The random thickness of indifference

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Abstract

Standard random utility models can account for stochastic choice. However, a common implication is that the realized utilities are equal with probability zero. This knife-edge aspect implies that indifference is thin because arbitrarily small changes in utility will break indifference. Semiorders can represent preferences where indifference is thick, however, choice is not random. We design an incentivized binary line length judgment experiment to better understand how indifference can be both thick and random. In the 2-choice treatment, subjects select one of the lines. In the 3-choice treatment, subjects select one of the lines or can express indifference, which directs the computer to "flip a coin" to decide. In every trial, there is a longer line and subjects were told this fact. For each of our line pairs, subjects make 5 decisions in the 2-choice treatment and 5 decisions in the 3-choice treatment. In the line pair with the smallest length difference, 49.7% of 2-choice treatment trials are optimal. For this line pair in the 3-choice treatment, only 1 out of 113 subjects selected indifference on all 5 available trials. There are well-known predictions that optimal choices will have shorter response times than suboptimal choices (Fudenberg, Strack, and Strzalecki, 2018) and we find evidence of this in our dataset. However, not much seems to be known about the response times and indifference. In the 3-choice treatment, we find that indifference choices have longer response times than suboptimal choices. We find that indifference choices are associated with risk aversion and a measure of the beliefs of the favorability of the coin flip. We do not find that indifference choices become more likely across trials, however we find the likelihood of selecting the longer line–in both 2-choice and 3-choice treatments–are decreasing across trials. We hope that the results of our experiment can help inform models of choice where indifference is both thick and random.

Keywords: choice theory, judgment, indifference, memory, search
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1 Introduction

Random utility models (RUMs) posit that subjects perceive the utility of each option with noise and select the option with the largest realized utility.[1] Consider a choice between left and right, where the objective utilities are U_L and U_R. A common RUM specification is that these options are perceived with additive noise: $U_L + e_L$ and $U_R + e_R$. The subject selects the option corresponding to that with the largest realized value. One attractive feature of RUMs is that they can model apparently stochastic choice.

However, one implication of the standard version of RUMs is that the realized utilities of the options are equal with probability zero.[2] In other words, RUMs can offer an account for random choice but it is not clear how typical RUMs can account for situations where subjects express indifference[3] between options.

In contrast to the knife-edge implication that indifference is *thin*, Luce (1956) offers a characterization of semiorders where indifference is *thick*. As a motivating example, Luce (1956) considers a long row of cups of coffee. The experimenter does not place any sugar in the first cup, places one gram of sugar in the second cup, two grams in the third, and so on, where the last cup has a great deal of sugar. Luce posits that the subject would be indifferent between any two adjacent cups of coffee, but clearly not indifferent between the extreme cups. In this sense, indifference is claimed to be thick but apparently *not random*.[4]

We design an experiment to produce data that could inform models where indifference is both thick and random. Subjects make choices involving pairs of lines of different lengths. Subjects are paid an increasing amount in the line selected.[5] Length is an easily understood, single attribute feature that is useful as a proxy for utility.[6] Due to the objectively measur-

[1] Classic references include Becker, DeGroot, and Marschak (1963) and Luce and Suppes (1965). See Ok and Tserenjigmid (2022) for a description of RUMs where preferences are not necessarily complete.

[2] This feature can be referred to as *noncoincident* (Falmagne, 1983) or *balanced* (Falmagne, 2002).

[3] Here we refer to indifference as expressing "I am fine with either option" or "you pick for me." We acknowledge that this choice could also be due to a preference for randomization (Agranov and Ortoleva, 2017).

[4] Horan (2021) develops a model of stochastic semi-orders, but indifference is not random.

[5] See Smith (1976) for an early discussion of induced-values experiments.

[6] Early studies of judgments of length include Münsterberg (1894) and Cattell (1902). See Laming and Laming (1992) for a translation and a discussion of a German language paper from 1852. For other examples of incentivized line judgments, see Duffy, Gussman, and Smith (2021), Duffy and Smith (2023), and Duffy and Smith (2024).

able nature of our choice objects–unlike standard economics choice experiments–we are able to observe whether the optimal choice was made. There is a large literature, referred to as *psychophysics*, which studies how physical objects are perceived or experienced.[7] Our psychophysics design permits us to present materially identical choice sets without the repetition being apparent to subjects and allows us to learn the effects of small changes in the differences in the valuations.

In the *2-choice treatment*, subjects select one of these two lines. In the *3-choice treatment*, subjects select one of the lines or can express indifference, which directs the computer to "flip a coin" to decide. In every trial, there is a longer line and subjects were told this fact. Therefore, it was never the case that both options in a coin flip had identical material payoffs. In order to better understand the randomness, we direct subjects to make choices in identical material conditions on 5 different trials.

We find that most subjects select indifference in at least one trial. In fact, only 21 of 113 (18.6%) of our subjects did not select indifference on any trial.

Despite that most subjects selected indifference on some trials, there was considerable randomness in these choices. There were 518 sets of 5 decisions made by the same subject under identical material incentives in 3-choice trials where indifference was selected at least once. However, on only 3 sets (0.58%) of these trials did subjects select indifference on all 5 trials. In the other 515 sets, subjects selected indifference between 1 and 4 times. Another way to view the randomness is to consider the line pair in our experiment with the smallest difference in length. In the 2-choice treatment, the longer line was selected on 49.7% of the trials. For this line pair in the 3-choice treatment, only 1 out of 113 subjects selected indifference on all 5 available trials.

There are well-known predictions that optimal choices will have shorter response times than suboptimal choices (Fudenberg, Strack, and Strzalecki, 2018) and evidence of this in the literature (Duffy and Smith, 2023, 2024). While we find these effects in our dataset, not much seems to be known about the response times associated with choices of indifference. In

[7] See Weber (1834), Fechner (1860), and Thurstone (1927) for classic references, and Falmagne (2002) and Gescheider (1997) for excellent overviews of the field. See Brañas-Garza and Smith (2024) for an introduction designed for experimental economists.

3-choice treatment trials, we find that indifference choices have longer response times than suboptimal choices.

We find that indifference choices are associated with risk aversion and a measure of the beliefs of the favorableness of the coin flip. We find some evidence that indifference choices are associated with a lower measure of cognitive ability and worse performance on the 2-choice trials. We do not find that indifference choices become more likely across trials, however we find the likelihood of selecting the longer line–in both 2-choice and 3-choice trials–are decreasing across trials.

We hope that the results of our experiment can help inform models of choice in which indifference is both thick and random.

2 Related literature

There is a small but interesting history of attempting to determine indifference relations in the lab. However, these efforts were designed to learn how subjects would trade off more of one good for less of another: market bundles of hats and shoes (Thurstone, 1931), bacon and eggs (Rousseas and Hart, 1951), and money and pens (MacCrimmon and Toda, 1969).[8]

Although it can be standard to force a choice between objects, there are examples of designs where subjects can express indifference. For example Regenwetter and Davis-Stober (2012) permit subjects to express indifference among objectively specified gambles and Kramer and Budescu (2005) permit subjects to express indifference among ambiguous gambles. Costa-Gomes, Cueva, Gerasimou, and Tejiščák (2022) find that choices involving real goods are more consistent in a treatment where subjects can defer (presumably difficult) choices rather than in a treatment where choice is forced.[9]

There is recent literature on better understanding an apparent preference for randomization. For example, Agranov and Ortoleva (2023) present subjects with multiple price lists involving choices between a sure payment and lotteries of varying compositions. Rather than forcing a choice between the options, the subjects also have the ability to determine a ran-

[8] See Roth (1993) for more on these efforts.

[9] Also see Gerasimou (2024).

domization between the options.[10] Expected utility predicts that subjects would select the randomization for at most one row. However, Agranov and Ortoleva (2023) find that more than 70% of their subjects randomize in two or more rows. It is possible to interpret this as evidence of thick indifference.

There is a literature in economics that studies the implications of the differences in the utility on stochastic choice (Mosteller and Nogee, 1951; Debreu, 1958; Gerasimou, 2021; Alós-Ferrer & Garagnani, 2021, 2022a, 2022b). Our research continues these efforts, but we allow subjects to express indifference between the choice objects.

There is a small but growing literature that incentivizes judgments of imperfectly perceived objects in an effort to improve economics.[11] Halevy, Walker-Jones, and Zrill (2023) incentivizes judgments of the areas of rectangles.[12] Similar to our design, there is always a larger object. Subjects are asked whether they prefer to bet on which of the two rectangles has a larger area or to randomize over those bets. The subjects are also asked for their (possibly nondegenerate) beliefs about the areas. The authors find that a majority of subjects report point (degenerate) beliefs that sum to 1, and not randomizing between bets unless reported beliefs are both 0.5. On the other hand, the authors argue that deviations from this are best explained by incomplete preferences.

Payzan-LeNestour and Woodford (2022) design an incentivized experiment where subjects are presented with two shades of grey. The subjects are directed to indicate which of the two are darker, or to indicate that they have an identical shade. Despite the interesting questions involved, the authors do not analyze these 'indifference' choices.

We note a literature on incentivized line length judgments, Duffy, Gussman, and Smith (2021), Duffy and Smith (2023), and Duffy and Smith (2024). The authors find a gradual (not sudden) relationship between the differences in the lengths of the lines and the probability that the optimal choice was made. The authors also find that optimal choices tend to have faster

[10] For related designs, see Sopher and Narramore (2000), Cettolin and Riedl (2019), Permana (2020), and Feldman and Rehbeck (2022).

[11] See Brañas-Garza and Smith (2024) for a review of this literature. Also see Crosetto and Gaudeul (2016), Crosetto and Gaudeul (2024), and Lunn and Somerville (2021).

[12] See Tversky and Russo (1969) for another design where subjects perform judgments on the areas of rectangles.

response times than suboptimal choices.[13] Additionally, the authors find that the assumption of Gumbel errors fits their data better than the assumption of normally distributed errors. However, these designs forced a choice of one of the lines and were therefore not designed to study indifference. Here we include treatments where subjects can express indifference.

3 Experimental design

3.1 Line selection task

Subjects made choices between pairs of lines.[14] In every pair, there was a longer and shorter line, and subjects were informed of this. The longer line in every pair was 240 pixels (11.171 cm). The length of the shorter line was determined by subtracting various amounts from the longer line. These values ranged from 1 pixel (0.0465 cm) to 30 pixels (1.396 cm).[15] Below, we refer to line lengths in pixels, rather than in cm.

There was a line situated on the left of the screen and a line situated on the right, although neither line was visible at the beginning of each trial. The longer line was programmed to be on the left side of the screen with an independent probability of 0.5. When subjects clicked on any point on the left (right) half of the screen, the left (right) line would appear and the right (left) line would disappear. There were no time or click restrictions: subjects could click back and forth to view the lines as many times and for as long as they preferred.

There were two line selection treatments: a *2-choice* treatment and a *3-choice* treatment. In the 2-choice treatment, subjects were forced to select either the line on the left or the line of the right.[16] In the 3-choice treatment, subjects could select left or right, but they could also express indifference, whereby the computer would "flip a coin" to determine which line was selected.

In both treatments, there was a box on the left half of the screen and a box on the right half of the screen. Both boxes were near the upper screen edge. In the 3-choice treatment, there

[13] This result appears to be consistent with the predictions of Fudenberg, Strack, and Strzalecki (2018).
[14] The lines each had a height of 0.36 cm and were the identical shade of grey.
[15] There were 12 possible values for the shorter line: 240 minus one of $\{1, 2, 3, 4, 5, 7, 9, 11, 13, 15, 20, 30\}$.
[16] Psychologists often refer to this as a 2 Alternative Forced Choice (2AFC) design.

was also a box above these left and right boxes, where the subject could select indifference. At the beginning of each trial, these boxes were empty. Subjects would indicate their choice by clicking on the box that corresponds to their choice. A click on an empty box would fill that box with a smaller black box. Subjects could change their choice any number of times within the trial. When subjects were satisfied with their choice, they could end the trial by pressing Enter or space, and proceed to the next trial. Subjects were only able to end the trial if both lines were viewed at least once and a selection (left, right, or indifference) was made.

See Figure 1 for a screenshot from a 2-choice trial and Figure 2 for a screenshot from a 3-choice trial.

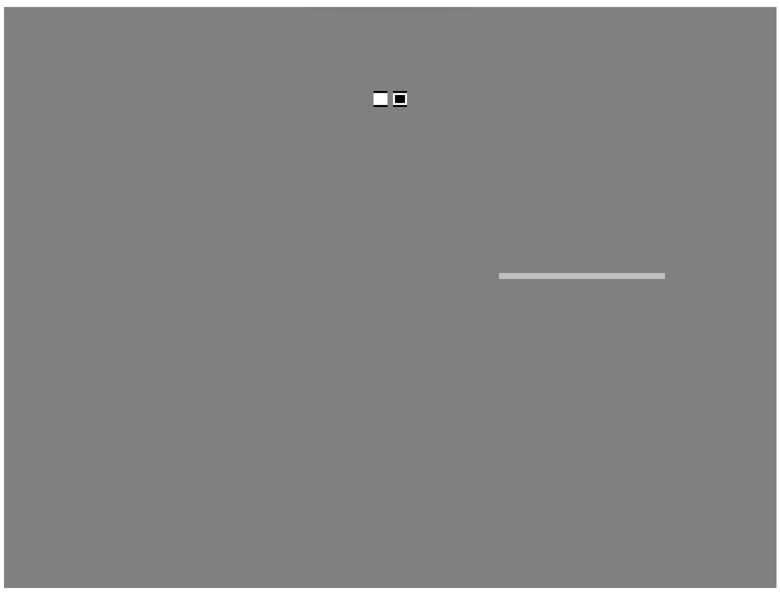

Figure 1: A 2-choice trial where the line on the right is being viewed and the line on the right is currently selected.

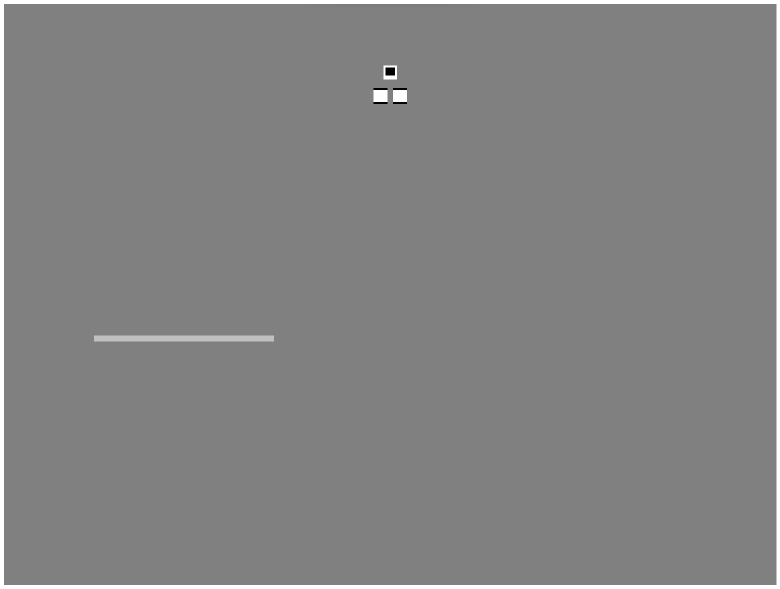

Figure 2: A 3-choice trial where the line on the left is being viewed and indifference is currently selected.

There were 12 unique pairs of lines. Each subject made 5 selections for each pair in the 2-choice treatment and 5 selections in the 3-choice treatment.

Subjects made 60 line pair decisions in the *2-choice* treatment and 60 line pair decisions in the *3-choice* treatment, for a total of 120 choices.

Subjects were paid as a function of the length of the selected line. Recall that the longer line was always 240 pixels and the shortest possible line was 210 pixels. If a line of pixel length x was selected, the payment in that trial was:[17]

$$\$10 * \frac{(x - 210)}{(240 - 210)}.$$

The 2-choice and 3-choice treatments were arranged into alternating blocks of 20 trials. Subjects were given the 2-choice treatment in the first block with an independent probability of 0.5. At the start of each block, subjects were presented with a screen for 5 seconds, informing them of the choice treatment for the next 20 trials. Further, before every line selection trial, subjects were presented with a screen for 0.5 seconds, reminding them of the choice treatment

[17] Because there are 12 different shorter lengths, the payment in every trial is one of the following 13 values: \$10.00, \$9.67, \$9.33, \$9.00, \$8.67, \$8.33, \$7.67, \$7.00, \$6.33, \$5.67, \$5.00, \$3.33, \$0.00.

in the upcoming trial.

3.2 Survey questions

After the 120 line selection trials were completed, but before the subjects were paid, subjects were given a set of survey questions, administered via paper.[18] We elicited the preferred pronoun of the subject, the handedness (right or left) of the subject, unincentivized responses to the standard version of the three Cognitive Reflection Test (CRT) questions (Frederick, 2005), an optional estimate of their grade point average, and two questions designed to measure the trust in the computer coin flip.

Finally, we implemented a measure of risk aversion with a modified Holt and Laury (2002) lottery task. Subjects made nine choices between a sure option of $5 and a risky option that paid $10 with probability $\{0.1, 0.2, \ldots, 0.9\}$, and $0 otherwise. Subjects were compelled to provide responses such that there was a switch from sure to risky at most once. Subjects would roll a 10-sided die to learn which decision was to be paid. If the subject selected the risky option in that decision, then the subject would roll again to determine whether payment was $10 or $0.[19]

3.3 Payment details

One randomly selected 2-choice treatment trial and one randomly selected 3-choice treatment trial were designated for payment. Subjects were also paid a $5 show-up fee. Finally, subjects were paid an additional $5 or $10 based on the outcome of the lottery task. Immediately following the experiment, subjects were paid in cash, rounded up to the nearest $0.10. The average payment was $30.00, with a maximum of $35.00 and a minimum of $21.40.

[18] See https://osf.io/sxkud/ for the survey.
[19] See the paper survey for more details.

3.4 Experimental Details

The experiment was programmed on E-Prime software (Psychology Software Tools, Pittsburgh, PA).[20] A total of 116 subjects participated in the experiment. However data from two subjects did not properly record, and we were not able to recover their line selections.[21] We exclude another subject, who did not understand the experiment in the early trials.[22] Therefore, our dataset has 113 subjects each making 120 line judgments, for a total of $13,560$ line pair decisions, with $6,780$ in the 2-choice treatment and $6,780$ in the 3-choice treatment.[23] Further, there were two subjects whose survey responses cannot be accurately identified.[24] Therefore, survey questions have, at most, observations from 111 subjects.

The data and full set of screenshots are available at https://osf.io/sxkud/. The online demonstration of the experiment is available at: https://eprimego.com/download/BSK8TM9M.

3.5 Discussion of the design

Subjects were told that there is always a longer line in every trial. This was done in an effort to reduce the incentives to select indifference because material payoffs for the lines would never be identical.

The longer line in each pair is the same length. This is motivated by the results that the length of the lines can affect the accuracy of choice (Duffy, Gussman, and Smith, 2021; Duffy and Smith, 2023).

[20] See the appendix for details about the computer settings and the trial-specific random offsets of the line positions.

[21] These subjects (111 and 165) do not appear in the final dataset.

[22] The response time in the first trial was 14 minutes and the response time in the second trial was 16 minutes. This subject (149) appears in the final dataset.

[23] Among these 113 subjects, 54 were given the 3-choice treatment in the first block and 59 were given the 2-choice treatment in their first block.

[24] These subjects were originally labeled 177 and 178. However, in the dataset, they are relabeled 298 and 299.

4 Results

4.1 Summary statistics

Table 1 characterizes the total number of choices within each line pair and choice treatment.

Table 1: Numbers of choices by line pairs

	2-choice trials		3-choice trials		
Pair	Longer	Shorter	Longer	Indifference	Shorter
$\{240, 239\}$	281	284	259	105	201
$\{240, 238\}$	321	244	270	94	201
$\{240, 237\}$	337	228	310	88	167
$\{240, 236\}$	371	194	307	102	156
$\{240, 235\}$	391	174	340	84	141
$\{240, 233\}$	419	146	376	85	104
$\{240, 231\}$	454	111	394	78	93
$\{240, 229\}$	481	84	440	61	64
$\{240, 227\}$	496	69	463	48	54
$\{240, 225\}$	514	51	480	51	34
$\{240, 220\}$	545	20	522	34	9
$\{240, 210\}$	557	8	547	12	6

A characterization of the 565 observations per pair in the 2-choice trials and 3-choice trials.

Every subject makes 5 selections for every line pair in the 3-choice treatment. Therefore, the number of instances that subjects selected indifference for that line pair can range from 0 to 5. See Table 2 for characterization of the number of indifference selections by each subject for each line pair.

Table 2: Number of subjects selecting indifference by line pair

Pair	Total	Indifference choices					
		0	1	2	3	4	5
$\{240, 239\}$	105	55	27	18	11	1	1
$\{240, 238\}$	94	59	29	13	9	3	0
$\{240, 237\}$	88	62	29	10	9	3	0
$\{240, 236\}$	102	57	30	13	8	3	2
$\{240, 235\}$	84	60	32	13	6	2	0
$\{240, 233\}$	85	59	33	14	4	3	0
$\{240, 231\}$	78	66	27	12	5	3	0
$\{240, 229\}$	61	73	23	13	4	0	0
$\{240, 227\}$	48	77	25	10	1	0	0
$\{240, 225\}$	51	75	27	9	2	0	0
$\{240, 220\}$	34	90	15	6	1	1	0
$\{240, 210\}$	12	105	5	2	1	0	0

A total of 113 subjects made 5 decisions in the 3-choice trials for each of the 12 line pairs. For every line pair, a subject-level characterization the indifference choices, which range from 0 to 5.

There are 1,356 subject-line pair observations (113 subjects making choices within 12 line pairs). There are 838 instances where there were no indifference selections and only 3 instances where indifference was selected in each of the 5 choices. Therefore, there were 515 instances where indifference was selected between 1 and 4 times out of a possible 5.

Additionally, consider the observations associated with the pair $\{240, 239\}$. This is the smallest length difference in our experiment. Table 1 indicates that in 2-choice treatment trials, the longer line was selected in 281 of 565 trials (49.7%). In other words, less than half of these choices were optimal. Despite this, in the 3-choice treatment trials involving this pair, only 1 out of 113 subjects selected indifference on all 5 trials.[25]

More generally in Table 2, one can make 60 comparisons of adjacent cells within the same row. It is notable that each of these comparisons are non-increasing in the number of indifference choices from x to $x + 1$, where $x \in \{0, ...4\}$.

[25] A *just noticeable difference* (jnd) is defined as the smallest change in the stimulus intensity required to be noticeable by subjects. The concept of jnd is important in the history of psychophysics (Falmagne, 2002; Gescheider, 1997) and served as a motivation for semiorders (Luce, 1956). One interpretation of the jnd is that sensation is constant for differences in intensity that are smaller than the jnd. On the basis of the 2-choice observations, a 1-pixel difference would seem to be smaller than the jnd. However, the 3-choice observations suggest that sensation is not constant even between lines with only a 1-pixel difference.

We also note that 21 of 113 (18.6%) subjects never selected indifference.[26] See Table $A1$ for the distribution of total number of indifference selections by subject and Table $A2$ for a subject-level characterization of the 2-choice trials. Also, see Table $A3$ for a subject-level characterization of indifference choices between adjacent rows in Table 2. This table illustrates the persistence of individual indifference choices across different choice pairs.[27]

4.2 Indifference choices

Here we investigate the nature of the choices of indifference. We define the *Selected indifference* variable to be 1 if indifference was selected in that trial, and 0 otherwise. We conduct logistic regressions with Selected indifference as the dependent variable. The *Absolute difference* variable is the absolute value of the difference in pixels between the line lengths. The *Right longer* variable is 1 if the longer line was on the right, and 0 if the longer line was on the left. We also include *Trial* and the *Absolute difference-Trial* interaction as independent variables.

Due to the repeated nature of the observations, we offer fixed-effects specifications where we estimate dummy variables for each subject. These are designed to capture possible heterogeneity in subject-specific propensity to select indifference. We also run fixed-effects specifications where we attempt to account for a possible subject-specific bias that favors the left or right lines. We restrict attention to the $6,780$ trials in the 3-choice treatment as selecting indifference is only possible in these trials. We summarize these regressions in Table 3.

[26] We find it interesting that Agranov and Ortoleva (2023) report that 21% of their subjects never select a randomization.

[27] Agranov, Healy, and Nielsen (2023) find that subjects exhibit persistence in selecting randomizations.

Table 3: Logistic regressions of the Selected indifference variable

	(1)	(2)	(3)	(4)
Absolute difference	-0.0072^{***}	-0.0072^{***}	-0.0071^{***}	-0.0084^{***}
	(0.0006)	(0.0006)	(0.0005)	(0.0012)
Right longer	0.0196^{**}	0.0195^{**}	-	-
	(0.0073)	(0.0073)		
Trial	-	-0.00002	-0.00005	-0.00020
		(0.00010)	(0.00011)	(0.00016)
Absolute difference*Trial	-	-	-	0.00002
				(0.00002)
Subject fixed effects	*Yes*	*Yes*	*Yes*	*Yes*
Subject right dummies	*No*	*No*	*Yes*	*Yes*
AIC	4113.3	4115.3	4148.0	4148.3

We provide the average marginal effects and the standard errors in parentheses. We do not provide the estimates of the intercepts or the subject-specific dummy estimates. AIC refers to the Akaike information criterion (Akaike, 1974). Each regression has 6,780 observations. *** denotes $p < 0.001$, ** denotes $p < 0.01$, * denotes $p < 0.05$, and † denotes $p < 0.1$.

As expected from the summary statistics, the likelihood of indifference choices are decreasing in the absolute difference between the lines. What is perhaps not expected is that the Right longer variable is positive and significant. In other words, indifference is more likely to be selected when the longer line is on the right than when it is on the left.[28] We do not find evidence that indifference becomes more or less likely across trials and we do not find that sensitivity to the length differences changes across trials.

In Tables $A4$ and $A5$, we conduct analyses similar to that summarized in Table 3, but with the Selected longer variable in (respectively) the 3-choice and the 2-choice treatments. In both, we find that the longer line is selected with a likelihood that is decreasing across trials but we do not find evidence that subjects are differentially sensitive to Absolute difference across trials.

We now explore the relationship between selecting indifference and other observable characteristics of the subjects. Similar to Table 3, we conduct logistic regressions with Selected indifference as the dependent variable and Absolute difference and Right longer as independent

[28] Some research indicates that subjects tend to devote more attention to options on the left and they are more likely to select options on the left (Bowers and Heilman, 1980; Nicholls, Bradshaw, and Mattingley, 1999; Charles, Sahraie, and McGeorge, 2007). This effect is sometimes referred to as *pseudoneglect*.

variables.

It is possible that there is a relationship between skill in the judgment task and selecting indifference. We include the *2-choice correct* variable, which is the fraction of correct choices in the 2-choice treatment. It is possible that there is a relationship between cognitive ability and selecting indifference. We include the *CRT sum* variable which is the total number of CRT questions answered correctly. This variable ranges from 0 to 3. It is possible that there is a relationship between subject-specific risk aversion and selecting indifference. Recall the task where subjects made 9 choices between a sure payment of $5 and a risky option that paid $10 with probability $\{0.1, 0.2, \ldots, 0.9\}$. The *First risky choice* variable indicates the row that the subject first switched from the safe to the risky choice. This variable ranges from 1 (least risk averse) to 10 (most risk averse).

It is possible that there is a relationship between selecting indifference and the trust in the fairness of the computer coin flip. We ask, "What is your belief about the probability that the computer 'coin flip' selects the longer line for you?" with possible answers "More than 50%", "Exactly 50%", and "Less than 50%". Based on the response, the *Belief you* variable respectively obtains a value of 1, 0, or -1. It is also possible that subjects have unique beliefs about the fairness that they face, which could be different than the fairness others face. We ask another question identical to above, but exchange "for you" with "for others". Based on the response, the *Belief others* variable respectively obtains a value of 1, 0, or -1. These belief questions are increasing in the perceived favorableness of a coin flip for either them or others.

Recall that we could not successfully interpret every survey response. As a result, the numbers of observations vary across regressions. We do not include any subject-specific fixed-effects. These regressions are summarized in Table 4.

Table 4: Logistic regressions of the Selected indifference variable

	(1)	(2)	(3)	(4)	(5)	(6)
Absolute difference	-0.007^{***}	-0.008^{***}	-0.008^{***}	-0.008^{***}	-0.008^{***}	-0.008^{***}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Right longer	0.023^{**}	0.023^{**}	0.022^{**}	0.023^{**}	0.025^{**}	0.024^{**}
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
2-choice correct	-0.013	–	–	–	–	-0.177^{**}
	(0.019)					(0.056)
CRT sum	–	-0.012^{**}	–	–	–	-0.007
		(0.004)				(0.005)
First risky choice	–	–	0.009^{***}	–	–	0.008^{***}
			(0.002)			(0.002)
Belief you	–	–	–	$0.013^{\dagger}$	–	-0.004
				(0.007)		(0.008)
Belief others	–	–	–	–	0.043^{***}	0.035^{***}
					(0.008)	(0.009)
Subject dummies	*No*	*No*	*No*	*No*	*No*	*No*
Observations	6,780	6,600	6,660	6,600	6,480	6,480
AIC	4919.9	4838.4	4834.2	4843.3	4746.4	4713.9

We provide the average marginal effects and the standard errors in parentheses. We do not provide the estimates of the intercepts. AIC refers to the Akaike information criterion (Akaike, 1974). *** denotes $p < 0.001$, ** denotes $p < 0.01$, * denotes $p < 0.05$, and † denotes $p < 0.1$.

We find that our measure of risk aversion is significantly related to selecting indifference.[29] We also find that the beliefs in the favorableness of the coin flip for others is also significantly related to selecting indifference. We find some evidence that better performance on the 2-choice task and higher CRT scores are negatively related to selecting indifference.

4.3 Relationship between indifference and response times

Previous research has found that optimal decisions are faster than suboptimal decisions. For example, see Henmon (1911), Kellogg (1931), Duffy, Gussman, and Smith (2021), Duffy and Smith (2023), and Duffy and Smith (2024). However, possible endogeneity makes this inference difficult. For example, it is possible that faster subjects are also more likely to select optimal actions. It is also possible that more difficult choices are both slower and less likely to be optimal. However, in our recent efforts, conditional on the attributes of the subject and

[29] Agranov and Ortoleva (2023) find an analogous result.

conditional on the specifics of the choice set in that trial, optimal choices tend to be faster than suboptimal choices.[30] Further, these results appear to be consistent with the predictions of Fudenberg, Strack, and Strzalecki (2018).

The relationship between optimal choice and response times can provide clues on deliberation. Likewise, examining the response times for choices of indifference can also provide clues on deliberation. Below, we compare the response times for indifference choices with the response times for suboptimal choices in the 3-choice trials. Our regressions therefore have $2,072$ observations. We perform linear regressions with the log of response times as the dependent variable. Similar to the above analyses, we employ Absolute difference, Right longer, and Trial as independent variables. We also include the subject-specific fixed-effects as in previous analyses.

In the analysis below, we include Selected indifference as an independent variable. Further, we include specifications with the Selected indifference-Trial interaction as an independent variable. These regressions are summarized in Table 5.

Table 5: Regressions of the log of Response time variable

	(1)	(2)	(3)	(4)
Absolute difference	-0.0003	-0.0004	0.00009	0.00001
	(0.0010)	(0.00103)	(0.00105)	(0.00105)
Trial	-0.0030^{***}	-0.0033^{***}	-0.0030^{***}	-0.0033^{***}
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Right longer	-0.0117	-0.0106	-	-
	(0.0109)	(0.0108)		
Selected indifference	0.0573^{***}	0.0020	0.0560^{***}	0.0008
	(0.0124)	(0.0224)	(0.0128)	(0.0230)
Trial*Selected indifference	-	0.0009^{**}	-	0.0009^{**}
		(0.0003)		(0.0003)
Subject fixed effects	Yes	Yes	Yes	Yes
Subject right dummies	No	No	Yes	Yes
Demographics	No	No	No	No
AIC	-13.4	-7.8	120.0	126.0

We provide the coefficient estimates and the standard errors in parentheses. We do not provide the estimates of the intercepts, the subject-specific dummy estimates, or the demographics estimates. AIC refers to the Akaike information

[30] We also note that we find this result in our 2-choice treatment trials (Table $A8$).

criterion. Each regression has $2,072$ observations. *** denotes $p < 0.001$, ** denotes $p < 0.01$, * denotes $p < 0.05$, and † denotes $p < 0.1$.

We note that in specifications (1) and (3), the positive Selected indifference coefficients suggest that indifference choices are associated with longer response times than suboptimal choices. In specifications (2) and (4), we note that these estimates are not significant. However, the Selected indifference-Trial interaction estimates suggest that the effect becomes stronger across trials. We also note that the coefficient of Absolute difference is not significant in any specification. This is clearly driven by restriction to indifferent or suboptimal decisions in the 3-choice treatment.

The reader is possibly concerned about the possible endogeneity in our results. However, when we conduct Spearman correlations between the unstandardized residuals and the Selected indifference variable in specifications $(1) - (4)$, the p-values respectively are 0.3811, 0.4617, 0.2901, and 0.3732. We interpret this as suggesting a lack of endogeneity in these results.

Duffy and Smith (2024) report that in a forced choice task that optimal decisions are faster than suboptimal decisions. Interestingly, the authors find that this relationship becomes weaker across trials. In contrast, here we find the relationship between response times and indifference becomes stronger across trials.

In order to check the robustness of the results in Table 5, we conduct an analysis where we only include observations from subjects who selected indifference on at least one trial (Table $A6$). Our results are not changed. We also conduct an analysis, similar to Table 5, but the dependent variable is the number of view clicks in that trial (Table $A7$). Again, our results are not changed. Finally, we replicate the results from previous studies that correct decisions in the 2-choice treatment have shorter response times than incorrect decisions (Table $A8$).

In summary, we find that response times are longer for indifference choices than suboptimal choices and that this is robust to the specification.

5 Conclusions

We present the results in an incentivized binary line length judgment experiment. Subjects are paid an increasing amount in the line selected. There is a treatment where the subjects select one of the two lines. There is another treatment where subjects select one of the lines or can express indifference, which directs the computer to "flip a coin" to decide. Subjects make multiple decisions in materially identical settings in both the 2-choice and the 3-choice treatments.

We find that indifference is both thick and random. Indifference choices are thick in the sense that the majority of subjects select indifference on at least one trial and that indifference is expressed in each of our choice menus, regardless of the difference between the lengths. Indifference choices are random in that the overwhelming minority of indifference selections occur on each of the five repetitions of that choice menu for that subject.

Our results suggest that indifference choices have longer response times than suboptimal choices and that these results are not driven by endogeneity. We find that subjects who are more risk averse and those that express confidence in the fairness of the coin flip are more likely to select indifference. We also find some evidence that subjects with a lower score of cognitive ability and those who are worse at the line judgment task are more likely to select indifference.

We admit that our design might underestimate the extent of indifference, because it remains possible that subjects might randomize—attempt to execute the coin flip—on their own by making different selections in different materially identical trials. Such a strategy would seem to be difficult to execute because the repetitions are not obvious to the subjects. However, we cannot rule out this possibility.

On the other hand, our design might also overestimate the extent of indifference. If subjects are ambiguity averse, then the probability of the coin flip might be preferred over the unknown probability of their choices that are associated with their imperfect perception.

Further, since subjects are paid as a linear function of the length of the selected line, we are not able to distinguish between sensitivity to line length or sensitivity to the dollar amounts.

One way to attempt to disentangle these effects would be to pay a flat amount for optimal choices, regardless of their difficulty.

Other payment schemes can perhaps offer additional insights. In Duffy and Smith (2024), subjects are in treatments that pay at a higher or lower rate for the line selection task. Subjects in the higher payment trials exerted more effort–but they were not more accurate–than those in the lower payment trials. It remains an open question about the effects of the rate of payment on selecting indifference.

It is worthwhile reflecting on the contours of a model that would be consistent with our results. Tyson (2021) and Horan, Manzini, and Mariotti (2022) describe random utility models where sufficiently close error realizations are indistinguishable, whereby the decision maker might express indifference. A different interpretation of these indifference regions is that the decision maker is capable of—but simply decides not to—distinguish between choices that are sufficiently close. In our setting, this could be modeled as two thresholds: one between left and indifference and one between right and indifference.

Another possibility is that the uncertainty is not fully realized and the thresholds are soft. In this model, the subjects might receive an imperfect signal with varying precision. Recent experimental work on the confidence of choices (Arts, Ong, and Qiu, 2024) could be interpreted as the subject's perception of this precision.[31]

We hope that our results will prompt additional experimental and theoretical work on the random thickness of indifference.

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[31] See Olschewski and Scheibehenne (2024) for evidence the awareness of a subject's own imperfect perception.

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Appendix-For Online Publication

Experimental details

The sessions were performed on standard 21.5 inch (54.6 cm) Dell EliteDisplay E221 monitors. E-Prime imposed a resolution of 1024 pixels by 768 pixels. Our computer screens have a width of 47.664 cm and our program divided this width into 1024 pixels. We could have made our pixels smaller. However, the width of our screens have a maximum resolution of 1920 pixels. Therefore, the minimum possible pixel width would be 0.0244 cm.

Each computer had a double click speed setting of 6 out of 11. Each computer had a pointer speed setting of 6 out of 11.

Both lines appeared in rectangular regions on the screen. These rectangles were 400 pixels by 150 pixels. The boundaries of these rectangles were not visible to subject. There was a rectangular region on the left of the screen. The nearest edge of the screen was 56 pixels from both the left and right rectangles. There were 112 pixels separating the right and left boxes.

The lines were offset, both vertically and horizontally, within these rectangles. There was a minimum cushion of 10 pixels between the boundary of the rectangle and the line. Regardless of the number of line views, the offsetting was fixed for both lines throughout each trial.

Subject-level summary statistics

Table $A1$ characterizes the distribution of the total number of indifference selections made by subjects.

Table $A1$: Distribution of subjects by indifference choices

Choices	Number	Percent	Choices	Number	Percent
0	21	0%	15	3	25.0%
1	11	1.7%	16	1	26.7%
2	9	3.3%	17	1	28.3%
3	5	5.0%	18	1	30.0%
4	6	6.7%	19	3	31.7%
5	6	8.3%	20	1	33.3%
6	3	10.0%	21	0	35.0%
7	9	11.7%	22	5	36.7%
8	5	13.3%	23	3	38.3%
9	4	15.0%	24	0	40.0%
10	3	16.7%	25	0	41.7%
11	4	18.3%	26	1	43.3%
12	2	20.0%	27	0	45.0%
13	2	21.7%	28	1	46.7%
14	2	23.3%	29	1	48.3%

A characterization of the distribution of the total number of indifference choices for each subject and the percent of the 60 observations in the 3-choice trials where indifference was selected.

Table $A2$ characterizes the number of longer selections within each line pair in 2-choice trials.

Table $A2$: Number of longer selections in 2-choice trials

	Aggregate		Subject-specific longer					
Pair	Longer	Shorter	0	1	2	3	4	5
$\{240, 239\}$	281	284	2	21	34	35	18	3
$\{240, 238\}$	321	244	2	10	33	35	25	8
$\{240, 237\}$	337	228	2	4	30	41	30	6
$\{240, 236\}$	371	194	1	5	18	39	37	13
$\{240, 235\}$	391	174	0	3	20	34	34	22
$\{240, 233\}$	419	146	0	6	7	28	45	27
$\{240, 231\}$	454	111	0	0	9	16	52	36
$\{240, 229\}$	481	84	0	1	3	16	39	54
$\{240, 227\}$	496	69	0	1	4	4	45	59
$\{240, 225\}$	514	51	0	0	2	7	31	73
$\{240, 220\}$	545	20	0	1	1	2	9	100
$\{240, 210\}$	557	8	0	0	0	2	4	107

A total of 113 subjects made 5 decisions in the 2-choice trials for each of the 12 line pairs. For every line pair, a subject-level characterization the longer choices, which range from 0 to 5.

See Table $A3$ for characterization of the number of indifference selections by each subject for each line pair.

Table $A3$: Difference in number of subjects selecting indifference for line pairs

	Change in indifference choices											Absolute change	
Pairs	−5	−4	−3	−2	−1	0	1	2	3	4	5	1 or less	2 or less
$\{240, 238\}$ min $\{240, 239\}$	0	0	0	11	15	67	14	6	0	0	0	85.0%	100%
$\{240, 237\}$ min $\{240, 238\}$	0	0	1	8	21	59	16	6	2	0	0	85.0%	97.3%
$\{240, 236\}$ min $\{240, 237\}$	0	1	2	4	18	55	22	7	2	2	0	84.1%	93.8%
$\{240, 235\}$ min $\{240, 236\}$	0	1	3	9	18	59	16	6	1	0	0	82.3%	95.6%
$\{240, 233\}$ min $\{240, 235\}$	0	0	1	5	17	64	22	3	1	0	0	91.2%	98.2%
$\{240, 231\}$ min $\{240, 233\}$	0	1	1	3	21	65	17	5	0	0	0	91.2%	98.2%
$\{240, 229\}$ min $\{240, 231\}$	0	1	1	7	18	68	14	4	0	0	0	88.5%	98.2%
$\{240, 227\}$ min $\{240, 229\}$	0	0	3	6	16	67	18	3	0	0	0	89.4%	97.3%
$\{240, 225\}$ min $\{240, 227\}$	0	0	0	6	16	68	16	6	1	0	0	88.5%	99.1%
$\{240, 220\}$ min $\{240, 225\}$	0	0	0	6	24	69	10	3	1	0	0	91.2%	99.1%
$\{240, 210\}$ min $\{240, 220\}$	0	0	1	4	13	93	2	0	0	0	0	95.6%	99.1%

A total of 113 subjects made 5 decisions in the 3-choice trials for each of the 12 line pairs. Every row lists the difference in the number of subjects selecting indifference for adjacent line pairs. Because the value for any line pair ranges from 0 to 5, these differences range from −5 to 5. We also list the percent of the subjects who had an absolute change of one or fewer from adjacent rows and the percent who had an absolute change of two or fewer from adjacent rows.

Other specifications

Here we conduct an analysis similar to that summarized in Table 3, but the dependent variable is *Selected longer*, not Selected indifference. We summarize these regressions in Table $A4$.

Table $A4$: Logistic regressions of the Selected longer variable in 3-choice

	(1)	(2)	(3)	(4)
Absolute difference	0.025***	0.025***	0.024***	0.026***
	(0.001)	(0.001)	(0.001)	(0.002)
Right longer	−0.074***	−0.074***	-	-
	(0.010)	(0.010)		
Trial	-	−0.0003*	−0.0003*	−0.00009
		(0.0002)	(0.0001)	(0.00023)
Absolute difference*Trial	-	-	-	−0.00003
				(0.00003)
Subject fixed effects	*Yes*	*Yes*	*Yes*	*Yes*
Subject right dummies	*No*	*No*	*Yes*	*Yes*
AIC	7121.8	7119.0	6619.8	6620.4

We provide the average marginal effects and the standard errors in parentheses. We do not provide the estimates of the intercepts or the subject-specific dummy estimates. AIC refers to the Akaike information criterion (Akaike, 1974). Each regression has 6,780 observations. *** denotes $p < 0.001$, ** denotes $p < 0.01$, * denotes $p < 0.05$, and † denotes $p < 0.1$.

We note that the likelihood that longer line is selected is increasing in the absolute difference in the lengths. We also see that the longer line is less likely to be selected when it is on the right. Additionally, the likelihood the longer line is selected is decreasing across trials, but we do not find a diminished sensitivity to the absolute difference variable across trials.

We conduct an analysis, identical to that summarized in Table $A4$, but with data from the 2-choice treatment, not the 3-choice treatment. This analysis is summarized in Table $A5$.

Table $A5$: Logistic regressions of the Selected longer variable in 2-choice

	(1)	(2)	(3)	(4)
Absolute difference	0.025***	0.025***	0.024***	0.025***
	(0.001)	(0.001)	(0.001)	(0.002)
Right longer	−0.068***	−0.068***	-	-
	(0.009)	(0.009)		
Trial	-	−0.0004**	−0.0004**	−0.00025
		(0.0001)	(0.0001)	(0.00021)
Absolute difference*Trial	-	-	-	−0.00002
				(0.00003)
Subject fixed effects	*Yes*	*Yes*	*Yes*	*Yes*
Subject right dummies	*No*	*No*	*Yes*	*Yes*
AIC	6406.0	6400.2	5871.9	5873.3

We provide the average marginal effects and the standard errors in parentheses. We do not provide the estimates of the intercepts or the subject-specific dummy estimates. AIC refers to the Akaike information criterion (Akaike, 1974). Each regression has 6,780 observations. *** denotes $p < 0.001$, ** denotes $p < 0.01$, * denotes $p < 0.05$, and † denotes $p < 0.1$.

The results are very similar to those from Table *A*5. The longer line selection is increasing in the absolute difference and less likely when the line is on the right. We also see that performance decreases across trials but we do not observe a diminished sensitivity to Absolute difference across trials.

Here we conduct an analysis similar to Table 5, but we only include observations from subjects who selected indifference on at least one trial. This analysis is summarized in Table *A*6.

Table *A*6: Regressions of the log of Response time variable

	(1)	(2)	(3)	(4)
Absolute difference	−0.0007	−0.0008	−0.0004	−0.0005
	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Trial	−0.0029***	−0.0033***	−0.0029***	−0.0033***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Right longer	−0.014	−0.013	-	-
	(0.011)	(0.011)		
Selected indifference	0.0580***	0.0022	0.0570**	−0.0006
	(0.0123)	(0.0232)	(0.0128)	(0.0238)
Trial*Selected indifference	-	0.0009**	-	0.0009**
		(0.0003)		(0.0003)
Subject fixed effects	*Yes*	*Yes*	*Yes*	*Yes*
Subject right dummies	*No*	*No*	*Yes*	*Yes*
Demographics	*No*	*No*	*No*	*No*
AIC	−33.3	−27.0	89.5	95.6

We provide the coefficient estimates and the standard errors in parentheses. We do not provide the estimates of the intercepts, the subject-specific dummy estimates, or the demographics estimates. AIC refers to the Akaike information criterion. Each regression has 1,777 observations. *** denotes $p < 0.001$, ** denotes $p < 0.01$, * denotes $p < 0.05$, and † denotes $p < 0.1$.

Our results are largely unchanged from those of Table 5. When we conduct Spearman correlations between the unstandardized residuals and the indifference variable in specifications

$(1) - (4)$, the p-values respectively are 0.3289, 0.3996, 0.2534, and 0.3250. It seems that the results from Table 5 are robust to restricting observations to subjects who selected indifference at least once.

To further test robustness, we include a different measure of effort in making the decision: view clicks. We count the number of times that the subject clicked to reveal one of the two lines in that trial, up to 25. We refer to this variable as *View clicks*. We employ View clicks as the dependent variable, but the analysis is otherwise unchanged from Table 5. These regressions are summarized in Table $A7$.

Table $A7$: Regressions of the View clicks variable

	(1)	(2)	(3)	(4)
Absolute difference	-0.006	-0.007	0.0007	-0.0003
	(0.020)	(0.020)	(0.020)	(0.020)
Trial	-0.024^{***}	-0.029^{***}	-0.024^{***}	-0.029^{***}
	(0.003)	(0.004)	(0.003)	(0.004)
Right longer	-0.196	-0.182	-	-
	(0.205)	(0.205)		
Selected indifference	0.754^{**}	0.050	0.747^{**}	0.0242
	(0.234)	(0.424)	(0.242)	(0.435)
Trial*Selected indifference	-	0.011^{*}	-	0.012^{*}
		(0.006)		(0.006)
Subject fixed effects	Yes	Yes	Yes	Yes
Subject right dummies	No	No	Yes	Yes
Demographics	No	No	No	No
AIC	11486.8	11491.3	10956.8	10961.2

We provide the coefficient estimates and the standard errors in parentheses. We do not provide the estimates of the intercepts, the subject-specific dummy estimates, or the demographics estimates. AIC refers to the Akaike information criterion. Each regression has $2,072$ observations. *** denotes $p < 0.001$, ** denotes $p < 0.01$, * denotes $p < 0.05$, and † denotes $p < 0.1$.

Our results are largely analogous to those in Table 5. When we conduct Spearman correlations between the unstandardized residuals and the indifference variable in specifications $(1) - (4)$, the p-values respectively are 0.7086, 0.8354, 0.6108, and 0.7353.

In order to attempt to replicate the previous results that suboptimal decisions have longer response times than optimal decisions, we restrict attention to 2-choice trials and we employ the Selected longer variable. These regressions are summarized in Table $A8$.

Table $A8$: Regressions of the log of Response time variable

	(1)	(2)	(3)	(4)
Absolute difference	-0.0066^{***}	-0.0066^{***}	-0.0068^{***}	-0.0068^{***}
	(0.0003)	(0.0003)	(0.0004)	(0.0003)
Trial	-0.0026^{***}	-0.0031^{***}	-0.0026^{***}	-0.0030^{***}
	(0.0001)	(0.0002)	(0.0001)	(0.0002)
Right longer	0.0079	0.0077	-	-
	(0.0054)	(0.0054)		
Selected longer	-0.037^{***}	-0.075^{***}	-0.021^{**}	-0.058^{***}
	(0.007)	(0.013)	(0.007)	(0.013)
Trial*Selected longer	-	0.0006^{***}	-	0.0006^{**}
		(0.0002)		(0.0002)
Subject fixed effects	Yes	Yes	Yes	Yes
Subject right dummies	No	No	Yes	Yes
Demographics	No	No	No	No
AIC	-720.9	-716.5	-507.0	-501.7

We provide the coefficient estimates and the standard errors in parentheses. We do not provide the estimates of the intercepts, the subject-specific dummy estimates, or the demographics estimates. AIC refers to the Akaike information criterion. Each regression has $6,780$ observations. *** denotes $p < 0.001$, ** denotes $p < 0.01$, * denotes $p < 0.05$, and † denotes $p < 0.1$.

We find evidence that trials where the longer line was selected have shorter response times than trials where the shorter line was selected. When we conduct Spearman correlations between the unstandardized residuals and the indifference variable in specifications $(1)-(4)$, the p-values respectively are 0.5054, 0.6317, 0.6568, and 0.7916.