power. A survey seeking 200 US residents was posted on Amazon Mechanical Turk. In response, 192 participants (M_{age} = 31.86 years; 98 women, 87 men, 7 unreported) completed the survey.

Procedure. We first asked participants to complete the automated operation span (automated OSPAN) task, which is a validated measure of working memory capacity (Turner & Engle, 1989; Unsworth, Heitz, Schrock, & Engle, 2005). The automated OSPAN task measures how well an individual can maintain information in memory while performing another cognitive task simultaneously. Across multiple trials, participants had to evaluate whether a numeric operation (e.g., 3 X 3 = 18) was True or False. After each operation, we presented participants with a letter (e.g., E). Each trial comprised 3 to 7 operation-letter pairings. At the end of each trial, participants were given a multiple-choice test in which they were asked to identify the letters shown during the trial (in the order displayed) from a total of 12 options. There were a total of 15 trials in which participants were exposed to a total of 75 operation-letter pairings. Participants' working memory score was calculated by adding the number of correctly recalled operations-letter pairings across all perfectly recalled sets (for a detailed description of the procedure and the scoring, see Conway et al., 2005; Unsworth et al., 2005).

Participants were then randomly assigned to either sequential or simultaneous option presentation condition. We asked participants to choose one of five lotteries, each of which would give one of two rewards with equal probability. The procedure was identical to that used in Experiment 3 except that participants were presented with five trials that were a subset of the ten trials used in Experiment 3 (see Appendix C for the stimuli).

Results

Nine participants who scored zero in the working memory task (i.e., did not recall any set correctly) were excluded from the analyses because they were likely to be unmotivated or highly distracted. The mean working memory score of the remaining participants was 49, ranging from 3 to 75. We regressed the percentage of trials in which participants chose the optimal option in the lottery choice task on condition (sequential = 0, simultaneous = 1), participants' working memory score (mean-centered), and their interaction. As in the previous experiments, there was a main effect of option presentation, B = 15.03, SE = 4.66, 95% CI [5.83,24.23], t(179) = 3.22, p = .001, Cohen's d = .46, indicating that participants in the simultaneous condition chose the optimal option on a greater percentage of trials, $M_{simultaneous}$ = 50.43%, 95% CI [43.88%,57.00%], SD=37.33%, $M_{sequential}$ = 35.82% 95% CI [29.23%,42.42%], SD = 25.21% . The main effect of working memory score was non-significant, B = .14, SE = .12, 95% CI [-.10,.38], t(179) = 1.18, p = .24, but we found an interaction between option presentation condition and working memory score, B = .60, SE = .24, 95% CI [.12,1.08], t(179) = 2.47, p = .01. To investigate the interaction effect, we assessed the relationship between working memory score and choice separately within each of the presentation conditions. As shown in Figure 1, in the simultaneous condition, participants with higher working memory scores were more likely to choose the most optimal option, B = .44, 95% CI [.03,.85], t(90) = 2.14, p = .04. However, this relationship disappeared in the sequential condition, B = -.16, 95% CI [-.42,.11], t(89) = -1.19, p = .24.[8]

Discussion.

Experiment 5 tested two competing mechanisms for why simultaneous presentation helps people make more optimal decisions than sequential presentation: because simultaneous presentation allows for more in-depth cognitive processing, or because sequential presentation imposes a bigger load on working memory. Supporting the idea that simultaneous presentation leads to more optimal decision making because it allows for more cognitive processing, we found that individual differences in working memory capacity were associated with optimal decision making only in the simultaneous condition. In other words, when the option presentation allowed participants to easily compare the options, an individual difference associated with information processing capacity predicted participants' ability to make optimal choices.

In the sequential presentation condition, in which it was more difficult for participants to compare the options, participants' working memory span was unrelated to their ability to make optimal decision. This finding argues against working memory load as the mechanism explaining differences in optimal decision making across the two conditions because if sequential presentation led to more suboptimal decision making than simultaneous presentation because it imposed a greater load on working memory, then individual differences in working memory capacity would have predicted optimal choice in the sequential presentation condition, but this was not the case.

Experiments 6a, 6b, and 6c

Experiment 5's finding that participants' working memory score was unrelated to the percentage of trials on which they selected the optimal option indicates that between-condition differences in memory load might not be contributing to the difference in optimal choice between the simultaneous and sequential option presentation conditions. Given that one cannot make firm conclusions based on null effects, we decided to further investigate whether memory load moderates the effect of option presentation on optimal choice using a series of three experiments. If sequential presentation was reducing people's ability to choose the optimal option because it imposed a greater memory load compared to simultaneous presentation, then adding an external source of memory load to both conditions would reduce the advantage of simultaneous presentation. However, if memory load is not the mechanism at play, then adding an external source of memory load to both conditions would not reduce the difference between the two conditions.

Method

Participants. We recruited 293 US participants (M_{age} = 36.63 years; 166 women, 127 men) from Amazon Mechanical Turk for Experiment 6a, 89 participants (M_{age} = 20.61 years; 41 women, 48 men) from a large public university in Singapore for Experiment 6b, and 634 US participants from (M_{age} = 34.81 years; 375 women, 254 men, 5 unreported) from Amazon Mechanical Turk for Experiment 6c. Across all three experiments, we randomly assigned participants into one cell of a 2 (Sequential vs. Simultaneous presentation) X 2 (High vs. Low memory load) design. Experiments 6a and 6c were conducted online but Experiment 6b was conducted in the lab.

Procedure. We used a similar procedure across all three experiments. Across five trials, we asked participants to make choices among five options presented either sequentially or simultaneously. In Experiments 6a and 6b, we presented participants with the five lotteries used in Experiments 4 and 5 (see Appendix C for the stimuli). In Experiment 6c, we presented participants with the product purchase options used in Experiment 2 (see Appendix B for the stimuli).

We manipulated memory load by adopting a procedure widely used in the literature (e.g., Gilbert, Pelham, & Krull, 1988; Menon & Kahn, 2003; Monga & Houston, 2006; Shiv & Fedorikhin, 1999; Wadhwa & Zhang, 2015). At the start of the experiment, we told participants that they would see some numbers (in Experiments 6a and 6b) or letters (in Experiment 6c), which they must memorize. We further informed them that we would test their recall at a later stage. In the high memory load condition, we asked participants to memorize 549872 (Experiment 6a), 4293758 (Experiment 6b), & SWJXHYU (Experiment 6c). In the low memory load condition, we asked participants to memorize 7 (Experiment 6a), 7777777 (Experiment 6b), & W (Experiment 6c). Participants then proceed to complete the choice task. At the end of the choice task, we asked participants to recall the numbers and letters that they were asked to memorize.

Results

For each experiment, we submitted the percentage of trials in which the participants chose the optimal option to a 2 (option presentation condition) X 2 (memory load condition) ANOVA. Table 1 reports the results from the three ANOVA analyses. Across the three experiments, we observed only a significant effect of option presentation. Participants who viewed options simultaneously chose the optimal option on a greater percentage of trials as compared to those who viewed options sequentially. The effect of memory load and its interaction with option presentation remained non-significant across the three experiments.

Discussion

Experiments 6a through 6c corroborate the correlational results obtained in Experiment 5. Across the three experiments, differences in memory load had no effect on participants' likelihood of choosing the optimal option, irrespective of whether they viewed the options sequentially or simultaneously. If participants were less likely to choose the optimal option when viewing options one at a time because of higher memory load, an external source of memory load should reduce the advantage offered by simultaneous presentation. However, across the three experiments, we observed neither a main effect of the memory load manipulation nor any interaction between memory load and option presentation, suggesting that between-condition differences in memory load is unlikely to be the mechanism explaining between-condition differences in participants' likelihood of choosing the optimal option.

Experiment 7

Whereas Experiments 6a, 6b, and 6c indicated that higher memory load did not reduce the advantage of simultaneous presentation over sequential presentation, Experiment 7 tested whether higher cognitive processing load would indeed reduce the advantage. This hypothesis is based on Experiment 4's finding that between-condition differences in the depth of cognitive processing mediated the effect of simultaneous presentation on more optimal choice. Thus, if we restrict participants' processing resources, then the advantage of simultaneous presentation should decrease. To manipulate processing load without manipulating memory load, we used a dual task paradigm (e.g., Brandstatter, Lengfelder, & Gollwitzer, 2001; Brunken, Steinbacher, Plass & Leutner, 2002; Cierniak, Scheiter, & Gerjets, 2009; Finley, Benjamin, & McCarley, 2014). In the no processing load condition, participants were asked to make choices without working on a secondary task, as in the previous studies. In the processing load condition, participants were asked to work on a secondary task while making choices. This secondary task would therefore tax their cognitive processing resources available for the primary choice task. We hypothesized that the difference in optimal choice between the sequential and the simultaneous presentation conditions would attenuate under high processing load.

Method

Participants. A power analysis based on Cohen's d = .52 (from Experiment 3, which used a superset of the current stimuli), α = .05 (two-tailed), and power = 80% indicated that we would need to recruit 60 participants per cell. To ensure that we have high power, we decided on a larger target sample size of 100 participants per cell, which would give us 93% power. A survey seeking 400 US residents was posted on Amazon Mechanical Turk. In response, 395 participants (M_{age} = 35.44 years; 256 women, 137 men, 2 unreported) completed the survey. We randomly assigned participants into one cell of a 2 (Sequential vs. Simultaneous presentation) X 2 (Processing load vs. No load) design.

Procedure. The primary task used the same lotteries as in Experiments 4 and 5. Across five trials, we asked participants to choose one of five lotteries, each yielding one of two rewards with equal probability, presented either sequentially or simultaneously (see Appendix C for the stimuli).

We manipulated processing load by varying whether participants were asked to complete a secondary task that required cognitive processing while working on the primary choice task. We developed a website in which participants' computer screen was divided into two parts, with 70% of the screen on the left reserved for the primary task, and 30% of their screen on the right reserved for the secondary task. In the no load condition, the right side remained blank. In the processing load condition, the secondary task appeared on the right side.

In the processing load condition, at the start of the experiment, participants were informed that they would have to complete two tasks simultaneously—a math task and a coin toss game. In the math task, participants were presented with statements about the addition of two two-digit numbers (e.g., "The sum of 35 and 22 is 77"), half of which were true and half were false. Each statement remained on the screen for exactly five seconds, and then the next statement appeared. Participants could select either True or False during the five seconds when each statement was displayed on the screen. We decided to show each math statement for a fixed duration to ensure that participants would not ignore the primary task and just solve as many math problems as possible. To ensure that participants were involved in both tasks, we told them that the respondent who got the most number of math statements correct per minute while completing the coin toss game at the same time would receive a bonus of $10. Thus, it was in participants' interest to work on both tasks simultaneously.

In the no load condition, there was no secondary task. To maintain equivalence across conditions, participants were informed that one respondent would be randomly selected to receive a bonus of $10.

Results

We submitted the percentage of trials in which the participants chose the optimal option to a 2 (option presentation condition) X 2 (processing resources load condition) ANOVA. We found a main effect of option presentation, $F(1,391) = 20.75$, $p < .0001$, $\eta^2_p = .05$, a significant main effect of cognitive load, $F(1,391) = 14.91$, $p = .0001$, $\eta^2_p = .04$, and a significant interaction, $F(1, 391) = 6.82$, $p = .009$, $\eta^2_p = .02$. To illustrate the main effects, participants who viewed options simultaneously chose the optimal option on more trials compared to those who viewed options sequentially, $M_{simultaneous} = 36.78\%$, 95% CI [33.23, 40.09], $SD = 27.92\%$, $M_{sequential} = 25.25\%$, 95% CI [21.63, 28.76], $SD = 22.90\%$, $t(393) = 4.50$, $p < .0001$. Further, participants in the processing load condition chose the optimal option on fewer trials compared to those in the no load condition, $M_{processing\_load} = 26.18\%$, 95% CI [22.53, 29.84], $SD = 21.16\%$, $M_{no\_load} = 36.06\%$, 95% CI [32.49, 39.63], $SD = 29.57\%$, $t(393) = -3.83$, $p = .0002$.

To analyze the interaction effect, we conducted a series of independent samples t-tests (see Figure 2). First, we compared the participants' performance within the processing load and no load conditions. In the no load condition, participants who viewed options simultaneously chose the optimal option on a greater percentage of trials compared to those who viewed options sequentially, $M_{simultaneous} = 44.81\%$, 95% CI [39.35, 50.26], $SD = 29.56\%$, $M_{sequential} = 26.77\%$, 95% CI [21.15, 32.39], $SD = 26.73\%$, $t(200) = 4.55$, $p < .0001$. However, in the processing load condition, there was no significant difference between the two option presentation conditions, $M_{simultaneous}$ = 28.51%, 95% CI [24.38, 32.65], SD = 23.55%, $M_{sequential}$ = 23.62%, 95% CI [19.29, 27.96], SD = 17.95%, t(191) = 1.63 , p = .10.

Analyzing the interaction effect another way, we reasoned that if simultaneous option presentation helps people make more optional choices because it leads to more in-depth cognitive processing, then the effect of processing resources load would be especially pronounced for participants who viewed options simultaneously. Confirming this prediction, among participants who viewed options simultaneously, processing load significantly decreased the percentage of trials on which they chose the optimal option, t(203) = -4.37, p < .0001. However, the presence of processing load had no effect among participants who viewed options sequentially, t(188) = -.96, p = .34.[9]

Discussion

Experiment 7 provided converging experimental evidence for the findings of Experiments 4 and 5, that people make better decisions when viewing simultaneously presented options because they can engage in more in-depth cognitive processing about the options, compared to when they view sequentially presented options. When participants' cognitive processing resources were taxed by a secondary task, the simultaneous vs. sequential option presentation made no difference to their likelihood of choosing the optimal option. However, when their ability to process information was unhindered, participants were more likely to choose the optimal option when choosing among simultaneously rather than sequentially presented options.

General Discussion

Seven experiments showed that people choosing among multiple options presented all together were more likely to select the optimal option than those choosing from the same options but presented one at a time. In Experiment 1, when choosing among six consumer electronic products varying on five attributes, participants were more likely to choose the dominating option when they saw all the options simultaneously compared to when they saw the options one at a time. Experiment 2 found evidence for this effect when the dominance relationship was not transparent but was instead implicit: Participants were more likely to choose the lowest price per unit quantity (which had to be inferred from the price and the quantity) when they considered options simultaneously as compared to when they considered options sequentially. Experiment 3 found that this effect held for even more complex choices in which the optimal choice is based on two latent parameters: Participants were more likely to choose the dominating lottery (the one with the highest expected value and lower variance) when they considered the options simultaneously than when they considered the options sequentially.

Experiments 4-7 investigated the underlying mechanism. In Experiment 4, an open-ended thought protocol analysis revealed that participants in the simultaneous condition were more likely to use words related to depth of cognitive processing when describing their thoughts during the choice process, compared with those in the sequential condition, which mediated the effect of sequential-simultaneous processing on optimal choice. Experiment 5 found that individual differences in working memory span predicted optimal choice in the simultaneous condition, indicating that simultaneous presentation improves optimal choice because it allows people to engage in cognitive processing, making individual differences in processing capacity relevant. However, working memory span did not predict optimal choice in the sequential condition, indicating that it is unlikely that sequential presentation reduces optimal choice because it imposes a greater working memory load. Corroborating this correlational finding, Experiments 6a-6c showed that manipulations of memory load did not reduce the difference between the simultaneous and sequential conditions. Finally, Experiment 7 found that when participants' processing capacity was reduced because they were working on a secondary task, participants who viewed options together were no more likely to make the optimal choice compared to those who viewed options one at a time.

Theoretical Implications

Our research contributes to multiple streams of literature in the judgment and decision making area. First, we contribute to the highly important and relevant literature on choice architecture (Johnson et al., 2012; Thaler & Sunstein, 2008). Our research highlights a dimension of choice architecture that has as of yet not received much attention—whether options are presented simultaneously or sequentially. After deciding on the number of options to provide in a choice set (Cronqvist & Thaler, 2004; Kling, Mullainathan, Shafir, Vermeulen, & Wrobel, 2012), the choice architect has to decide how to present the options, even before they make other important decisions, such as whether to set defaults (Johnson & Goldstein, 2003). The current research suggests that choice architects should explicitly consider the option presentation format.

Second, we contribute to the nascent literature on sequential and simultaneous option presentation. Prior research in this area has focused on choice among options that differ from each other on qualitative dimensions, such as wine and chocolates (Mogilner et al., 2013), which are commonly studied in the consumer behavior literature. The present research instead studied choice among options that differ from each other on quantifiable dimensions, such as payoffs, probabilities, and numeric attribute values, which are more commonly studied in the judgment and decision making literature. Whereas simultaneous choice among qualitative options increases choice commitment and satisfaction with the chosen option (Mogilner et al., 2013), we find that simultaneous choice among quantitative dimensions helps decision makers choose the optimal option. We further demonstrate that more extensive and in-depth information processing underlies the facilitative effect of simultaneous option presentation on optimal choice. Therefore, our research contributes to this literature by documenting the influence of option presentation on novel outcomes using a completely different class of options as well as documenting a novel mechanism underlying this effect.

Third, we contribute to the literature on choice processes by documenting the relationship between working memory and decision quality. A rich body of research has shown that higher cognitive abilities, such as greater working memory capacity, are associated with higher general intelligence, deductive reasoning, and decision quality (Bara et al., 2001; Kyllonen & Christal, 1990; Stanovich & West, 2000). However, highlighting the role of contextual factors, Experiment 3 shows that this relationship holds only when the decision environment facilitates cognitive processing, as in the case of simultaneous condition.

Fourth, we contribute to the literature on cognitive load within social psychology and judgment and decision making, which has often used manipulations of memory load (often called cognitive load) to assess whether certain judgments and decisions are automatic or controlled (Gilbert, Pelham, & Krull, 1988). Although researchers have typically assumed that memory load also acts as a processing resources load (e.g., Shiv & Fedorikhin, 1999), our Experiments 6 and 7 suggest that this is not always the case: multiple studies found that manipulations of memory load had no impact on participants' likelihood of choosing the optimal option in the simultaneous vs. sequential conditions, whereas a manipulation of processing load eliminated the difference between the two conditions. Although many decision tasks might be affected in a similar manner by the two types of loads, the present research highlights the need for distinguishing between memory load and processing load, and understanding the types of judgments and decisions that are more affected by one or the other.

Our research has numerous managerial and policy implications. The findings suggest that recruiters might make better decisions if they interview multiple candidates simultaneously rather than interviewing one at a time; journal editors might make better decisions if they consider multiple research papers simultaneously rather than deciding the fate of one paper at a time; and consumers might make better decisions if they visit third party websites comparing different products simultaneously rather than viewing each product individually. Additionally, our findings suggest that for decisions in which there is a “right answer” from a policy perspective, policy makers should lead people to consider multiple options simultaneously rather than sequentially. For example, consumers choosing a car to buy in a dealer's parking lot typically consider one car model at a time, and thus view the options sequentially. As they examine each car, they see the fuel efficiency rating of the car on the label attached to its windshield, as required by law. Instead, the findings from Experiment 1 suggest that policy makers can require that the fuel efficiency label affixed on each car not only include the rating for that particular car but also for all leading cars in the given category (e.g., all family sedans with at least 5% market share in the country). If a customer has the goal of purchasing a relatively fuel efficient car, then the simultaneous presentation of this information is likely to increase the customer's chances of actually buying a more fuel efficient car.

Directions for future research

The current research shows that for decisions in which there is a clear optimal option, people are more likely to choose that option when considering options all together rather than one at a time. However, there exist contexts in which simultaneous option presentation might lead to worse outcomes than sequential option presentation. We discuss some of these possibilities below.

Context effects. We suspect that simultaneous presentation might exacerbate a number of decision making biases called context effects, such as the attraction effect (Huber, Payne, & Puto, 1982; Huber & Puto, 1983), the compromise effect (Simonson 1989), and the similarity effect (Tversky 1972). These biases arise when people compare simultaneously presented options involving tradeoffs (i.e., in which no option is the clear winner). As making tradeoffs is difficult, people often use certain heuristics that are based on the relationships between the options (e.g., dominance, intermediacy, and similarity) to simplify the choice. Studies testing for these biases have largely used simultaneously presented options. To the extent that relationships between options are more salient in simultaneous presentation, it is likely that these biases would be weakened if people are choosing among sequentially presented options.

Tradeoff aversion. In cases in which an optimal option does not exist, people would have to make tradeoffs, that is, they need to decide which attributes are more important and which are less important. For example, should one rather choose a car with better fuel economy or a car with more horsepower, given that fuel economy and horsepower are negatively correlated? When people are choosing among simultaneously presented options, the necessity to make trade-offs across different attributes would probably be more salient (Tversky & Simonson, 1993), which might reduce the decision maker’s satisfaction with their choice (Brenner, Rottenstreich, & Sood, 1999) and might even lead them to defer the choice (Dhar 1996). In such cases, if people consider options one at a time, the tradeoffs across different attributes might be less salient, and thus increase choice satisfaction. For example, to the extent that people evaluate options more holistically (e.g., engage in alterative-based rather than attribute-based comparisons) when considering one option at a time, they might be less susceptible to tradeoff aversion than when considering options simultaneously.

The size of the choice set. In the current studies, we asked participants to choose one of five or six options. In real life, people might often face a larger number of options. Future research can investigate whether considering all options simultaneously helps people make more optimal decisions even with larger choice sets, such as those with ten or twenty options. We suspect that there are critical thresholds for the number of options, the number of attributes, and their combination, beyond which simultaneous presentation of options would be cognitively taxing and might yield suboptimal decisions compared to sequential presentation. Future research can investigate how the benefits of simultaneous presentation parametrically change with these factors.

Reference values. In the present studies, we used options that though important, are not choices that people make on a daily, routine basis. For routine items, people might often have reference values stored in the long term memory. For example, when shopping in a supermarket, people may recruit prices of similar products that they had previously encountered (Monroe & Lee, 1999). In situations in which a large number of options are available, perhaps sequential presentation can lead to more efficient decision making if people compare each option encountered with their reference value and choose the first option that surpasses their reference value. In contrast, simultaneous presentation might focus people's attention on the available options rather than on their internal reference value, thereby increasing the complexity of the decision.

Non-comparable attributes. In this research, we examined choice among comparable options that varied on the same set of attributes. However, people often choose among options that are not comparable (Johnson 1984; Cho, Khan, & Dhar, 2013), for example, a family deciding between buying a new television or going on a vacation, or a manager deciding between hiring a programmer or a salesperson. In such cases, presenting options simultaneously might highlight the non-comparability of the option attributes and thus increase the difficulty of the choice task. In contrast, presenting options one at a time might encourage the decision maker to evaluate the utility of each option on its own and then compare the overall utilities of the different options rather than comparing their attributes. Thus, people might be more likely to make a decision and to be happy with their decision if choosing among sequentially presented rather than simultaneously presented non-comparable options.

Biases in joint evaluation. Whereas simultaneous option presentation is identical to joint evaluation (Hsee & Zhang, 2010), sequential option presentation has features of both joint evaluation and single evaluation—people consider one option at a time (as in single evaluation), but subsequently, have to make a choice (as in joint evaluation). Thus, we suspect that any bias that is more prominent in joint evaluation compared to single evaluation is likely to be stronger in simultaneous option presentation rather than sequential option presentation, although the magnitude of the difference is likely to be smaller. For example, people sometimes use simplifying rules to make decisions, such as the majority rule (Russo & Dosher, 1983), which corresponds to the idea of choosing the option that is superior on a majority of the attributes. In cases in which an option is marginally superior to other alternatives on a majority of attributes, but significantly inferior on a minority of attributes, the majority rule can lead to the decision maker to choose suboptimal options. Past research has found that people are more likely to use the majority rule when choosing among simultaneously presented options than when evaluating a single option (Zhang, Hsee, & Xiao, 2006). Similarly, when considering multiple options presented simultaneously, people give excessive weight to numeric attributes (e.g., the number of megapixels of a camera) than to qualitative attributes (e.g., the vividness of the camera's photographs), but not when they evaluate one option at a time (Hsee, Yang, Gu, & Chen, 2009). To the extent that people engage in more alterative-based rather than attribute-based comparisons when considering one option at a time, they might be less susceptible to numerous biases that are more likely to arise in joint evaluation than single evaluation.

Attribute importance. As is often the case in many real life decisions, participants in our experiments did not have a chance to think about the basis on which to make their choices before they viewed the options. However, in many cases, people may ruminate over a decision before finally making a choice. In such cases, it is possible that they assign importance of weights to the attributes. In such cases, when people view options sequentially, they can calculate a weighted score for each item and pick the item with the highest score. When they view items simultaneously, they might begin comparison options across attributes rather than computing the weighted score for each option. However, to compute a weighted score, the individual should be able to convert the values across different attributes to a common scale. To the extent this requirement is satisfied, sequential presentation may lead people to make more optimal decisions. However, we contend that in the absence of clear attribute weights or a common scale, simultaneous presentation will outperform sequential presentation as in such cases, the attribute weighting process will be suboptimal.

After considering some possible shortcomings of simultaneous option presentation compared to sequential presentation, we consider some additional benefits other than helping people choose the best option.

Order effects. In most of our studies, we randomized the order of the trials. In studies in which the order of the trials was not randomized, the location of the optimal option in the choice set was counterbalanced. Thus, our effects hold after controlling for order effects. However, prior research has found that when people consider options one at a time, they tend to prefer options that come later in the sequence, even when the order of options is randomly determined. For example, across 47 years of the Eurovision Song Contest, judges gave higher ratings to singers who performed later than those who performed earlier, even when the ordering was random (Bruine de Bruin, 2005). However, other research has found that in certain contexts, people judge the first option that they encounter more favorably (Carney & Banaji, 2012). As these biases arise when people consider options one at a time, presenting options simultaneously would be one way to eliminate serial position effects.

Negatively correlated attributes. People often choose among products with negatively correlated attributes (Curry and Faulds, 1986). For example, in many cases, the higher the quality of a good, the higher its price, which can lead to a psychological sense of conflict as people want both high quality and low price. When choosing among options with negatively correlated attributes, people may try to overcome conflict by considering options one at a time, as a higher value on one attribute can offset a lower value on another (compensatory strategy; Bettman, Johnson, Luce, & Payne, 1993). Another strategy to reduce conflict would be to compare multiple options on only a subset of attributes, one attribute at a time (noncompensatory strategy; Johnson, Meyer, & Ghose, 1989). When a dominant option exists in a choice set with negatively correlated attributes, people using a compensatory, alternative-based strategy are less likely to identify the dominating option as compared to those using a noncompensatory, attribute-based strategy (Hansen & Helgeson, 2001). As people are more likely to use a compensatory strategy when choosing among sequentially presented options but a noncompensatory strategy when choosing among simultaneously presented options, simultaneous presentation may lead to a lower sense of conflict, and help identify the optimal option even when the options have negatively correlated attributes.

Reducing implicit biases. It is likely that considering multiple options simultaneously makes transparent some sources of bias that people may be unaware of but which they can then correct. For example, people were less likely to exhibit gender bias in hiring when they viewed candidate profiles simultaneously rather than individually (Bohnet et al., 2015). Viewing candidates together probably made distinctions among the candidates, including their gender, more salient, and this heightened awareness probably led participants to suppress gender stereotypes while making their decisions. A possible mechanism underlying this effect is that although many people wanted to be egalitarian, they were unaware of their implicit gender bias when viewing one candidate at a time but more aware of it when viewing all candidates simultaneously. This raises the possibility that simultaneous presentation might make a host of implicit biases (Dasgupta 2004; Greenwald & Krieger, 2004) more salient, and thereby help people correct for them. Future research can investigate this mechanism and its implications for domains other than gender.

Ego depletion. Research on ego depletion has argued that when people engage in effortful mental activities, they have fewer resources to engage in subsequent effortful activities, and thus perform worse in subsequent activities (Baumeister, Bratslavsky, Muraven, & Tice, 1998; c.f., Carter, Kofler, Forster, & McCullough, 2015). It can be argued that considering one option at a time is more effortful compared to considering all options simultaneous, and thus ego-depletion is the mechanism explaining between-condition difference in decision quality. We contend that ego depletion cannot explain the pattern of results obtained in our experiments. Ego depletion tasks are more effortful (e.g., crossing out all the ‘e’s in a page following complex rules, as in Tice, Baumeister, Shmueli, & Muraven, 2007, Study 1), whereas the present experiments asked participant to make simple choices among five or six options. Research on the depleting effect of choices has typically asked participants to make a large number of choices, such as about 300 (Vohs et al., 2008). However, future research can examine whether considering options together can lead to lower ego depletion using standard dependent measures used in the ego-depletion literature and hence, better performance in a subsequent task.

Conclusion

Decision makers make multiple choices every day in which they either consider all possible options together or consider options one at a time. The present research helps advance the science of behavioral decision making by identifying an element of choice architecture that has not received much attention—whether options are presented sequentially or simultaneously. As one of the first empirical investigations of how sequential and simultaneous presentation of options influence choice quality, the findings from the present research have important implications to the way decision makers view options and policy makers present options.

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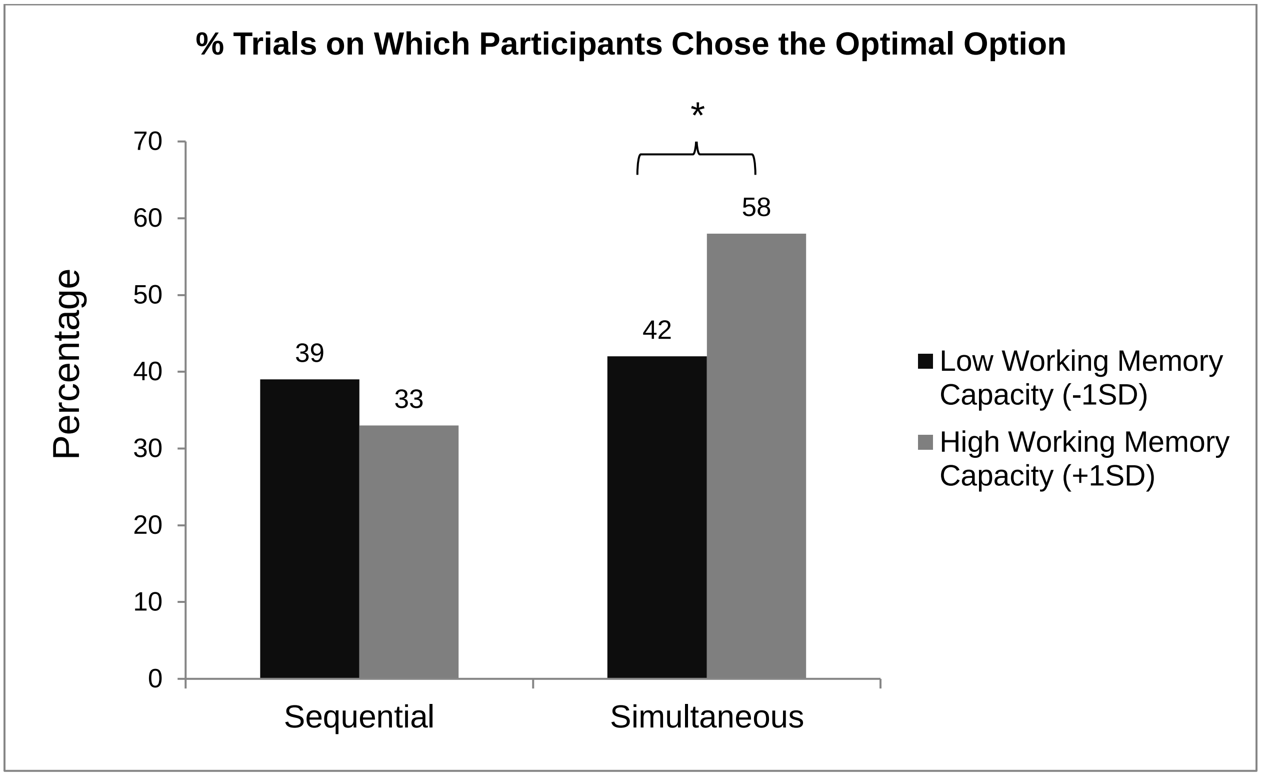
Tables

Table 1. Results from the three 2-way ANOVAs in Experiments 6a, 6b, & 6c

	Experiment 6a	**Experiment 6b**	**Experiment 6c**
Option presentation condition	$F(1,289) = 6.27$, $p = .01$	$F(1,88) = 10.91$, $p = .001$	$F(1,630) = 12.87$, $p = .0004$
Memory load condition	$F(1,289) = 1.03$, $p = .31$	$F(1,88) = .15$, $p = .70$	$F(1,630) = .30$, $p = .58$
Option presentation X Memory load	$F(1,289) = .67$, $p = .42$	$F(1,88) = .15$, $p = .70$	$F(1,630) = .07$, $p = .79$
% of trials with optimal option chosen	$M_{simultaneous} = 47.45\%$ $M_{sequential} = 38.04\%$	$M_{simultaneous} = 68.18\%$ $M_{sequential} = 44.00\%$	$M_{simultaneous} = 61.80\%$ $M_{sequential} = 53.63\%$

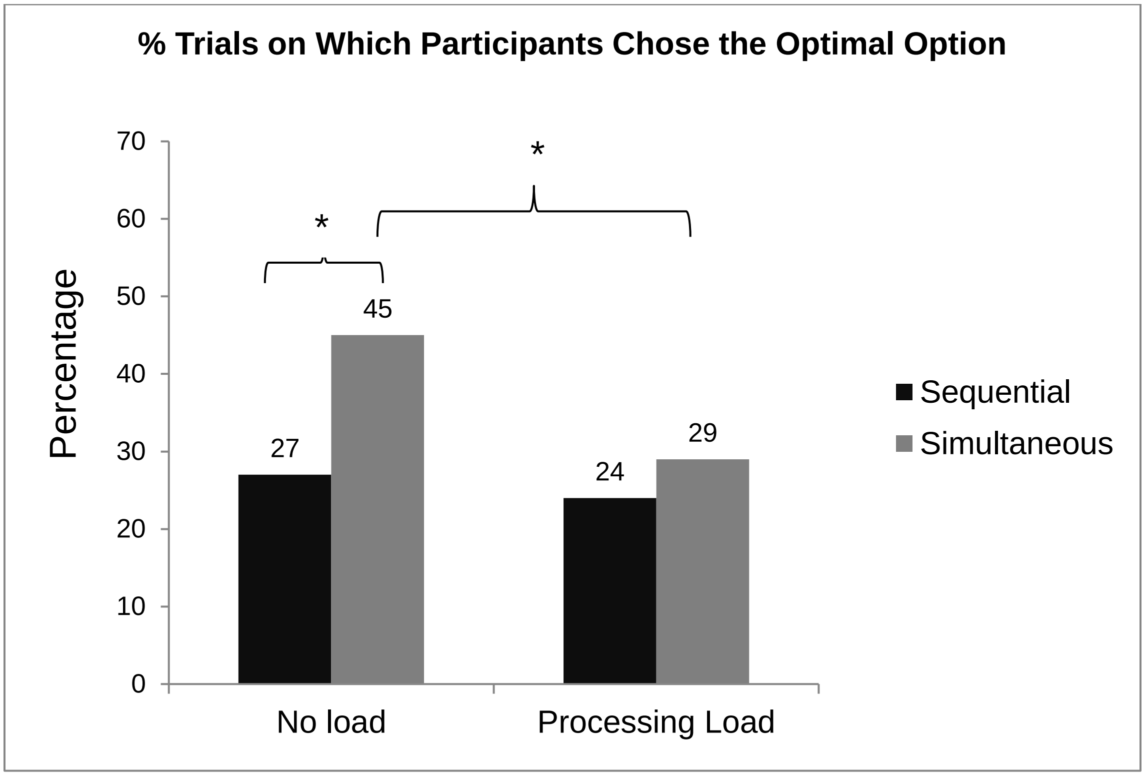
Figures

Figure 1. Percentage of trials in which participants chose the optimal option, based on their working memory capacity score and experimental condition (Experiment 4).



Figures

Figure 2. Percentage of trials in which participants chose the optimal option, based on experimental conditions (Experiment 7).



Appendix A – Stimuli used in Experiment 1

Product: Cell Phone					
Model	**Screen**	**RAM**	**Storage**	**Processor**	**Camera**
A	5.5 inches	2 GB	16 GB	1.5 Ghz	5 MP
B	**5.5 inches**	**2 GB**	**32 GB**	**1.8 GHz**	**8 MP**
C	5 inches	2 GB	32 GB	1.5 Ghz	5 MP
D	5 inches	1 GB	32 GB	1.8 GHz	5 MP
E	5 inches	1 GB	16 GB	1.8 GHz	8 MP
F	5.5 inches	1 GB	16 GB	1.5 Ghz	8 MP

Product: Camera					
Model	**Megapixel**	**Zoom**	**Screen Size**	**Battery**	**Video Quality**
A	12MP	3x	2.7in	15 hrs	720p
B	12MP	5x	2.7in	15 Hrs	480p
C	**12 MP**	**5x**	**3.6in**	**18 hrs**	**720p**
D	10MP	3x	3.6in	18 hrs	480p
E	10MP	3x	2.7in	18 hrs	720p
F	10MP	5x	3.6in	15hrs	480p

Product: Laptop					
Model	**Battery**	**Processor**	**RAM**	**Storage**	**Warranty**
A	7 hrs	2.1 Ghz	4GB	500 GB	2 yrs
B	7 Hrs	2.4 Ghz	4GB	500 GB	1 yr
C	5 Hrs	2.4 Ghz	6GB	500 GB	1 yr
D	**7 Hrs**	**2.4 Ghz**	**6 GB**	**750 GB**	**2 yrs**
E	5 Hrs	2.1 Ghz	4GB	750 GB	2 yrs
F	5 hrs	2.1 Ghz	6 GB	750 GB	1 yr

Product: Fridge					
Model	**Overall Capacity**	**Shelves**	**Freezer Capacity**	**Power Efficiency**	**Warranty**
A	**14.8 cu ft**	**5**	**3.7 cu ft**	**4 star**	**7 yrs**
B	14.8 cu ft	5	3.4 cu ft	3 star	5 yrs
C	13.7 cu ft	5	3.7 cu ft	3 star	5 yrs
D	13.7 cu ft	4	3.7 cu ft	4 star	5 yrs
E	13.7 cu ft	4	3.4 cu ft	4 star	7 yrs
F	14.8 cu ft	4	3.4 cu ft	3 star	7 yrs

Product: Microwave oven					
Model	**Capacity**	**Wattage**	**Preset Menus**	**Power Levels**	**Warranty**
A	1.4 cu ft	900 W	7	4	2 yrs
B	1.4 cu ft	1100 W	7	4	1 yr
C	1.1 cu ft	1100 W	9	4	1 yr
D	1.1 cu ft	900 W	9	5	1 yr
E	1.1 cu ft	900 W	7	5	2 yrs
F	**1.4 cu ft**	**1100 W**	**9**	**5**	**2 yrs**

Note. In each trial, the dominating option is indicated in bold.

Appendix B – Stimuli used in Experiment 2 and 6c

Product: Milk			
	Quantity and Price shown to participants		**Latent parameter not shown to participants**
Supplier	**Total quantity**	**Total Price ($)**	**Price per unit quantity ($)**
A	**35 Gallons**	**73.50**	**2.10**
B	27 Gallons	67.50	2.50
C	36 Gallons	82.80	2.30
D	29 Gallons	69.60	2.40
E	32 Gallons	72.32	2.26

Product: Ketchup			
	Quantity and Price shown to participants		**Latent parameter not shown to participants**
Supplier	**Total quantity**	**Total Price ($)**	**Price per unit quantity ($)**
A	33 Quarts	693.00	21.00
B	**45 Quarts**	**720.00**	**16.00**
C	54 Quarts	1080.00	20.00
D	37 Quarts	703.00	19.00
E	49 Quarts	1029.00	21.00

Product: Vanilla extract			
	Quantity and Price shown to participants		**Latent parameter not shown to participants**
Supplier	**Total quantity**	**Total Price ($)**	**Price per unit quantity ($)**
A	27 Fl Oz	51.30	1.90
B	44 Fl Oz	88.00	2.00
C	**35 Fl Oz**	**56.00**	**1.60**
D	41 Fl Oz	86.10	2.10
E	39 Fl Oz	78.00	2.00

Product: Coffee			
	Quantity and Price shown to participants		**Latent parameter not shown to participants**
Supplier	**Total quantity**	**Total Price ($)**	**Price per unit quantity ($)**
A	153 lb	749.70	4.90
B	121 lb	592.90	4.90
C	157 lb	785.00	5.00
D	**146 lb**	**616.12**	**4.22**
E	162 lb	891.00	5.50

Product: Organic cloves (grounded)			
	Quantity and Price shown to participants		Latent parameter not shown to participants
Supplier	**Total quantity**	**Total Price ($)**	**Price per unit quantity ($)**
A	24 Oz	93.60	3.90
B	37 Oz	151.70	4.10
C	21 Oz	84.00	4.00
D	41 Oz	164.00	4.00
E	**33 Oz**	**102.30**	**3.10**

Note. In each trial, the optimal option (lowest price per unit quantity) is indicated in bold.

Appendix C – Stimuli Used in Experiments 3 to 7 (except 6c)

Trial	Experiments	Pay-offs shown to participants		Latent parameters not shown to participants	
		Heads ($)	Tails ($)	Expected Value	Variance
1	3 to 7	**8**	**17**	**12.5**	**20**
		6	17	11.5	30
		2	23	12.5	110
		8	14	11.0	9
		4	20	12.0	64
2	3	**25**	**65**	**45**	**400**
		15	60	37.5	506
		25	35	30	25
		10	80	45	1225
		20	50	35	225
3	3	12	48	30	324
		14	**56**	**35**	**441**
		14	36	25	121
		10	60	35	625
		15	25	20	25
4	3 to 7	19	41	30	121
		18	**58**	**38**	**400**
		18	52	35	289
		21	29	25	16
		15	61	38	529
5	3	25	85	55	900
		30	60	45	225
		28	**82**	**55**	**729**
		28	72	50	484
		32	48	40	64
6	3 to 7	18	54	36	324
		22	34	28	36
		22	**58**	**40**	**324**
		20	44	32	144
		16	64	40	576

Trial	Experiments	Pay-offs shown to participants		Latent parameters not shown to participants	
		Heads ($)	Tails ($)	Expected Value	Variance
7	3	52	58	55	9
		41	99	70	841
		48	72	60	144
		44	**96**	**70**	**676**
		44	86	65	441
8	3 to 7	32	82	57	625
		41	49	45	16
		35	67	51	256
		39	**75**	**57**	**324**
		39	57	48	81
9	3	55	65	60	25
		52	88	70	324
		51	99	75	576
		53	77	65	144
		55	**95**	**75**	**400**
10	3 to 7	25	55	40	225
		19	81	50	961
		28	42	35	49
		22	68	45	529
		22	**78**	**50**	**784**

Note. In each trial, the optimal option (highest expected value and lower variance) is indicated in bold.

Footnotes

[1] We included an additional question in the survey “In your everyday life, do you consider options one at a time (sequentially) or do you tend to consider options all together (simultaneously)?” (1=Always consider options sequentially, 7=Always consider options simultaneously). The mean for this item was 4.71 ($SD = 1.47$).

[2]As the dependent measure could take only discrete values, we also conducted non-parametric tests to assess the robustness of the findings. A Wilcoxon rank-sum test confirmed that the difference between the two conditions was significant, $W = 8724.50$, $z = -2.77$, $p = .006$.

[3] A Wilcoxon rank-sum test confirmed that the difference between the two conditions was significant, $W = 51525.50$, $z = -2.62$, $p = .009$.

[4] As Experiment 2 was conducted at a later date than Experiment 3, Experiment 2’s effect size was not available when the power analyses calculations for Experiment 3 were conducted.

[5] A Wilcoxon rank-sum test confirmed that the difference between the two conditions was significant, $W = 17401.00$, $z = -4.48$, $p < .0001$.

[6] A Wilcoxon rank-sum test confirmed that the difference between the two conditions was significant, $W = 12596$, $z = 2.93$, $p = .003$.

[7] A Wilcoxon rank-sum test confirmed that the difference between the two conditions was significant for cognitive processing score, $W = 12521$, $z = 2.72$, $p = .007$, but non-significant for affective processing score, $W = 11058$, $z = -0.51$, $p = .61$.

[8] A Wilcoxon rank-sum test confirmed that the difference between the two conditions was significant, $W = 7435.50$, $z = -2.66$, $p = .008$. A non-parametric Spearman’s rank-

order correlation between working memory score and percentage of optimal options chosen was non-significant ($r = .02$, $p = .82$). The nonparametric Spearman rank-order correlation between working memory score and percentage of optimal options chosen was marginally significant in the simultaneous condition ($r = .18$, $p = .09$) and nonsignificant in the sequential condition ($r = -.14$, $p = .18$).

[9] Wilcoxon rank-sum tests confirmed these results. The difference between sequential and simultaneous presentation was significant within the no load condition, $W = 8225.5$, $z = -4.20$, $p < .0001$, and non-significant within the processing load condition, $W = 8502$, $z = -1.13$, $p = .26$. The difference between the processing load and no load conditions was non-significant for sequential presentation, $W = 8457.5$, $z = -.89$, $p = .37$, and significant for simultaneous presentation, $W = 8710.5$, $z = -4.07$, $p < .0001$.