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Thinking Fast Increases Framing Effects in Risky Decision-making

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Thinking Fast Increases Framing Effects in Risky Decision-making

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Abstract

Every day, people face 'snap' decisions when time is a limiting factor. In addition, the way a problem is presented can influence people's choices, known as framing effects. This paper explores how time pressure interacts with framing effects in risky decision-making. Specifically, does time pressure strengthen or weaken framing effects? On one hand, research has suggested that framing effects evolve through the deliberation process, growing larger with time (Svenson & Benson, 1993). On the other hand, dual process theory attributes framing effects to an intuitive, emotional system that responds automatically to stimuli (De Martino, Kumaran, Seymour, & Dolan, 2006). In our experiments, participants made decisions about gambles framed as either gains or losses with time pressure manipulated across blocks. Results showed increased framing effects under time pressure in both hypothetical and incentivized choices, lending support to the dual process hypothesis that these effects arise from a fast, intuitive system.

Keywords: Risky decision-making; time pressure; framing effects; dual process theory

Word Count: 1997

Thinking Fast Increases Framing Effects in Risky Decision-making

Everyday we find ourselves in settings where speeded or "snap" decisions need to be made. The stakes vary, from encountering a yellow light while driving and needing to risk getting caught in the red or safely slowing down; to navigating fast-paced Wall Street where high-velocity strategic decisions separate the bankrupt from the successful. Regardless of situation, time constraints often place a premium on rapid decision-making.

Researchers have also been intrigued by the finding that decision-makers respond in different ways to different but objectively equivalent variations of the same problem. For example, imagine you win $300 and you have a choice between receiving an additional $100 for sure or playing a gamble with a 50% chance to gain $200 and a 50% chance to gain nothing. Suppose you prefer the sure option of receiving the additional $100. Now, consider a slightly different situation where you win $500 and have a choice between losing $100 from your winnings for sure or playing a gamble with a 50% chance to lose nothing and a 50% chance to lose $200. In this situation, you find yourself selecting the gamble. This pattern of choices demonstrates a framing effect because your preferences between the sure option and the gamble change depending on the problem description, even though the expected value of the outcomes is the same.

According to theories of rational decision-making (including expected utility theory), people's decisions should be "description-invariant". That is, the manner in which the options are presented should not influence choices. A classic finding in risky decision-making is that people tend to be risk averse when a problem is presented as a gain and risk seeking when the same problem is presented as a loss (Kahneman & Tversky, 1979; Tversky & Kahneman, 1981).

These types of "framing effects" have been documented in a variety of situations including medical and clinical decisions (O'Connor et al., 1987; O'Connor, Pennie, & Dales, 1996), consumer choices (Levin & Gaeth, 1988; Loke & Lau, 1992) and social dilemmas (Brewer & Kramer, 1986; Fleishman, 1988). The goal of this paper is to explore how time pressure interacts with framing effects in risky decision-making. In particular, does time pressure exacerbate or mitigate framing effects? Previous research provides support for both of these possibilities.

Svenson and Benson (1993) examined the influence of time pressure in choices among lotteries as well as the famous Asian disease problem (Kahneman & Tversky, 1979). Their results showed that time pressure (a 40 second response deadline) reduced framing effects, suggesting the effects evolve over time. These results are consistent with findings in multi-alternative, multi-attribute choice showing context effects, such as the attraction (Huber, Payne, & Puto, 1982), compromise (Simonson, 1989), and similarity (Tversky, 1972) increase with longer deliberation time. These effects illustrate how choices between a fixed set of options can be altered by the inclusion of other options. Recent work by Pettibone (2012) and Trueblood, Brown, and Heathcote, (2014) showed that context effects emerged with longer deliberation, in line with predictions from sequential sampling models of decision-making (Roe, Busemeyer, & Townsend, 2001; Trueblood et al., 2014).

On the flip side, researchers have suggested that framing effects may be the result of two different systems of reasoning –the intuitive and deliberative systems. The intuitive system (or System 1) is responsible for fast processes which are affective, emotional, and automatic, while the deliberative system (or System 2) is responsible for slower processes that are more analytical, rational, and calculating in nature (Chaiken & Trope, 1999; Sloman, 1996; Kahneman & Frederick, 2002; Mukherjee, 2010; Stanovich & West, 2000). In a recent neuroimaging study, De

Martino, Kumaran, Seymour, and Dolan (2006) found that in risky decision-making, framing effects were associated with increased activation in the amygdala whereas orbital and medial prefrontal cortex (OMPFC) activity was related to a reduction of these effects. In particular, increased activation in the amygdala was associated with participants' tendency to choose sure options when the problem was framed as a gain and gamble options when the problem was framed as a loss. Participants that behaved more rationally showed greater activation in the OMPFC. These results support dual-process theory where there is conflict between deliberative processes and an intuitive, "emotional" amygdala-based system. If framing effects are mainly driven by the fast, intuitive system, then framing effects should increase under time pressure. With restricted deliberation time, the deliberative system is less likely to be engaged.

Our aim is to distinguish between two competing hypotheses related to the origin of framing effects. On one hand, framing effects could evolve through the deliberation process as described by Svenson and Benson (1993) and similar to context effects in preferential choice (Pettibone, 2012; Trueblood et al., 2014). Alternatively, framing effects could result from an intuitive system that produces quick automatic responses to stimuli. We test these hypotheses in three experiments.

Experiment 1

The stimuli in our experiments are adapted from De Martino et al. (2006). At the start of each trial, participants were given an initial amount of money. They then choose between a sure option to keep a portion of the initial amount and a gamble to possibly keep the entire initial amount, with the sure option presented in either a gain or loss frame. In both frames, the gamble was identical and presented as a pie chart color-coded to represent the probability of winning and losing. Participants completed two blocks of trials, one of which was under time pressure. Four variations of this task were run, manipulating several "tuning variables" (e.g., color of the pie chart) that should have no influence on the results. These variations were included to make sure that our findings are attributable to the actual framing effect rather than some arbitrary experimental variables. This provides evidence of the robustness of the phenomenon and its replicability.

Material and methods

Participants. 195 individuals (159 Female; M=20.24 years) from the University of California, Irvine participated in the study, receiving course credit for their participation (regardless of performance). All participants were undergraduate students and English speakers. We set a target sample size of about 50 participants for each of the four experimental variants. This sample size was selected based off of previous experiments using a within-subjects time pressure manipulation in decision-making (Trueblood et al., 2014). The lab could accommodate up to six participants during a single session. We stopped data collection with the session that would meet (and potentially exceed) the target sample size. For this final session, we allowed up to six participants to sign-up in anticipation of no-shows. Thus some experimental variants have slightly fewer than 50 participants and others have slightly more than 50 participants (see Table 2).

Materials. The experiment was comprised of two blocks, each block consisting of 144 test trials: 72 gain frames and 72 loss frames. We also included 16 "catch" trials in each block to assess accuracy and engagement in the task for a total of 160 trials per block. These catch trials had non-equivalent "sure" and "gamble" options in which one option had a significantly larger expected value. This produced a grand total of 320 trials.

For the test trials, 72 dollar amounts were selected randomly from a uniform distribution ranging from \$20 to \$90 to serve as the initial starting values. In addition, 72 probabilities were drawn randomly from a pool of three normal distributions (m = 0.28, 0.42, and 0.56; std = 0.2) to serve as the probability of winning the gamble. The initial amounts and probabilities of winning the gamble were randomly paired together to form 72 unique test trials. From these pairs we created the sure option for each trial to match the expected value of the gamble, depending on frame. For instance, for an initial amount of \$78 and a winning gamble percentage of 0.26, the sure option would either be “Keep \$20” (gain frame) or “Lose \$58” (loss frame). There were also 32 total catch trials composed of 16 gain frame trials and 16 loss frame trials. The initial starting values for these trials ranged from \$20 to \$90, similar to the test trials. In half of these trials, the sure option had a higher expected value than the gamble option. In the other half of the trials, the gamble option had a higher expected value than the sure option. Note that all gambles were hypothetical since there were no real consequences for participants’ decisions. Previous research has shown that there are no differences in the framing effect in hypothetical and real choices (Kühberger, Schulte-Mecklenbeck, & Perner, 2002). In Experiment 2, we examine the framing effect in decisions with real consequences.

We are interested in the framing effect that occurs with risky decision-making between the sure and gamble options. For this experiment, a framing effect occurs for a participant when a) in the gain frame, the decision-maker chooses the “sure” option; and b) in the loss frame for the same problem, the decision-maker chooses the “gamble” option. Thus, we categorize risk-averse behavior in gains and risk-seeking behavior in equivalent losses as a framing effect.

The two blocks were differentiated by the presence or absence of time pressure. One block is a time pressure block (TP) where participants are told that their goal is to “Respond quickly" and for each trial, are given 1000 ms to make a choice. Since the task involves earning money, a latent but unwritten goal of the TP block is to earn money. However, to ensure time pressure, the only directions given to participants in the TP block were to "Respond Quickly." If they failed to make a choice within this amount of time, they receive a feedback message that states that they did not respond in time and did not earn any money on that particular trial. If the participant makes a choice within the allotted time frame, they do not receive any feedback on that trial.

The other block is a no time pressure block (NTP). For this block, participants are told that they should "Maximize your money" (in experiment variants 1, 2, and 3 as described below) and are not penalized for the amount of time they take to respond. In this block, we provide feedback after every trial explaining the amount of money earned on that trial. This reinforces the initial goal of maximizing their money by emphasizing the money earned on each trial.

Our experimental design is based on ones used in perceptual decision-making to study the speed-accuracy tradeoff (Wickelgren, 1977). In "accuracy" conditions, participants are typically instructed to maximize accuracy and often only receive feedback related to accuracy. In "speed" conditions, participants are typically told to maximize speed and often only receive feedback related to speed.

Procedure. At the start of the experiment, participants completed three guided practice trials where they were told to select specific options (i.e., the gamble or sure thing). After the guided practice, participants completed an additional 10 practice trials where they could respond freely. In all of the practice trials, a legend appeared below the pie charts for each option explaining the amounts that could be won or lost (see Figure 1A and B). During the main task, the two blocks and the 160 trials in each block were randomized. As shown in Figure 1, at the start of each trial (in both the gain and loss frame), participants were given an initial starting amount (e.g., "You are given $78") and the goal for that block (e.g. "Respond Quickly"). Participants were instructed that they were not able to retain the entirety of the initial amount, but would have to choose between a sure option and a gamble option. 2 s after the initial amount was displayed, the screen automatically progressed to this choice screen. In the gain frame, participants selected between keeping a portion of the initial amount for sure ($20) or playing a gamble where they could either keep all of the initial starting amount ($78) with some probability (0.26) or lose all of this amount (equivalent to getting $0 for the trial). Note that the expected value of the gamble is 0.26 x $78 = $20, which is the same as the sure option. In the equivalent loss fame, the gamble was identical to the gain frame. For example, the gamble outcomes were keeping the initial starting amount of $78 with probability 0.26 or losing the entire amount with probability 0.74. The only difference between the gain and loss frames was the framing of the sure option. In the loss frame, the sure option was described as losing a portion of the initial amount. For example a sure loss of $58 is equivalent to keeping $20 (as described in the gain frame). Thus, the payoffs in the gain and loss frames were identical. In the gain frame, the sure option was presented as an amount retained in a 100% light gray pie chart (Figure 1A) (e.g., "Keep $20"). In the loss frame, the sure option was presented as an amount lost in a 100% dark gray pie chart (Figure 1B) (e.g., "Lose $58"). For both the gain and loss frames, the gamble option was presented as a pie chart representing the probability of keeping the entirety of the initial amount or losing the initial amount.

Variations in design. In this experiment we aimed to test people across a range of different possible tuning variables, and thus ran four variations of the study. The first variation (RG; 49 participants) involved color-coded distinctions between keeping an amount (represented by green) and losing an amount (represented by red). Additionally, the sure option was always placed on the left-hand side of the screen while the gamble option was always placed on the right-hand side of the screen.

The second variation (BW; 49 participants) was identical in all respects except for the red/green color-coding. Instead, options were represented by grayscale representations of keeping an amount (represented by light gray) and losing an amount (represented by dark gray), as shown in Figure 1.

The third variation (Random; 53 participants) was identical in all respects to the first variation (RG) except for the placement of the sure and gamble options. In this variation, the sure option was randomly placed on either the left-hand or right-hand side of the screen (while the red/green color coding remained).

The fourth and final variation (Losses; 44 participants) involved changing the framing of the problem from “Maximize your money”, a more positive goal, to “Minimize your losses”, a more negative goal. The remainder of this variation was identical to the first variation (RG), with the red/green coloration and fixed placement of the sure and gamble options.

Results

We analyzed the data from all 195 participants, removing the catch trials. The average proportion of catch trials answered correctly was 0.85. We found that there was no significant difference in the between-subjects experiment variations ($F(3,191) = 0.24$, $p > .250$, $\eta^2 < 0.01$), and present the collapsed results as follows. From Table 1, we see that there is a significant effect of frame ($F(1,194) = 339.39$; $p < .001$, $\eta^2 = 0.64$). This suggests behavior is consistent with the framing effect; that is, the tendency to be risk-seeking in losses and risk-averse in gains. There is also an interaction between block and frame ($F(1,194) = 76.18$; $p < .001$, $\eta^2 = 0.29$) showing an increase in framing effect for the TP block as compared to the NTP block. The mean response time for the no time pressure block was 2096 ms (std=3010 ms) while the mean response time for the time pressure block was 558 ms (std=408 ms). The data used in this analysis is available on the Open Science Framework at https://osf.io/9gyvd/.

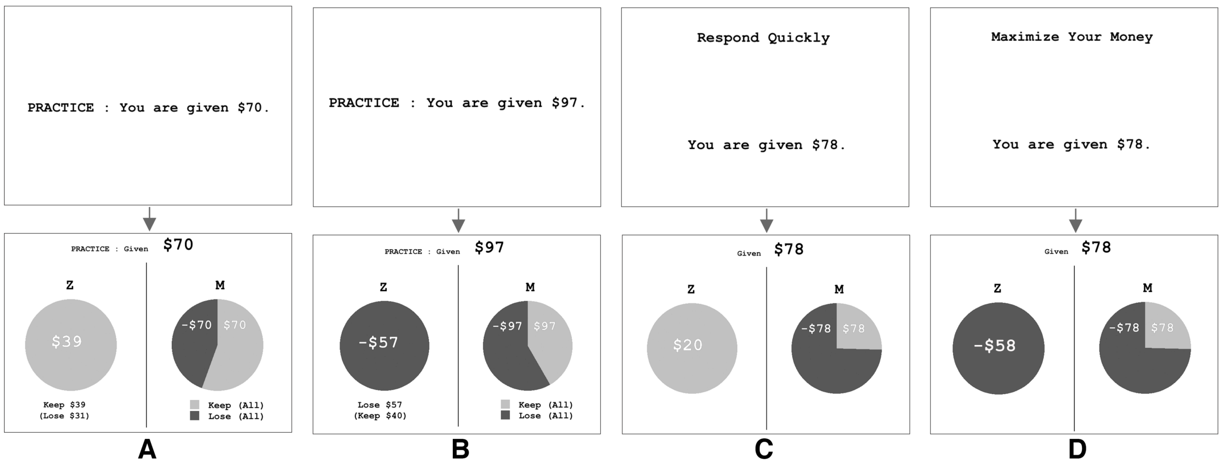

Fig 1. Series of screenshots from practice and test trials in Experiment 1. Figure 1A shows a pair of sequential screenshots from a practice trial (from experiment variation 2) in the gain frame. In the top screenshot of Figure 1A, participants are presented with an initial amount, and after 2 seconds the screen automatically progresses to the bottom screenshot: the choice selection screen, where the sure and gamble options are presented. The sure option is presented on the left side of the screen (in green in variations 1, 3, and 4; or light gray in variation 2) and the gamble is represented as some probability of keeping the entire initial amount (in green, or light gray) and losing the entire initial amount (in red, or dark gray). Because this is a practice trial, a legend and additional text are included under the options to remind participants of the values of each option. Figure 1B shows a pair of screenshots of a practice trial similar to Figure 1A, but in the loss frame. The sure option is again presented on the left (but in red, or dark gray) and the gamble is presented on the right (again represented as probabilities of keeping and losing the entire initial amount). Figure 1C illustrates a pair of screenshots from a test trial in the gain frame under time pressure (TP block). In the top screenshot, participants are instructed to "Respond Quickly" in addition to being given the initial amount. After 2 seconds the screen automatically progresses to the bottom screenshot where the options are presented in the same format as the practice trials, but with the legend and extra text removed. Figure 1D contains screenshots from a test trial with the same expected value as Figure 1C, but in the loss frame without time pressure (NTP block). The instructions are changed to "Maximize Your Money" (in experiment variations 1, 2, and 3) or "Minimize Your Losses" (in variation 4).

Table 1.

Repeated Measures ANOVA with block (TP, NTP), frame (gain, loss), and variation, examining the probability of selecting the gamble in Experiment 1.

	Sum of Squares	df	Mean Square	F	*p*	η2
Block	0.067	1	0.067	2.317	0.130	0.012
Block * Variation	0.020	3	0.007	0.234	0.872	0.004
Residual	5.496	191	0.029			
Frame	13.298	1	13.298	339.394	<.001	0.635
Frame * Variation	0.147	3	0.049	1.250	0.293	0.007
Residual	7.484	191	0.039			
Block * Frame	1.186	1	1.186	76.175	<.001	0.285
Block * Frame * Variation	0.008	3	0.003	0.168	0.918	0.002

Figure 2 shows individual choice proportions for the gamble in the TP and NTP blocks for the gain frame (left) and loss frame (right). In the gain frame, we see that the majority of participants (dots below the reference line; 138 out of 195, 0.71) selected the gamble more often in the NTP block as compared to the TP block, showing increased risk-aversion under time pressure. In the loss frame, we see that more participants (dots above the reference line; 113 out of 195, 0.58) selected the gamble more often in the TP block as compared to the NTP block, showing increased risk-seeking under time pressure. Under the gain frame, the mean proportion of gambles selected in the NTP block was 0.40, compared to the TP block at 0.31. Under the loss frame, the mean proportion of gambles selected in the NTP block was 0.59 compared to the TP block of 0.65. Table 2 shows the choice proportions for selecting the gamble for each of the variations. As mentioned earlier, these variations manipulate tuning variables that should be irrelevant to the task. Our results confirm this prediction. Frame and time pressure have similar influences on behavior in all four between-subjects variations.

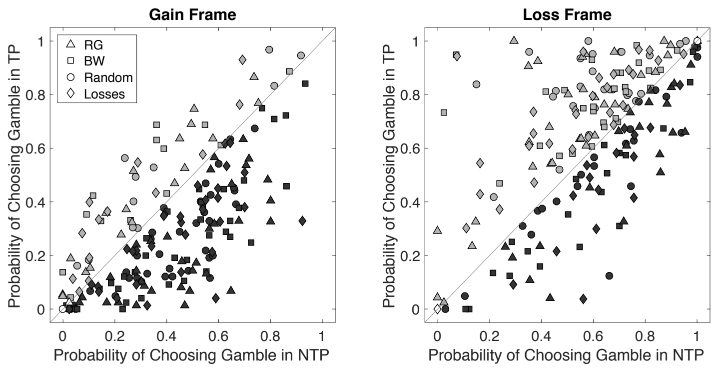

Fig 2. A scatterplot showing individual choice proportions for the gamble in the TP and NTP blocks for the gain frame (left) and loss frame (right) in Experiment 1. Each plot is coded by shape according to study variation, with RG (circle) referring to the colored study with fixed option position; BW (square) as the study identical to RG except for grayscale coloring; Random (triangle) as identical to RG except for the randomized placement of the options, and Losses (diamond) as identical to RG except for the use of a negative frame in the directions as opposed to a positive frame. Light gray shading indicates a participant's probability of choosing the gamble is greater in the time pressure block; dark gray shading indicates a participant's probability of choosing the gamble is greater in the NTP block; and no shading indicates a tie.

We also analyzed the framing effect on the problem level. For each participant and each pair of corresponding gain / loss choice problems, we calculated a *framing effect score* for TP and NTP conditions. This score is defined as the difference in choices for the gamble in the loss and gain frames. A positive score indicates evidence for the standard framing effect where gambles are preferred more in losses than gains. A higher score in the TP condition as compared to the NTP condition shows evidence for an increased framing effect under time pressure.

Figure 3 shows the framing effect scores for TP and NTP conditions for each problem averaged over participants for the four experimental variations. From the figure, we see that all of the problems in each variation had a positive framing effect score in the TP condition and the large majority had a positive framing effect score in the NTP condition as well (72 out 72 in the RG variation, 68 out of 72 in the BW variation, 71 out of 72 in the Rand variation, and 70 out of 72 in the Losses variation). This shows evidence for the standard framing effect where gambles are preferred in the loss frame as compared to the equivalent gain frame. Further, we see that more problems had a larger framing effect score in the TP condition than in the NTP condition (68 out 72 in the RG variation, 64 out of 72 in the BW variation, 71 out of 72 in the Rand variation, and 68 out of 72 in the Losses variation), showing an increase in the framing effect under time pressure.

Table 2.

Descriptive statistics for block (TP, NTP in Experiments 1 and 2 and LTP, STP in Experiment 3) and frame (gain, loss) for the probability of selecting the gamble in the four Experiment 1 variations, Experiment 2, and Experiment 3.

Variation	Block	Frame	Mean	SD	N
RG	NTP	Gain	0.401	0.227	49
		Loss	0.617	0.231	
	TP	Gain	0.301	0.237	
		Loss	0.692	0.262	
BW	NTP	Gain	0.430	0.255	49
		Loss	0.590	0.246	
	TP	Gain	0.327	0.244	
		Loss	0.637	0.280	
Random	NTP	Gain	0.402	0.238	53
		Loss	0.591	0.267	
	TP	Gain	0.292	0.237	
		Loss	0.642	0.277	
Losses	NTP	Gain	0.389	0.231	44
		Loss	0.558	0.231	
	TP	Gain	0.314	0.208	
		Loss	0.623	0.254	
Exp. 2	NTP	Gain	0.537	0.205	13
		Loss	0.663	0.215	
	TP	Gain	0.494	0.204	
		Loss	0.675	0.232	
Exp. 3	LTP	Gain	0.579	0.113	52
		Loss	0.617	0.133	
	STP	Gain	0.514	0.150	
		Loss	0.651	0.139	

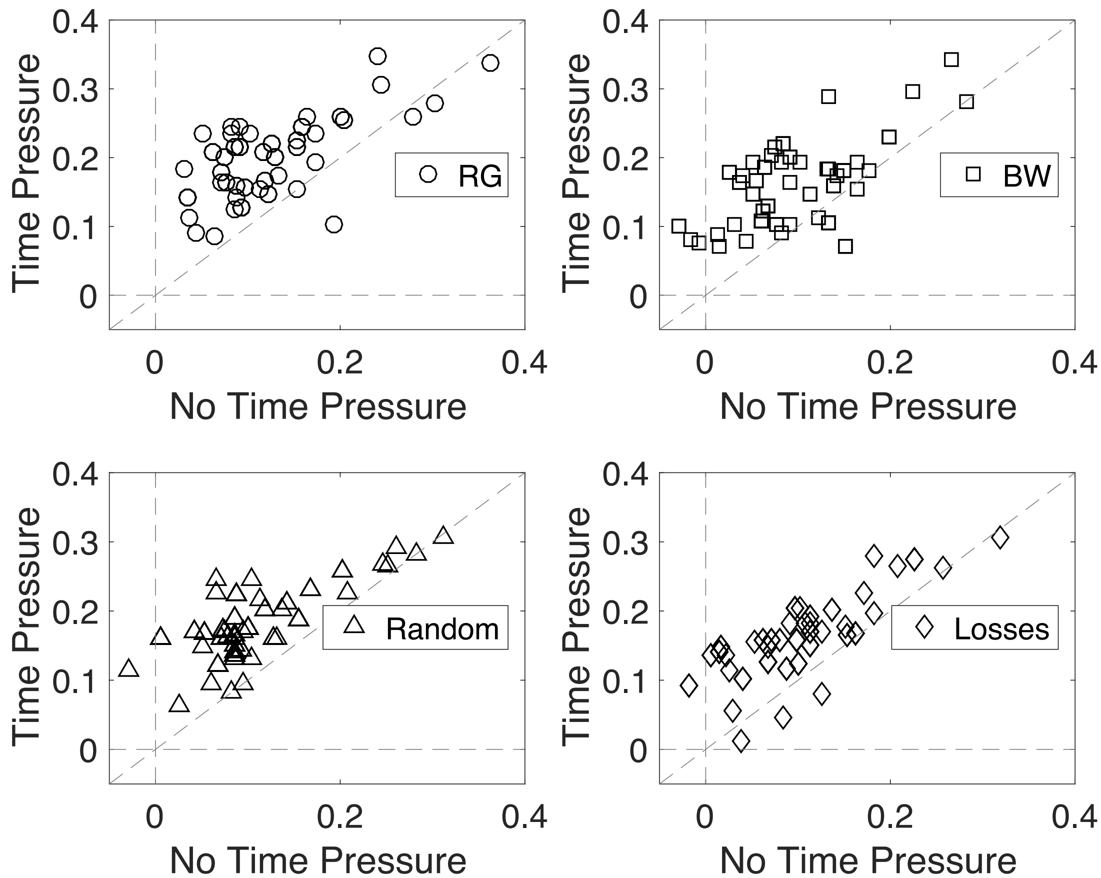

Figure 3. Framing effect scores for TP and NTP conditions for the four Experiment 1 variations. Points above the horizontal dotted line represent problems displaying a framing effect in the TP condition, points to the right of the vertical dotted line represent problems displaying a framing effect in the NTP condition, and points that fall above the dotted diagonal line represent problems displaying a larger framing effect in the TP condition as compared to the NTP condition.

Our main finding that framing effects increase with time pressure is further corroborated by a Bayesian repeated measures ANOVA performed using the open source software package JASP (JASP Team, 2016). As shown in Table 3, we report Bayes Factors (BF) comparing different models (including the null model) along with the Bayes Factors for the inclusion of specific variables. A Bayes Factor greater than 10 is typically considered strong support for the model or variable in question (Kass & Raftery, 1995). The Bayesian analysis supports our earlier claim that the tuning variations have no influence on the experimental results, that is, our results are attributable to the actual framing effect rather than some arbitrary experimental manipulations ($BF_{inclusion}$ = 0.02). A model that includes block, frame, and the interaction of block and frame is preferred to all other models (BF_M =304.86) as well as to the null model (BF_{10} > 1000). Also, the Bayes Factor for inclusion of both variables was large, $BF_{inclusion} \approx \infty$ for the inclusion of frame and $BF_{inclusion}$ > 1000 for the inclusion of block. Thus the data support the conclusion that a model with both frame (gain versus loss) and time pressure (present versus absent) gives the best account for the probability of choosing the gamble in the task.

Table 3.

Bayesian Repeated Measures ANOVA with block (TP, NTP), frame (gain, loss), and variation, examining the probability of selecting the gamble in Experiment 1.

Models	P(M)	P(M|Data)	BF_M	BF_10	% error
Null model (incl. subject)	0.053	7.897E-79	1.421E-77	1.000	
Block	0.053	1.221E-79	2.197E-78	0.155	1.398
Frame	0.053	5.286E-08	9.515E-07	6.694E+70	1.284
Block + Frame	0.053	1.303E-08	2.345E-07	1.650E+70	1.743
Block + Frame + Block*Frame	0.053	0.944	304.861	1.196E+78	2.774
Variation	0.053	1.947E-80	3.505E-79	0.025	0.395
Block + Variation	0.053	2.975E-81	5.356E-80	0.004	1.259
Frame + Variation	0.053	2.477E-09	4.458E-08	3.136E+69	6.401
Block + Frame + Variation	0.053	6.302E-10	1.134E-08	7.980E+68	6.738
Block + Frame + Block*Frame + Variation	0.053	0.051	0.959	6.406E+76	8.043

Effects	P(incl)	P(incl|data)	BF_Inclusion
Block	0.737	1.000	6.423E+06
Frame	0.737	1.000	∞
Variation	0.737	0.056	0.021
Block * Frame	0.316	1.000	3.126E+07
Block * Variation	0.316	7.537E-04	0.002
Frame * Variation	0.316	0.005	0.010
Block * Frame * Variation	0.053	1.569E-06	2.824E-05

Conclusions

Results of Experiment 1 showed risk-averse behavior in gains and risk-seeking behavior in losses in both blocks, in accord with the standard framing effect. Further, our results showed an increase in the framing effect under time pressure. These results were supported by both traditional and Bayesian statistical tests. The results hold when accounting for several fine-tuning experimental manipulations. These results diverge from those of Svenson and Benson (1993). Their time pressure condition was quite long (40 seconds) as compared to ours (1 second). Thus, participants in the Svenson & Benson (1993) study might have employed different decision strategies than our participants.

Experiment 2

In Experiment 1, participants made hypothetical choices among the options. While there is evidence that suggests hypothetical and incentivized choices are often the same (Kühberger, Schulte-Mecklenbeck, & Perner, 2002), it is possible that there is an interaction of incentives with time pressure. Thus we conducted a new experiment examining the influence of time pressure in incentivized choices. Further, in Experiment 1, participants received different instructions and feedback in the TP and NTP conditions. In Experiment 2, we control for these possible confounds by providing feedback on all trials (both TP and NTP) and by using similar instructions for both conditions.

Material and methods

Participants. 13 individuals (8 Female; M=20.57 years) from Jacobs University Bremen participated in the study; receiving 6 Euro per hour for their participation plus the amount of points won (1 point equals 0.1 cent). The experiment was in English and all participants were undergraduate students and English speakers. The sample size was set to 13 to match the number of trials with the previous experiment. Each trial was repeated four times (during four different sessions), resulting in 52 responses per trial (similar to the number of responses per trial in each variation of Experiment 1). We chose a multi-session experimental design with fewer participants for modeling purposes. The modeling results will be reported elsewhere.

Materials. Participants completed four experimental sessions on different days. Each session was comprised of four blocks, each block consisting of 80 trials: 36 gain frames, 36 loss frames, and 8 catch trials. As before, the catch trials had non-equivalent "sure" and gamble" options in which one option had a significantly larger expected value. The first two blocks were differentiated by the presence or absence of time pressure. Blocks 3 and 4 were replications of blocks 1 and 2. This produced a total of 144 gain frame trials, 144 loss frame trials, and 32 catch trials for a grand total of 320 trials per session (the same number of trials as in Experiment 1).

For the test trials, 36 values were drawn randomly from a pool of three normal distributions (m = 30, 60, and 90; std = 2) to serve as the initial starting amounts. In addition, 36 probabilities were drawn randomly from a pool of three normal distributions (m = 0.28, 0.42, and 0.56; std = 0.03) to serve as the probabilities of winning the gamble. The initial amounts and probabilities of winning the gamble were randomly paired together to form 36 unique test trials. From these pairs we created the sure option for each trial to match the expected value of the gamble, depending on frame.

Participants received feedback about the amount received after each trial (in both TP and NTP blocks). In the TP block, participants were given 1250 ms to make a choice. If they did not respond within this time limit, then they received zero points on the trial. In the NTP block, participants were not penalized for the amount of time taken to respond. At the beginning of the task, participants were told, "your goal is to maximize the amount of points that you win". At the start of the TP blocks, participants were instructed, "to make a decision quickly". At the start of the NTP blocks, participants were instructed to "spend as much time as you need on each trial". Thus, the overall goal of the experiment was to maximize winnings, and the only difference in instructions between TP and NTP blocks was related to the amount of time allowed for decisions.

Procedure. Participants first read instructions describing the task and the gamble display. These instructions were administered both on paper and on the computer. The paper instruction document is available on the Open Science Framework at https://osf.io/9gyvd/. After reading the instructions, participants completed six practice trials. An example practice trial is shown in Figure 4. After completing the practice trials, participants started the main task. In the main task, the blocks and the trials in each block were randomized. At the start of each trial (in both the gain and loss frame), participants were given an initial starting amount (e.g., 57 points). Participants were instructed that they were not able to retain the entirety of the initial amount, but would have to choose between a sure option and a gamble option. In the gain frame, participants selected between keeping a portion of the initial amount for sure (24 points) or playing a gamble where they could either keep all of the initial starting amount (57 points) with some probability (0.42) or lose all of this amount (0 points). As before, the only difference between the gain and loss frames was the framing of the sure option. For both frames, the gamble option was presented as a grayscale pie chart representing the probability of keeping the entirety of the initial amount or losing the initial amount. The sure option was randomly placed on either the left-hand or right-hand side of the screen.

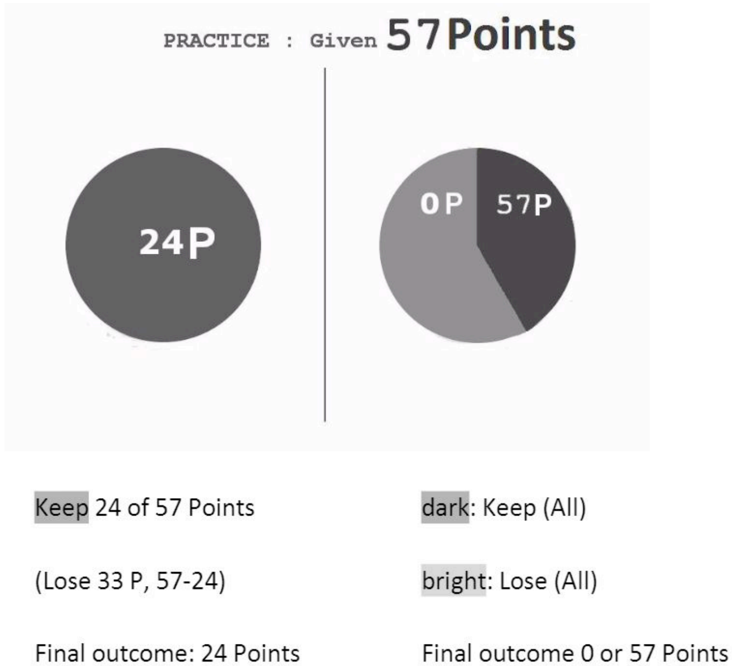

Fig 4. Example of a practice trial from Experiment 2. At the start of each trial, participants are given an initial amount of X points (e.g., 57 points). Participants then have to decide between two options: to keep / lose a portion of the initial amount with 100 percent probability, or to gamble to keep the entire initial amount or lose the initial amount. In this experiment, the gamble is described as keeping X points or loosing 0 points.

Results

We analyzed the data from all 13 participants, removing the catch trials. Due to a computer error, the data in some of the sessions on the first day did not record correctly. Therefore, the first session data of five participants was not included in the analyses. Across all sessions, the average proportion of catch trials answered correctly was 0.94. The mean response time in the NTP condition was 1573 ms (std=649 ms) while the mean response time for the TP condition was 668 ms (std = 61 ms). There was a significant effect of frame ($F(1,12) = 29.51$; $p < .001$, $\eta^2 = 0.71$), showing participants preferred the gamble more often in the loss frame than in the gain frame. There was also a significant interaction between block and frame ($F(1,12) = 5.47$; $p = .038$, $\eta^2 = 0.31$), showing an increase in framing effect for the TP condition as compared to the NTP condition. Bayesian analyses also confirmed these results, showing that a model that includes block, frame, and the interaction of block and frame is preferred to the null model ($BF_{10} > 1000$). The choice proportions for selecting the gamble in the different conditions is shown in the second to last row in Table 2. The data used in this analysis is available on the Open Science Framework at https://osf.io/9gyvd/.

Similar to Experiment 1, we also analyzed the framing effect on the problem level by calculating a framing effect score for TP and NTP conditions. As before, this score is defined as the difference in choices for the gamble in the loss and gain frames. Figure 5 shows the framing effect scores for TP and NTP conditions for each problem averaged over participants. From the figure, we see that all of the problems had a positive framing effect score in the TP condition and the large majority (32 out of 36) had a positive framing effect score in the NTP condition as well, showing evidence for the standard framing effect where gambles are preferred in the loss frame as compared to the equivalent gain frame. Further, we see that most problems (27 out of 36) had a larger framing effect score in the TP condition than in the NTP condition, showing an increase in the framing effect under time pressure.

Conclusions

Experiment 2 showed that time pressure increases the framing effect in incentivized choices. One important difference between the Experiments 1 and 2 is the increased level of risk-seeking behavior in Experiment 2. In the gain frame, participants in Experiment 2 tended to select the gamble about 50% of the time as compared to about 30-40% in Experiment 1. Thus, the framing effect in Experiment 2 is best described as a preference shift rather than a preference reversal. The difference in risk-seeking behavior between the two experiments could be the result of incentivized choices in Experiment 2.

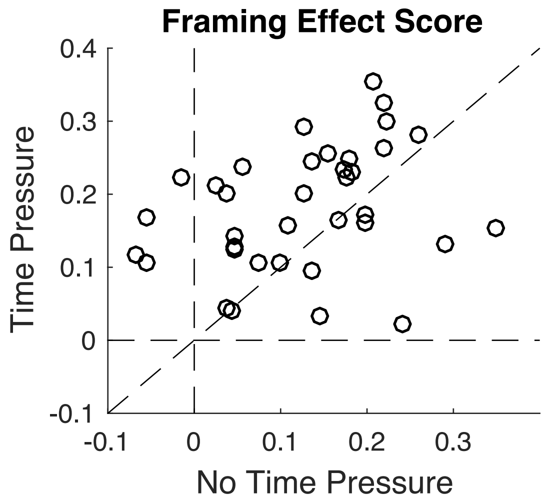

Figure 5. Framing effect scores for TP and NTP conditions in Experiment 2. Points above the horizontal dotted line represent problems displaying a framing effect in the TP condition, points to the right of the vertical dotted line represent problems displaying a framing effect in the NTP condition, and points that fall above the dotted diagonal line represent problems displaying a larger framing effect in the TP condition as compared to the NTP condition.

Experiment 3

In Kahneman and Tversky's (1979) demonstration of the framing effect, they compared sure gains (losses) to gambles with all positive (all negative) outcomes. Experiments 1 and 2 use slightly different formulations of the problem. To illustrate, let X be the initial amount, Y be the amount of the sure option, and p the probability of winning the initial amount in the gamble. In Experiment 1, the gambles were presented as 'Y for sure versus X with probability p or –X with probability 1-p' (see Figure 1). This presentation makes it appear that the choice is between a sure gain (loss) versus a probabilistic gain or loss (containing both positive and negative outcomes). In Experiment 2, the gambles were presented as 'Y for sure versus X with probability p or 0 with probability 1-p' (all positive outcomes, see Figure 4). In the third experiment, we use a more traditional approach following Kahneman and Tversky (1979). We also examine the influence of short and long time pressure, rather than comparing time pressure and no time pressure as in the previous experiments.

Material and methods

Participants. 74 individuals 38 Female; M=24.4 years) from Jacobs University Bremen participated in the study; receiving 6 Euro per hour for their participation plus the amount of points won (20 points equals 0.1 cent). The experiment was in English and all participants were undergraduate students and English speakers. We targeted a sample size of 50 participants with a minimum catch trial accuracy of 75% correct. After running 74 participants, we had 52 participants that met the catch trial accuracy criterion and thus stopped data collection.

Materials. Participants completed four blocks of trials, each block consisting of 80 trials: 32 gain frames, 32 loss frames, and 16 catch trials. There were 16 unique gain (loss) frame trials created by combining 4 different initial starting amounts (25, 50, 75, 100) with 4 different probabilities of winning the gamble (0.3, 0.4, 0.6, 0.7). From these pairs we created the sure option for each trial to match the expected value of the gamble, depending on frame. Each test trial was shown twice in each block. As before, the catch trials had non-equivalent "sure" and gamble" options in which one option had a significantly larger expected value. All trials within a block were randomized. In this experiment, we manipulated time pressure to either be short (STP) or long (LTP). Blocks 1 and 3 were LTP blocks where participants were given 3000 ms to make a choice. Blocks 2 and 4 were STP blocks where participants were given 1000 ms to make a choice. In total, there were 128 gain frame trials, 128 loss frame trials, and 64 catch trials for a grand total of 320 trials (the same total number of trials as in Experiments 1 and 2).

Participants received feedback about the amount received after each trial (in both STP and LTP blocks). If they did not respond within the time limits, then they received zero points on the trial. Similar to Experiment 2, at the beginning of the task, participants were told, "your goal is to maximize the amount of points that you win". In both STP and LTP blocks, participants saw count down bars (i.e., vertical bars displayed below the pie charts as illustrated in Figure 6). As the trial progressed the vertical bars would disappear one at a time, counting down towards the time limit. In the STP trials, the bars counted down to the 1000 ms deadline. In the LTP trials, the bars counted down to the 3000 ms deadline. Thus, the overall goal of the experiment was to maximize winnings, and the only difference between STP and LTP blocks was related to the amount of time allowed for decisions.

Procedure. Participants first read instructions describing the task and the gamble display. Similar to Experiment 2, these instructions were administered both on paper and on the computer. The paper instruction document is available on the Open Science Framework at https://osf.io/9gyvd/. After reading the instructions, participants completed six practice trials. After completing the practice trials, participants started the main task. At the start of each trial (in both the gain and loss frame), participants were given an initial starting amount (e.g., 75 points or 50 points in Figure 6a and b). Participants were instructed that they were not able to retain the entirety of the initial amount, but would have to choose between a sure option and a gamble option. In the gain frame, participants selected between keeping a portion of the initial amount for sure (45 points in Figure 6a) or playing a gamble where they could either keep all of the initial starting amount (75 points in Figure 6a) with some probability or lose all of this amount (0 points in Figure 6a). In the loss frame, participants selected between losing a portion of the initial amount for sure (-30 points in Figure 6b) or playing a gamble where they could either lose all of the initial starting amount (-50 points in Figure 6b) with some probability or lose none of this amount (0 points in Figure 6b). For both frames, the gamble option was presented as a grayscale pie chart representing the probability of keeping the entirety of the initial amount or losing the initial amount. The sure option was randomly placed on either the left-hand or right-hand side of the screen.

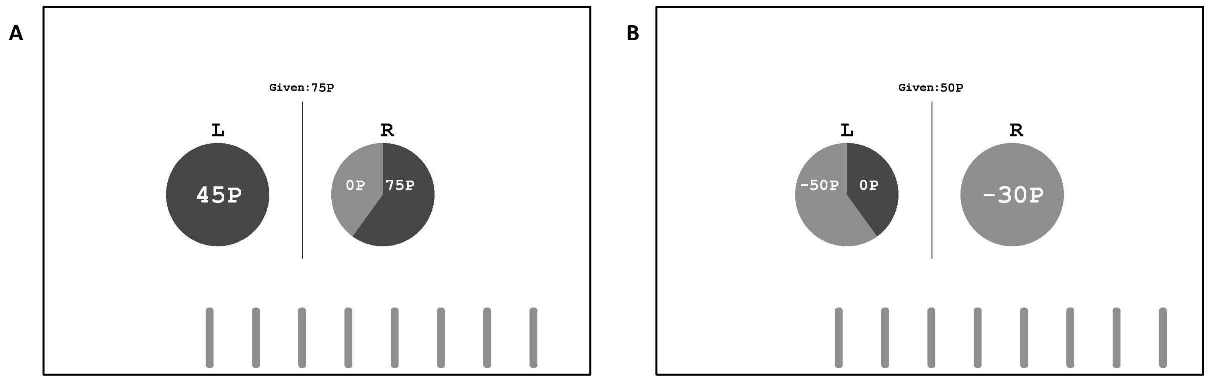

Fig 6. Screen shots from two trials in Experiment 3. Figure 6A shows a gain frame trial where the gamble is presented as winning a positive amount (75 points) or receiving nothing. Figure 6B shows a loss frame trial where the gamble is presented as losing a negative amount (-50 points) or losing nothing. The vertical bars below the pie chart count down backwards towards the trial deadline (1000 ms in the STP blocks and 3000 ms in the LTP blocks).

Results

We analyzed the data from the 52 participants with a minimum catch trial accuracy of 75%. The average proportion of catch trials answered correctly was 83%. These catch trials were removed for all subsequent analyses. The mean response time in the LTP condition was 1429 ms (std=316 ms) while the mean response time for the STP condition was 665 ms (std = 64 ms). There was a significant effect of frame ($F(1,51) = 26.34$; $p < .001$, $\eta^2 = 0.34$), showing participants preferred the gamble more often in the loss frame than in the gain frame. There was also a significant interaction between block and frame ($F(1,51) = 22.92$; $p < .001$, $\eta^2 = 0.31$), showing an increase in framing effect for the STP condition as compared to the LTP condition. Bayesian analyses also confirmed these results, showing that a model that includes block, frame, and the interaction of block and frame is preferred to the null model ($BF_{10} > 1000$). The choice proportions for selecting the gamble in the different conditions is shown at the bottom of Table 2. The data used in this analysis is available on the Open Science Framework at https://osf.io/9gyvd/.

Similar to Experiments 1 and 2, we also analyzed the framing effect on the problem level by calculating a framing effect score for STP and LTP conditions. As before, this score is defined as the difference in choices for the gamble in the loss and gain frames. Figure 7 shows the framing effect scores for STP and LTP conditions for each problem averaged over participants. From the figure, we see that all of the problems had a positive framing effect score in the STP condition and the majority (11 out of 16) had a positive framing effect score in the LTP condition as well, showing evidence for the standard framing effect where gambles are preferred in the loss frame as compared to the equivalent gain frame. Further, we see that most problems (14 out of 16) had a larger framing effect score in the STP condition than in the LTP condition, showing an increase in the framing effect under increased time pressure.

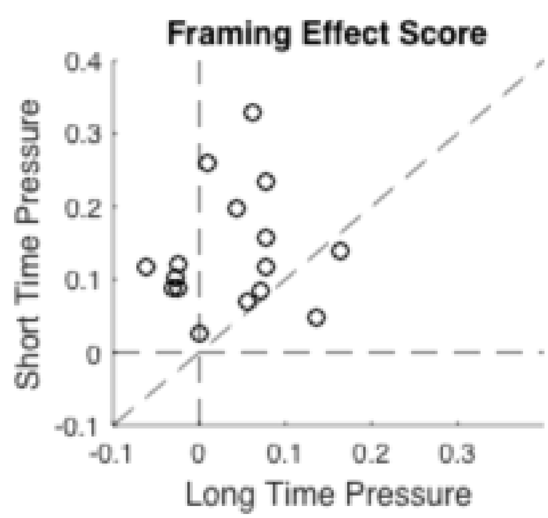

Figure 7. Framing effect scores for STP and LTP conditions in Experiment 3. Points above the horizontal dotted line represent problems displaying a framing effect in the STP condition, points to the right of the vertical dotted line represent problems displaying a framing effect in the LTP condition, and points that fall above the dotted diagonal line represent problems displaying a larger framing effect in the STP condition as compared to the LTP condition.

Conclusions

Experiment 3 shows that the results from Experiments 1 and 2 hold when sure gains (losses) are compared to gambles with all positive (all negative) outcomes. The results also hold for short and long time pressure manipulations, further generalizing the results of Experiments 1 and 2.

General Discussion

The present experiments showed that participants chose the sure option for gains and the gamble option for losses more frequently when forced to make quick decisions. These results are consistent with a dual process theory explanation of framing effects, where the effect is driven by the quick, intuitive system. Our findings are complementary to neuroimaging results by De Martino et al. (2006) showing increased activation in the amygdala when participants exhibited framing effects in risky choice.

Our results are also consistent with predictions of a dual-process model recently proposed by Loewenstein, O'Donoghue, and Bhatia (2015), which assumes choices arise from the interaction of the deliberative system (a utility function) and the intuitive system (an affective motivation function). Their model also incorporates a will power function where the depletion of will power results in increased weight on the intuitive system. They show that the model can account for a wide range of phenomena in the domains of intertemporal choice, risky decision-making, and social preferences. Importantly, the model predicts that when will power is depleted, framing effects will increase in risky decision-making. Time pressure provides one avenue to restrict will power. Thus, our experiments provide empirical support for their model predictions. Note that some of our results (such as risk aversion in gains and risk seeking in losses) are also consistent with Prospect Theory (Kahneman & Tversky, 1979). However, Prospect Theory cannot explain why framing effects increase with time pressure.

While our results are consistent with a dual-process explanation, we cannot rule out the possibility of a single process. Our results could arise from a single process that involves an attention switching mechanism as proposed in decision field theory (Busemeyer & Townsend, 1993; Roe et al., 2001) and the multistage attention-switching model (Diederich, 2015). In these models, preference evolves over time modulated by changes in attention. Preference for a given option might depend on the order of attended attributes or the time spent attending to an attribute. Time pressure might alter the attention process (e.g., by altering the time spent attending to different features) thus resulting in changes of behavior. In particular, time pressure could change attention to the lowest ranked payoff as suggested by the TAX model (Birnbaum & Chavez, 1997).

Future work could examine other manipulations aimed at distinguishing intuitive and deliberative processes, such as decreasing deliberation with cognitive load (see for example, Whitney, Rinehart & Hinson, 2008) or manipulating affect (Suter, Pachur, & Hertwig, 2016; Pachur, Hertwig, & Wolkewitz, 2014) In general, we encourage researchers to use direct manipulations (such as time pressure) in testing ideas from dual process theory. As recently discussed by Krajbich, Bartling, Hare, and Fehr (2015), simply using response time data alone to infer that choices are “intuitive” is inherently flawed due to the multiple sources of variability in data. Direct manipulations avoid the problems with “reverse inference” and lend more direct support for dual-process accounts.

Author Contributions

All authors contributed to the study concept and design. Testing and data collection along with data analyses for Experiment 1 were performed by L. Guo under the supervision of J. S. Trueblood. Testing and data collection for Experiments 2 and 3 were lead by A. Diederich. The data analyses for Experiments 2 and 3 were performed by J. S. Trueblood. L. Guo and J. S. Trueblood drafted the manuscript, and A. Diederich provided critical revisions. All authors approved the final version of the manuscript for submission.

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