

Supplementary Material:

Impulsiveness moderates the effects of exogenous attention on the  
sensitivity to gains and losses in risky lotteries

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## A Manipulation Check: Manipulating exogenous attention in the context of free choice worked in the majority of trials

The total presentation duration (PD) of an outcome depended on three factors, the first two of which were under experimental control: (1) the treatment PD determined how long a given outcomes was presented for across three conditions (400ms, 600ms, 800ms); (2) the presentation order was randomized and (3) participants were free to choose when to terminate a given trial and could therefore observe a given attribute multiple times. If an outcome was presented for longer first, the total PD for the target attribute was longer independent of participants behavior. However, if the target attribute (i.e. the attribute presented for the longer duration specified via the treatment PD) was presented second, participants could in fact choose to view the baseline attribute for longer before making a decision. Note that this is not possible in the 800ms conditions, since the treatment PD of the non-target outcome was always 400ms. Let us consider the following example: the target attribute was presented at the longer treatment PD of 600ms and is presented second. If the participant makes their decision right after seeing the first non-target outcome for the second time, then the total target PD will be less than the total non-target PD. We therefore conduct two analyses to first check the magnitude of this effect in our data by testing whether our treatments indeed led to the desired total PDs, and then perform a re-analysis of our data in which we directly model the difference in total presentation duration for target relative to non-target attribute (supplement section B).

Figure S1 shows a violin plot that reflects the percentage of time that Losses appear on the screen, conditional on the treatment conditions (Loss Longer / Gain Longer) and presentation order (Loss first / Gain first). Panel A displays the distribution for when the losses are presented first, while panel B shows the distribution for when gains are shown first. As expected, we find that the treatments are most effective when the outcome has longer treatment PDs and is presented first. Nonetheless, in the cases with longer treatment PDs for losses when gains were presented first, our treatment was effective (i.e., loss total PDs were relatively longer) in 65.5% of the cases. In the cases with longer treatment PDs for gains and when losses were presented first, we see that 63.4% of the total PDs were longer for gains. In the equal condition, the outcome that is presented first was seen for an equal or longer amount of time. Hence, we conclude that on average the treatments are effective in inducing longer focus times. It must be noted, however, that we model the intention to treat.

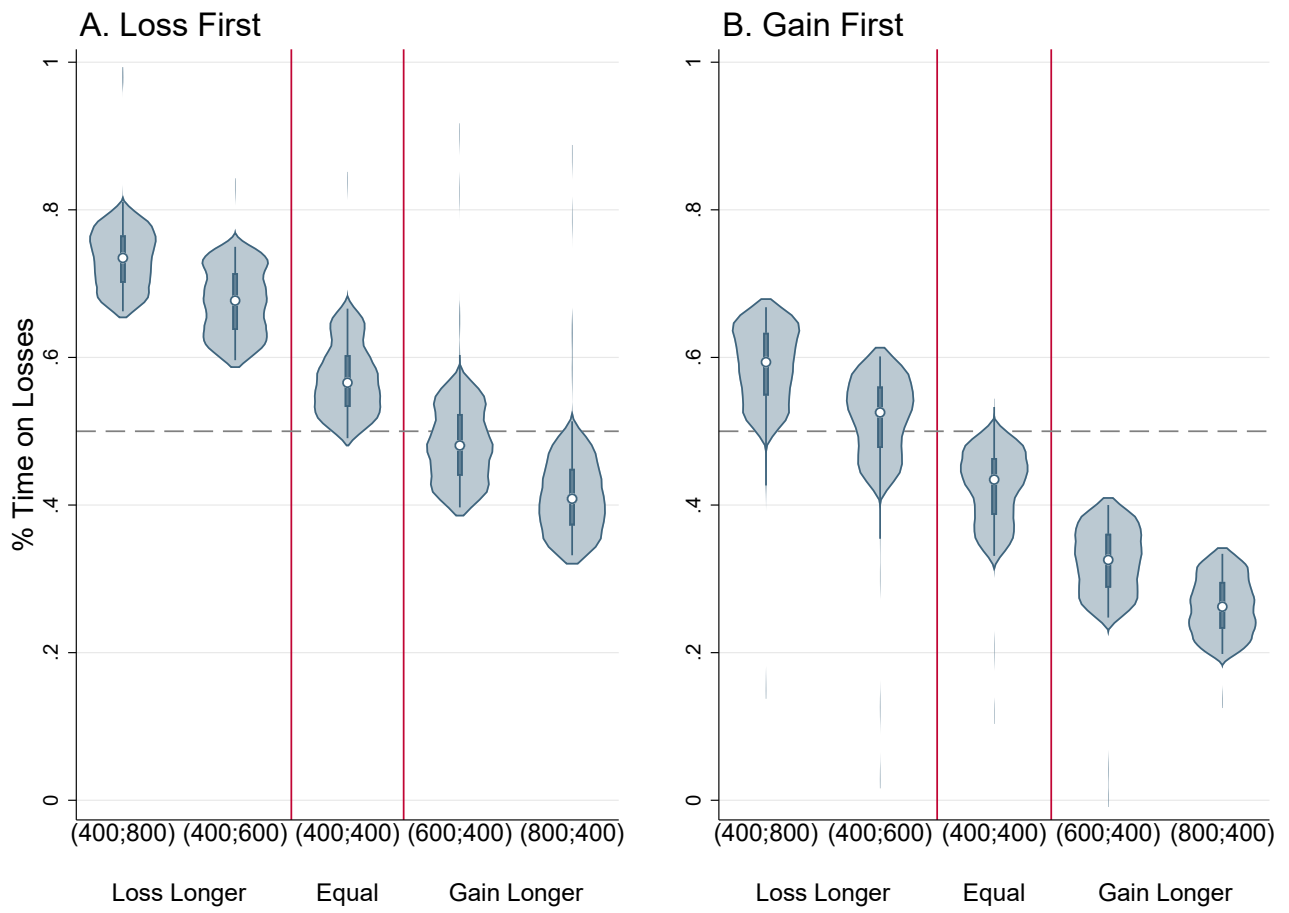


Figure S1: Proportion of time on Losses by treatment conditions

## B Results for effective treatment

Table S1 shows the effects of longer fixations when the treatments were effective. The variable  $\Delta PD_X > Yms$  is a dummy variable that takes the value of one if the intended treatment condition in fact increased the total Presentation Duration for attribute X by at least Y ms. When gains are presented for effectively longer periods than the losses, we find similar effects as in our main estimations. Specifically, an increase in total presentation duration to gains increases the sensitivity to both gains and losses. The effects of longer presentation durations for losses, however, are non-significant.

Table S1: Estimations of Decision Models by Difference in total PD

	(1)	(2)	(3)
Decision			
L	0.300*** (0.025)	0.302*** (0.024)	0.305*** (0.023)
$(\Delta PT_L > 0ms)=1 \times L$	0.034 (0.020)		
$(\Delta PT_L > 100ms)=1 \times$		0.033 (0.024)	
$(\Delta PT_L > 200ms)=1 \times L$			0.037 (0.026)
$(\Delta PT_G > 0ms)=1 \times L$	0.055* (0.023)		
$(\Delta PT_G > 100ms)=1 \times L$		0.058* (0.024)	
$(\Delta PT_G > 200ms)=1 \times L$			0.051* (0.023)
G	0.243*** (0.022)	0.234*** (0.022)	0.242*** (0.021)
$(\Delta PT_L > 0ms)=1 \times G$	0.021 (0.018)		
$(\Delta PT_L > 100ms)=1 \times G$		0.032 (0.020)	
$(\Delta PT_L > 200ms)=1 \times G$			0.027 (0.021)
$(\Delta PT_G > 0ms)=1 \times G$	0.057** (0.019)		
$(\Delta PT_G > 100ms)=1 \times G$		0.070*** (0.020)	
$(\Delta PT_G > 200ms)=1 \times G$			0.058** (0.021)
Observations	7653	7653	7643
AIC	3563.061	3549.922	3527.503
BIC	3604.718	3591.579	3569.152

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## C Descriptive statistics

Table S2: Response times (seconds) based on treatment conditions and Impulsiveness.

Condition (TG, TL)	Non-Impulsive	Impulsive	p-value diff.
(400,800)	1.824	1.849	0.525
(400,600)	1.932	2.035	0.017
Loss Longer	1.878	1.942	0.028
Equal	1.716	1.735	0.621
Gain Longer	1.903	1.892	0.690
(600,400)	1.829	1.820	0.823
(800,400)	1.977	1.964	0.7331

Note, due to multiple comparisons a Bonferroni-corrected threshold requires p-values below 0.0071 for significance.

Table S3: Proportion of lottery acceptance by condition

Condition (TG, TL)	Mean	SD
(400,400)	0.577	0.494
(400,600)	0.577	0.494
(400,800)	0.567	0.496
(600,400)	0.579	0.494
(800,400)	0.580	0.494
Total	0.576	0.494

## D Moderating effect of impulsiveness with different scales

The figures below display the effect of the treatment conditions on the decision weights conditional on the participant being classified as impulsive or non-impulsive. Each set of figures uses a different impulsiveness sub-scale of the BIS-11. In each set of figures, the first row shows the effects on the decision weights on gains, while the second row shows the effects on the decision weights on losses. The left column describes the treatment effects of non-impulsive participants and the right column for impulsive ones. These effects represent the difference in the decision weights relative to the Equal condition (400ms, 400ms) for that specific group (Impulsive or non-Impulsive). Treatment conditions are described as (PD Gains, PD Losses) in ms. The confidence intervals are at a 95% of confidence. Conditions Loss Longer and Gain Longer show the pooled results of both conditions where the said outcome is presented for longer. Parameters estimated from models 1i and 2i using the different impulsiveness sub-scales. Results extracted from tables S4, S6 and S5.

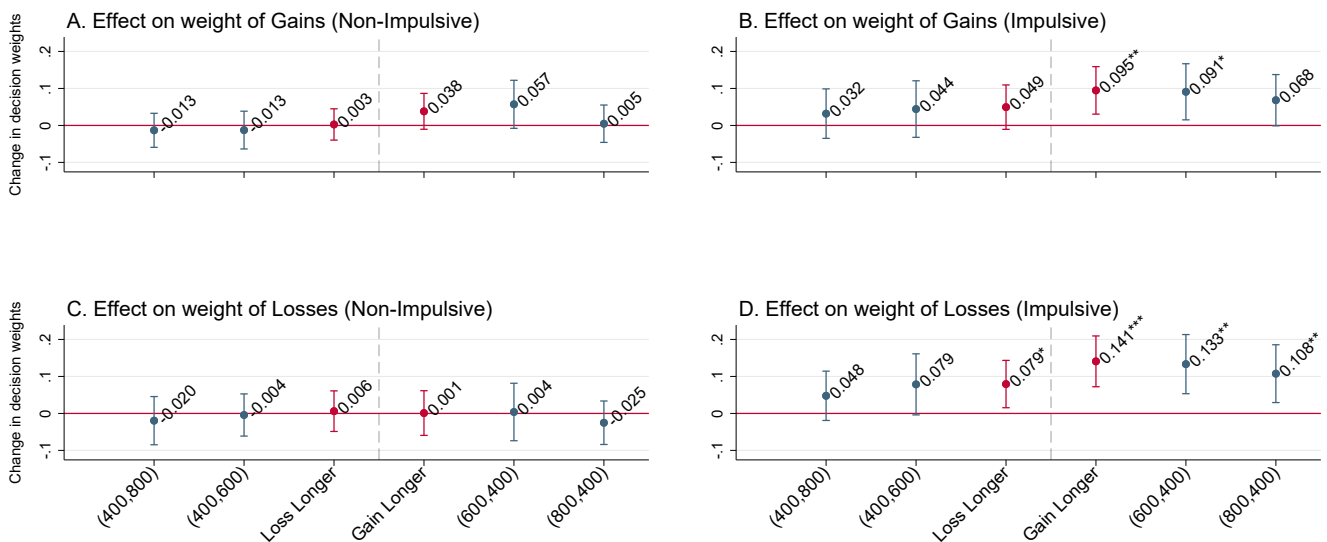


Figure S2: Moderating effect of BIS-11 attentional factor

Table S4: Estimations of Decision Models by Impulsiveness (BIS-11, Attention)

	Model 1i		Model 2i		Model 3i	
L	0.320***	(0.039)	0.320***	(0.039)	0.332***	(0.034)
Impulsive $\times$ L	-0.0513	(0.051)	-0.0513	(0.051)	0.0243	(0.045)
Loss longer $\times$ L			0.00608	(0.028)		
(400;600) $\times$ L	-0.00428	(0.029)				
(400;800) $\times$ L	-0.0196	(0.033)				
Gain longer $\times$ L			0.000930	(0.031)		
(600;400) $\times$ L	0.00383	(0.040)				
(800;400) $\times$ L	-0.0252	(0.030)				
Impulsive $\times$ Loss longer $\times$ L			0.0733	(0.043)		
Impulsive $\times$ (400;600) $\times$ L	0.0828	(0.051)				
Impulsive $\times$ (400;800) $\times$ L	0.0673	(0.048)				
Impulsive $\times$ Gain longer $\times$ L			0.140**	(0.047)		
Impulsive $\times$ (600;400) $\times$ L	0.129*	(0.057)				
Impulsive $\times$ (800;400) $\times$ L	0.133**	(0.050)				
G	0.245***	(0.030)	0.245***	(0.030)	0.268***	(0.028)
Impulsive $\times$ G	-0.0146	(0.043)	-0.0146	(0.043)	0.0178	(0.038)
Loss longer $\times$ G			0.00261	(0.022)		
(400;600) $\times$ G	-0.0126	(0.026)				
(400;800) $\times$ G	-0.0132	(0.023)				
Gain longer $\times$ G			0.0381	(0.025)		
(600;400) $\times$ G	0.0570	(0.033)				
(800;400) $\times$ G	0.00463	(0.026)				
Impulsive $\times$ Loss longer $\times$ G			0.0468	(0.037)		
Impulsive $\times$ (400;600) $\times$ G	0.0568	(0.047)				
Impulsive $\times$ (400;800) $\times$ G	0.0451	(0.041)				
Impulsive $\times$ Gain longer $\times$ G			0.0566	(0.041)		
Impulsive $\times$ (600;400) $\times$ G	0.0339	(0.051)				
Impulsive $\times$ (800;400) $\times$ G	0.0636	(0.044)				
Observations	7464		7670		7670	
<i>AIC</i>	2934.2		3567.2		4475.9	
<i>BIC</i>	3072.6		3650.5		4503.6	

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

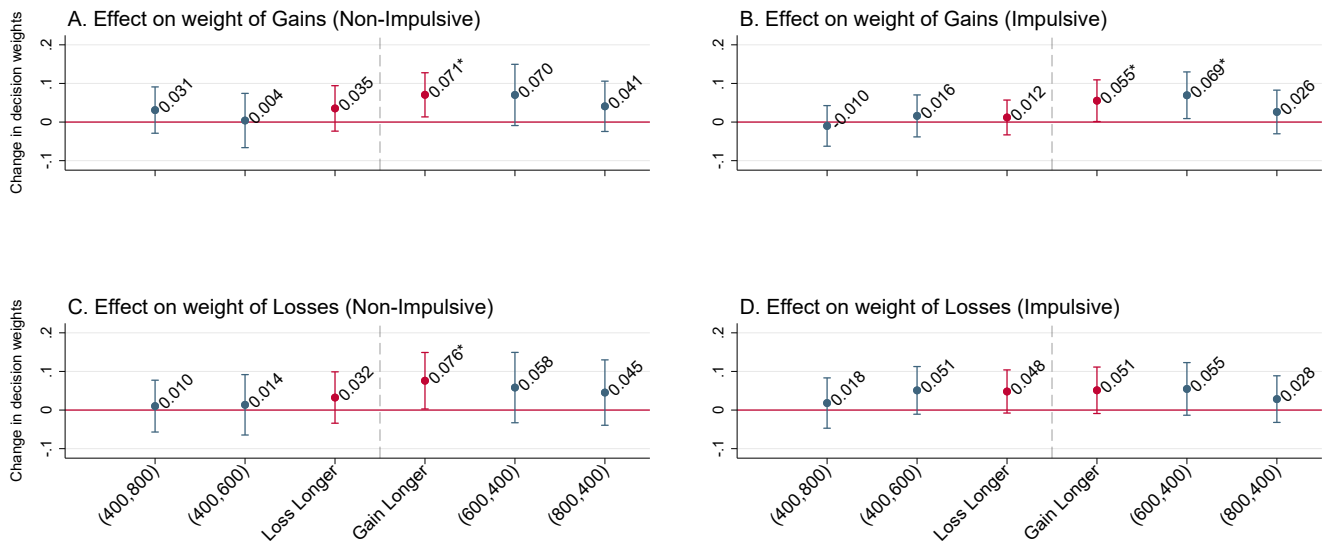


Figure S3: Moderating effect of BIS-11 motor factor



Table S5: Estimations of Decision Models by Impulsiveness (BIS-11, Motor)

	Model 1i		Model 2i		Model 3i	
L	0.336***	(0.040)	0.336***	(0.040)	0.388***	(0.038)
Impulsive $\times$ L	-0.0811	(0.051)	-0.0811	(0.051)	-0.0880	(0.047)
Loss longer $\times$ L			0.0324	(0.034)		
(400;600) $\times$ L	0.0135	(0.040)				
(400;800) $\times$ L	0.0102	(0.034)				
Gain longer $\times$ L			0.0759*	(0.037)		
(600;400) $\times$ L	0.0582	(0.046)				
(800;400) $\times$ L	0.0453	(0.043)				
Impulsive $\times$ Loss longer $\times$ L			0.0156	(0.044)		
Impulsive $\times$ (400;600) $\times$ L	0.0374	(0.051)				
Impulsive $\times$ (400;800) $\times$ L	0.00793	(0.048)				
Impulsive $\times$ Gain longer $\times$ L			-0.0248	(0.048)		
Impulsive $\times$ (600;400) $\times$ L	-0.00350	(0.058)				
Impulsive $\times$ (800;400) $\times$ L	-0.0169	(0.053)				
G	0.268***	(0.032)	0.268***	(0.032)	0.314***	(0.032)
Impulsive $\times$ G	-0.0564	(0.043)	-0.0564	(0.043)	-0.0726	(0.040)
Loss longer $\times$ G			0.0353	(0.030)		
(400;600) $\times$ G	0.00398	(0.036)				
(400;800) $\times$ G	0.0310	(0.031)				
Gain longer $\times$ G			0.0705*	(0.029)		
(600;400) $\times$ G	0.0702	(0.040)				
(800;400) $\times$ G	0.0407	(0.033)				
Impulsive $\times$ Loss longer $\times$ G			-0.0235	(0.038)		
Impulsive $\times$ (400;600) $\times$ G	0.0120	(0.045)				
Impulsive $\times$ (400;800) $\times$ G	-0.0410	(0.041)				
Impulsive $\times$ Gain longer $\times$ G			-0.0152	(0.040)		
Impulsive $\times$ (600;400) $\times$ G	-0.000832	(0.051)				
Impulsive $\times$ (800;400) $\times$ G	-0.0146	(0.044)				
Observations	7464		7670		7670	
<i>AIC</i>	2921.0		3550.5		4449.0	
<i>BIC</i>	3059.4		3633.9		4476.8	

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

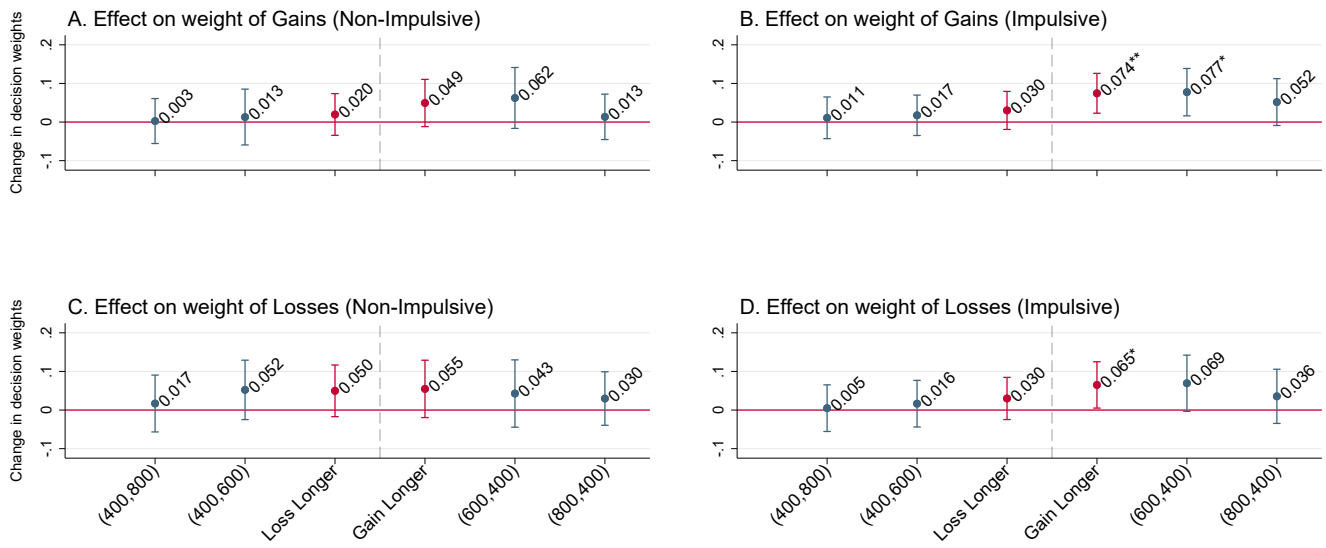


Figure S4: Moderating effect of BIS-11 non-planning factor

Table S6: Estimations of Decision Models by Impulsiveness (BIS-11, Non-Planning)

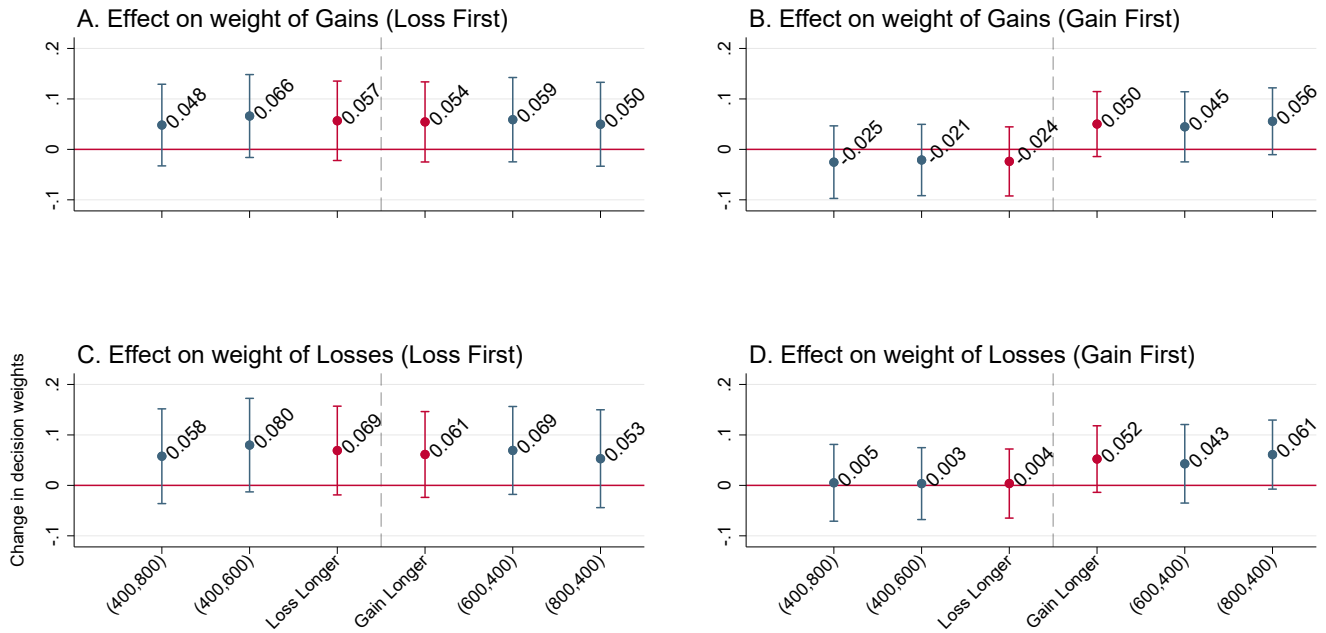
	Model 1i		Model 2i		Model 3i	
L	0.332***	(0.038)	0.332***	(0.038)	0.385***	(0.030)
Impulsive $\times$ L	-0.0754	(0.050)	-0.0754	(0.050)	-0.0876	(0.045)
Loss longer $\times$ L			0.0498	(0.034)		
(400;600) $\times$ L	0.0522	(0.039)				
(400;800) $\times$ L	0.0170	(0.038)				
Gain longer $\times$ L			0.0548	(0.038)		
(600;400) $\times$ L	0.0428	(0.044)				
(800;400) $\times$ L	0.0299	(0.035)				
Impulsive $\times$ Loss longer $\times$ L			-0.0198	(0.044)		
Impulsive $\times$ (400;600) $\times$ L	-0.0358	(0.050)				
Impulsive $\times$ (400;800) $\times$ L	-0.0121	(0.049)				
Impulsive $\times$ Gain longer $\times$ L			0.0103	(0.049)		
Impulsive $\times$ (600;400) $\times$ L	0.0266	(0.058)				
Impulsive $\times$ (800;400) $\times$ L	0.00569	(0.050)				
G	0.270***	(0.032)	0.270***	(0.032)	0.305***	(0.026)
Impulsive $\times$ G	-0.0658	(0.043)	-0.0658	(0.043)	-0.0606	(0.039)
Loss longer $\times$ G			0.0196	(0.028)		
(400;600) $\times$ G	0.0129	(0.037)				
(400;800) $\times$ G	0.00256	(0.030)				
Gain longer $\times$ G			0.0493	(0.031)		
(600;400) $\times$ G	0.0623	(0.040)				
(800;400) $\times$ G	0.0134	(0.030)				
Impulsive $\times$ Loss longer $\times$ G			0.0105	(0.037)		
Impulsive $\times$ (400;600) $\times$ G	0.00450	(0.046)				
Impulsive $\times$ (400;800) $\times$ G	0.00839	(0.041)				
Impulsive $\times$ Gain longer $\times$ G			0.0251	(0.041)		
Impulsive $\times$ (600;400) $\times$ G	0.0151	(0.051)				
Impulsive $\times$ (800;400) $\times$ G	0.0383	(0.043)				
Observations	7464		7670		7670	
<i>AIC</i>	2922.9		3557.6		4451.9	
<i>BIC</i>	3061.3		3640.9		4479.7	

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## E Moderating effects of presentation order

Figure S5 shows the effect of the treatment conditions on the decision weights conditional on which attribute was presented first. The first row shows the effects on the decision weights on gains, while the second row shows the effects on the decision weights on losses. The left column presents the treatment effects when losses are presented first and the right column when gains are presented first. These effects represent the difference in the decision weights with the Equal condition (400ms, 400ms) when the corresponding attribute was presented first (losses left, gains right). Treatment conditions are described as (PD Gains, PD Losses) in ms. The confidence intervals are at a 95% of confidence. Conditions Loss Longer and Gain Longer show the pooled results of both conditions where the said outcome is presented for longer. Parameters estimated from models 3 and 4 from Table S7. Table S8 shows the same analysis with a Dummy for the last fixation instead of the first.



Estimated values and significance is shown alongside markers. \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Figure S5: Moderating effect of presentation order

Table S7: Estimations of Decision Models by Presentation Order (with Dummy for First viewed Outcome)

	Model 1f		Model 2f	
L	0.280***	(0.036)	0.347***	(0.026)
G. First $\times$ L	0.0211	(0.045)	-0.00867	(0.021)
Loss longer $\times$ L	0.0690	(0.045)		
Gain longer $\times$ L	0.0612	(0.043)		
Loss longer $\times$ G. First $\times$ L	-0.0654	(0.062)		
Gain longer $\times$ G. First $\times$ L	-0.00908	(0.054)		
G	0.226***	(0.033)	0.279***	(0.021)
G. First $\times$ G	0.0308	(0.044)	-0.00675	(0.020)
Loss longer $\times$ G	0.0567	(0.040)		
Gain longer $\times$ G	0.0544	(0.041)		
Loss longer $\times$ G. First $\times$ G	-0.0805	(0.058)		
Gain longer $\times$ G. First $\times$ G	-0.00425	(0.054)		
Observations	7009		7593	
<i>AIC</i>	2652.3		3906.7	
<i>BIC</i>	2734.6		3934.5	

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table S8: Estimations of Decision Models by Presentation Order (with Dummy for Last viewed Outcome)

	Model 1l		Model 2l	
L	0.321***	(0.046)	0.345***	(0.023)
Gain Last $\times$ L	-0.0138	(0.055)	-0.0225	(0.022)
Loss longer $\times$ L	0.0247	(0.049)		
Gain longer $\times$ L	0.0387	(0.050)		
Loss longer $\times$ Gain Last $\times$ L	-0.0345	(0.076)		
Gain longer $\times$ Gain Last $\times$ L	-0.000206	(0.060)		
G	0.240***	(0.035)	0.272***	(0.019)
Gain Last $\times$ G	0.0178	(0.047)	-0.00994	(0.020)
Loss longer $\times$ G	0.0460	(0.036)		
Gain longer $\times$ G	0.0252	(0.038)		
Loss longer $\times$ Gain Last $\times$ G	-0.0861	(0.063)		
Gain longer $\times$ Gain Last $\times$ G	0.0118	(0.058)		
Observations	7048		7048	
<i>AIC</i>	2661.5		2657.1	
<i>BIC</i>	2743.8		2684.6	

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## F Impulsiveness as a continuous measure

Table S9: Estimations of Decision Models by Impulsiveness (Continuous Measure)

	Model 1i		Model 2i		Model 3i	
Decision						
L	0.301***	(0.000)	0.301***	(0.000)	0.345***	(0.000)
L × Impulsive	-0.0738*	(0.018)	-0.0738*	(0.018)	-0.0514*	(0.037)
Loss longer × L			0.0343	(0.111)		
(400;600) × L	0.0267	(0.278)				
(400;800) × L	0.00798	(0.735)				
Gain longer × L			0.0541*	(0.019)		
(600;400) × L	0.0511	(0.070)				
(800;400) × L	0.0268	(0.271)				
Loss longer × L × Impulsive			0.0270	(0.353)		
(400;600) × L × Impulsive	0.0344	(0.341)				
(400;800) × L × Impulsive	0.0172	(0.575)				
Gain longer × L × Impulsive			0.0547	(0.077)		
(600;400) × L × Impulsive	0.0633	(0.069)				
(800;400) × L × Impulsive	0.0418	(0.168)				
G	0.243***	(0.000)	0.243***	(0.000)	0.278***	(0.000)
G × Impulsive	-0.0620*	(0.017)	-0.0620*	(0.017)	-0.0435	(0.051)
Loss longer × G			0.0202	(0.284)		
(400;600) × G	0.00801	(0.728)				
(400;800) × G	0.00533	(0.790)				
Gain longer × G			0.0572**	(0.004)		
(600;400) × G	0.0657**	(0.009)				
(800;400) × G	0.0271	(0.196)				
Loss longer × G × Impulsive			0.0250	(0.229)		
(400;600) × G × Impulsive	0.0395	(0.143)				
(400;800) × G × Impulsive	0.0115	(0.646)				
Gain longer × G × Impulsive			0.0449	(0.054)		
(600;400) × G × Impulsive	0.0313	(0.250)				
(800;400) × G × Impulsive	0.0502*	(0.036)				
Observations	7464		7670		7670	
<i>AIC</i>	2923.7		3560.3		4455.6	
<i>BIC</i>	3062.1		3643.6		4483.4	

*p*-values in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## G Instructions

Welcome! You are participating in a study funded by the University of Amsterdam. In this study you will have to make a series of decisions about risk. Depending on your answers you can get a bonus payment

- **Expected duration:** The overall study should last about 20 minutes.
- **Requirements:** You need to be 18 or older and be able to speak and read English.
- **Risks and Benefits:** There are no expected risks associated with the participation in this study. Your decisions will affect how much you earn in the end. Aside from the participation fee, you can obtain a bonus payment depending on your decisions. This bonus can go up to 2 pounds.
- **Confidentiality:** Your decisions and identity will not be revealed to anyone. Moreover, you will be assigned to an identification number and all your decisions will be registered as such. No one will be able to link your decisions to you.
- **Voluntary Participation:** Your participation in this study is voluntary. You can decide to stop your participation at any time throughout the experiment, but you cannot earn the additional bonus if you do not finish the experiment. You do not need any reason to withdraw from the study.
- **Questions:** If you have any questions about the experiment, please write to the researcher Alejandro Hirmas at [a.hirmas@uva.nl](mailto:a.hirmas@uva.nl)

I agree to the conditions and want to participate in the study.

Continue

Thank you for participating in our experiment on how people react to different decision situations. The overall duration of the study should be about 20-25 minutes. This experiment uses Experimental Currency Units (ECU). Each ECU is equivalent to 2.5p (0.025 Pounds). You have received an initial Bonus Payment of 40 ECUs. This amount can *increase (or decrease)* depending on your decisions of this experiment. This bonus payment is additional to your participation fee.

In this study, you will be shown 44 different lotteries and will be asked to make decisions about whether you wish to accept each lottery or not. The lotteries, that you will see, offer a *positive (Gain)* and a *negative (Loss)* outcome with equal probability (fifty-fifty, same as a coin toss). *Gain* and *Loss* amounts will change for each new decision situation, so consider each lottery carefully before you make a decision. At the end of the experiment, one of the 44 lotteries will be selected at random.

If you **reject** the selected lottery, nothing will happen. If you **accept** it, one of the outcomes will be played out via a virtual coin flip. If the good state occurs (e.g., heads), the *Gains* will be *added* to your initial bonus payment. If the bad state occurs (e.g., tails), the *Losses* may be *subtracted* from your bonus payment. Therefore, your decisions in the experiment together with the outcome of the coin flip will determine your bonus payment.

**For example:**

Let's say in the selected lottery (one of the 44), the possible outcomes are 32 (heads) and -20 (tails).

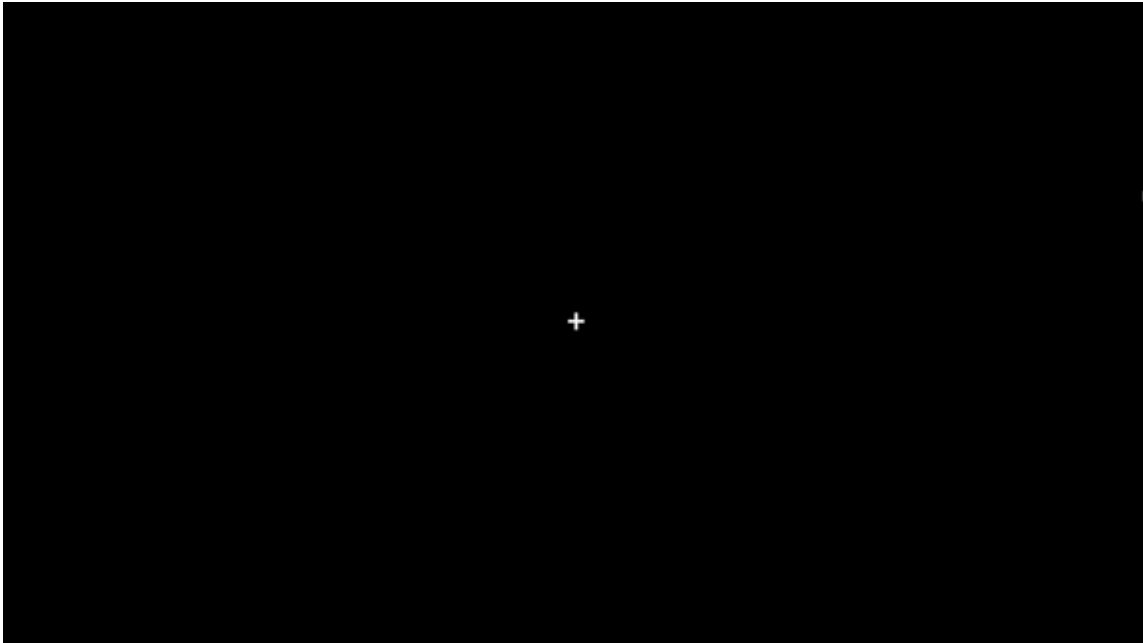
If you decide to **reject**, then, your bonus payment will remain unchanged.

If you decide to **accept**, then a random outcome is determined.

- If the random outcome is heads, you *add* 32 to your bonus payment.
- If the random outcome is tails, you *subtract* 20 to your bonus payment.

In each decision situation, the presentation of the lottery goes as follows. First, you will see a cross in the middle. Then, the outcomes (*Gain* and *Loss*) will appear on the screen in alternation (similar to the black screen below). If you wish to **accept** the lottery, then press the upwards key (↑). In case you want to **reject**, press the downward key (↓). Once you have made your decision, it will be notified on the screen. You have a maximum of 6 seconds (starting after the cross appeared) to make your decision, so you need to press the key you decided before these 6 seconds. In case you don't answer within 6 seconds, we will ask you to answer faster, and if that decision situation gets selected in the end, you will get the *negative* outcome for certain.





After each decision situation, you will be informed about your decision. Next, we will ask you about your confidence in your decision. You will be presented with a scale that goes from 1 to 7 (See picture below). The scale will have a marker (green bar). You can move the marker to the left by pressing the left key (←) and you can move it to the right by pressing right key (→). Once you have placed the marker in the confidence level you want to select, then you need to press the Enter key or the letter A to accept. After you have selected your confidence level, the next trial will begin.



## Questions


Now we will ask you a couple of questions regarding the instructions to see that everything is clear. After you answer these questions correctly, we will show you 3 practice trials for you to get used to making decisions in the current experiment. The lottery that will be selected will not come from these trials, these are simply there for you to try out how to make decisions in this experiment.

After you completed the practice trials, we will notify you and the actual experiment will start, with decisions that can count towards your final payout. After you finish all the decisions, a short survey will be presented. Once you finish the survey, one of the lotteries will be selected and your bonus payment will be calculated.

How many decisions are you going to make (without counting the practice trials)?

How many outcomes will be selected for payment?

To accept a lottery, you need to press:

Can the lottery, selected in the end, come from the first 3 trials?