Controlling ambiguity: The illusion of control in decision-making under risk and ambiguity

Alex Berger and Agnieszka Tymula

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Abstract

The finding that individuals are ambiguity averse in the domain of medium likelihood gains is robust across laboratory studies. We conducted a laboratory experiment to examine whether we can lower this aversion to ambiguity by giving participants an illusion of control over the probability of winning by allowing them to choose the winning color in what objectively are 50-50 gambles. We found that while our illusion of control manipulation does not increase participants' preference for risky gambles with known probability of winning, it does increase participants' tolerance for ambiguous gambles with unknown probability of winning. When the illusion of control is absent, the structural model estimates of ambiguity tolerance are 29% lower. Our results highlight the importance of considering the illusion of control in the estimation of ambiguity attitudes.

Keywords: illusion of control, ambiguity aversion

Affiliation: School of Economics, University of Sydney, A02, Sydney, NSW 2006, Australia. Phone: +61 2 9351 2840, Fax: +61 2 9351 4341.

Send correspondence to: agnieszka.tymula@sydney.edu.au

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There is no conflict of interest to declare.

1. Introduction

Individuals undertake many risks in their daily lives, and the perception of the extent of control they have over those risks varies between individuals and from one context to another. In general, people who believe that they have less control over the events in their lives, report more concurrent and future stressful experiences and experience more psychological and physical problems. A large body of literature has studied an individual personality trait, locus of control, that measures the degree to which people believe that they have control over the outcomes in their lives. In summary, this research found that feeling in control over the resolution of uncertainties in our lives results in better health and socioeconomic outcomes and is therefore desirable. In this paper, we use an incentive-compatible laboratory experiment to investigate whether individuals show a preference for control over uncertain options, even if it is completely illusory because it does not change the probability distribution over the possible outcomes.

The illusion of control term has been formally defined in psychology as "an expectancy of a personal success probability inappropriately higher than the objective probability would warrant" (Langer, 1975). In her original study, Langer (1975) showed that the illusion of control can be induced in a multitude of ways such as giving participants a choice in the chance task which has no effect on their probability of success, allowing them to be more involved in the resolution of the chance task, and through increased familiarity or practice with the chance task. In a hypothetical lottery game, Langer (1975) found that people who selected their own winning numbers, later demanded more money to sell their lottery ticket than those who were assigned random winning numbers. The most recent meta-analysis on the effect of the illusion of control by Stefan and David (2013) and based on 20 experimental psychology studies published between 1996 and 2010 found that the illusion of control had an overall weighted mean effect size of 0.62 on a variety of dependent variables consisting of behavioral measures explicitly designed to capture judgments and perceptions of controllability or enhanced expectations of personal success.

These psychological studies thus suggest that understanding the illusion of control in economic context is important for several reasons. People seem to be healthier and generally better-off when they perceive to have more control. This implies that people may have a preference for the options that give them more control over the resolution of uncertainty. If this is the case, then giving people the illusion of control, which often has low implementation costs, may be a powerful nudge to steer them towards some types of behaviors. Finally, in economic experiments, we often give participants the illusion of control over the resolution of uncertainty without controlling for the effect that it may have on behavior, potentially biasing our estimates. Understanding whether and when the illusion of control occurs is therefore important for the public policy, decision theory, and experimental economics methodology.

In contrast to the studies in psychology, economic experiments to date have been largely unsuccessful in inducing the illusion of control. Charness and Gneezy (2010) found that while the majority (68%) of the participants had a preference for control (they preferred to roll the die personally rather than have the experimenter role the die for them), they were not willing to pay to exercise this control. They also found that the amounts participants wagered on risky lotteries did not differ depending on whether they rolled the die or the experimenter rolled the die for them, suggesting that the illusion of control in the form of rolling a dice to resolve uncertainty is worthless to the participants in their study. Li (2011) found that participants showed a preference for control (choosing their winning numbers in a risky lottery as opposed to them being chosen by someone else or randomly) and some participants (9/30) were even willing to pay to choose their own winning numbers. Only one participant, however, believed that this control increased their probability of success suggesting that a different concept than the illusion of control drives the result. Finally, Filippin and Crosetto (2016) using a Bomb Risk Elicitation Task investigated whether the lack of evidence for the illusion of control in previous economic studies is because the illusion of control was implemented over the resolution of uncertainty rather than over the choice of the lottery as has been sometimes done in psychology. They found no evidence of the illusion of control on either choices or beliefs under both types of the illusion of control. Overall, these three studies in economics suggest that the illusion of control does not exist or at least that it is not something that participants are willing to pay for. Although these studies used slightly different methodologies, all of them investigated the effect of the illusion of control on attitudes towards options with *known* risks, that is when the exact odds of winning are precisely known. However, most real-life decisions are less clearly described and feature risks with at least to some degree ambiguous probability distributions over the outcomes. This distinction between known and ambiguous risk may be important. Intuitively, when the probabilities of outcomes are precisely given, such as when tossing a coin, it is irrational to believe that the probability of heads versus tails depends on who tosses a coin. However, when probabilities are not explicitly stated, for example when drawing a ball from a box filled with 100 red and blue balls in some unknown proportion, there is more wiggle room to choose and influence beliefs. Whether the illusion of control affects attitudes towards options with unknown risks has not been explicitly studied in the economic literature.

Research on choice under ambiguity has found that people tend to show ambiguity aversion for binary gambles in the domain of gains when the ambiguity is centered around the 50-50 chances of winning (Kocher, Lahno, and Trautmann, 2018). People prefer lotteries with clear probabilities of success to lotteries with ambiguous probabilities of success. While no paper has explicitly studied the effect of the illusion of control on ambiguity aversion, Tymula and Whitehair (2018) documented an unusual finding that teenagers showed a greater preference for ambiguous lotteries the larger the level of ambiguity. This finding is contrary to previous results in Tymula et al. (2012) with the same age group and a very similar task. The only meaningful difference between the two studies is that in ambiguous trials participants could choose their own winning color in Tymula and Whitehair (2018) but not in Tymula et al. (2012). While the illusion of control was not exogenously manipulated in any of the studies, their comparison is suggestive that the illusion of control may affect ambiguity attitudes. We, therefore, use a laboratory experiment to explicitly test the following two hypotheses based on the literature discussed above:

Hypothesis 1: When given an illusion of control over the chances of winning in a lottery, participants will choose lotteries with an ambiguous probability of winning more often.

Hypothesis 2: When given an illusion of control over the chances of winning in a lottery, participants will not choose lotteries with a known probability of winning more often.

In our task participants repeatedly choose between $5 for sure and a lottery with known (unknown) probability of winning which allows us to elicit each individual’s risk (ambiguity) attitude. We implement the illusion of control by allowing the participants to choose their winning color in the lottery, a choice that does not affect the probability distribution over the outcomes. In the control treatment, the winning color is selected in front of the participants by a random device implemented by a student volunteer who is unrelated to the study. In line with previous economic experiments, we do not find any traces of the evidence for the illusion of control in risk attitudes. However, we find that the illusion of control significantly increases participants' propensity to take gambles with ambiguous winning probability.

2. Methods

2.1Experimental design

2.1.1 Study participants

We report results from 219 adult participants[1] (104 males, mean age 22.42, standard deviation 3.89) recruited from the University of Sydney student pool using ORSEE (ref). All participants gave informed consent and the study was approved by the Ethics Office at the University of Sydney. Before completing the experimental task, all participants read the instructions (available in Appendix A) and had an opportunity to ask clarifying questions. The data was collected in October 2018 and May 2019.

2.1.2 The task

To assess participants' risk and ambiguity tolerance we presented them with a list of 60 questions where they were asked to choose between two monetary options. The task was administered using pen and paper. These questions were presented in six sets of 10 questions, each set printed out on a single sheet of paper. All sets of questions are provided in Appendix B as they were presented to the participants. The first three sets (30 questions) assessed the participants' risk tolerance. In these questions, participants indicated whether they prefer receiving a certain amount of $5 or a lottery that offered some amount of money with a given probability. The reward and the probability of obtaining that reward varied across the 30 questions. The rewards ranged from $5 to $41 and the probability of

[1] Out of 227 participants eight are omitted from the analysis. These participants either did not choose a winning color in the IOC treatments or changed their winning color depending on the question instead of selecting the same color for all 30 questions.

obtaining the reward was either 25%, 50% or 75%. The probabilities of winning were communicated via 3 bags full of 100 red and blue poker chips of varying proportion (see Figure 1A). Sets four, five and six (another 30 questions) assessed the participants' ambiguity tolerance. They differed from the first 30 questions only in that the exact probability of obtaining the reward was to some extent ambiguous to the participant. We achieved this by obfuscating a proportion of the bag's contents with a grey box (see Figure 1B). This ambiguity level (the percent of the bag that was obfuscated) was either 26%, 50% or 74% and was always centered around the 50% chance of winning. The images of the six bags used in the experiment represented real physical bags with corresponding contents. Participants knew that when they select a lottery, they may be later asked to put their hand into the physical bag and without looking pick a chip which color will determine their earnings. The bags remained visible to the participants throughout the entire duration of the experiment. Participants, therefore, knew that these bags were not manipulated by the experimenters and were informed they could inspect the contents of each bag at the end of the experiment.

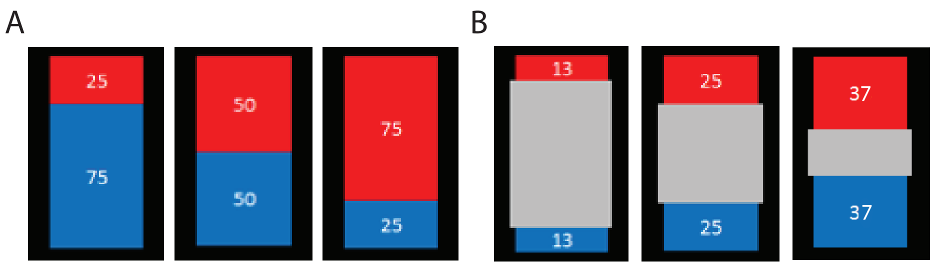

Figure 1 Images used to communicate the probability of winning in the questions used to assess A: risk and B: ambiguity attitudes. Each image represents a bag full of 100 red and blue poker chips. The numbers within the coloured boxes represent how many chips of a given colour are in the bag for sure. The chips behind the grey box can be in any proportion of red and blue such that the total number of chips sums up to 100.

2.1.3 Experimental treatment

Our experimental manipulation involves inducing in some of the participants an illusion of control (IOC) over the objectively given probability of winning. Importantly the manipulation should *not* change the rational beliefs over the probability of winning. We implemented our manipulation using a 2x2 between-subject design in which each session was randomly allocated to one of 4 treatments illustrated in Table 1.

		Ambiguity	
		Random	**IOC**
Risk	**Random**	Random Risk / Random Ambiguity (3, n=57, 21 male)	Random Risk / IOC Ambiguity (3, n=53, 33 male)
	IOC	IOC Risk / Random Ambiguity (3, n=55, 25 male)	IOC Risk / IOC Ambiguity (3, n=54, 25 male)

Table 1 Treatment design. Each session was randomly allocated to one of the 4 treatments shown below. IOC stands for our illusion of control treatment. Random is the control treatment. The numbers in brackets are the number of sessions and the number of participants in each treatment.

To induce the illusion of control we asked participants in the IOC Risk and IOC Ambiguity treatments to choose whether they would like the red or the blue poker chip to be their winning color. They were instructed to choose one winning color for all risky lotteries and/or one winning color for all ambiguous lotteries.[2] Regardless of which color participants chose, overall, they faced the same set of questions and their objective probability of winning remained the same. In the sets of questions that were used to assess risk attitudes, participants made choices between a certain amount of $5 and lotteries which probabilities of winning were represented with bags filled with 25 blue and 75 red, 50 blue and 50 red, or 75 blue and 25 red chips. By symmetry, independent of which color a participant chose to be their winning color they all faced the same winning probabilities: 25%, 50%, and 75%.[3] Similarly, in the sets of questions that were used to assess ambiguity attitudes, by choosing their winning color, participants were not able to affect the probability of winning which was always centered around 50-50. The bags were prepared ahead of the experiment and participants had no prior information about the content of the ambiguous bags. To make sure that participants did not think that the experimenter manipulated the contents of the bags in response to participants' choice of the winning color, the bags remained in plain view throughout the experimental sessions and participants were informed they could inspect the bags' contents after payment.

[2] Participants in the IOC Risk / IOC Ambiguity condition could choose a different winning color for the risky and the ambiguous set of questions.

[3] A potential confound was that in the IOC Risk treatment those who selected blue (re) as their winning color faced a descending (ascending) order of winning probabilities. A two sided unpaired t-test found that the proportion of times participants chose the risky lottery over the certain amount did not differ significantly depending on whether the order of winning probabilities was presented in a descending (0.75, 0.5 and 0.25) or an ascending order (0.25, 0.5 and 0.75) (0.618 vs. 0.609, p=0.673 in a two-sided unpaired t-test).

In our control treatments (Random Risk and Random Ambiguity), the winning color was drawn randomly by a student volunteer[4] found in the vicinity of the laboratory shortly before the experiment began. In front of all participants, a volunteer drew one poker chip from a bag containing two red and two blue poker chips. Participants were shown the contents of the bag before the volunteer drew the poker chip to ensure they knew the chance of either color was even. For subjects in the Random Risk / Random Ambiguity treatment, the winning color drawn by the volunteer would be the winning color for all 60 questions. For participants in either the IOC Risk / Random Ambiguity or Random Risk / IOC Ambiguity treatments, the chip drawn by the volunteer would determine the winning color for the set of 30 questions where they could not choose it themselves.

After completing all 60 questions participants answered a psychometric survey assessing their desirability for control (ref) which was then followed by a set of demographic questions (see Appendix C).

2.1.4 Payment

Participants were incentivized to choose according to their preferences as one of their decisions was chosen randomly to be realized for payment. Once all participants had completed the demographic questions they were called individually to a private room where their payment was resolved. To pick the decision for which they would be paid for, the participant drew one chip from a bag with 60 chips labeled between 1-60, corresponding to 60 questions in which they had made decisions throughout the experiment. If for the randomly selected question, the participant chose a certain amount of $5, they received it. If for the randomly selected question the participant chose a lottery, they drew one chip from the physical bag that corresponded to that lottery. If the chip was of their winning color, they received the lottery reward. If the chip was not of the winning color, they received $0. Additionally, each participant received a show-up fee of $10. The average amount earned by each participant was AUD22.45.

[4] The volunteer received $10 compensation.

2.2 Econometric approach

We analyze our data in two ways. First, we use simple proportions of the lottery choices to capture how often participants selected risky and ambiguous lotteries over the certain payout of \$5. To test our hypothesis that participants choose lotteries more often under the illusion of control, we compare these proportions in Random and IOC treatments using unpaired t-tests and report one-sided p-values. We also run logistic regressions with a participant's choice in each of the questions as the dependent variable and participants' characteristics as controls. Our dependent variable is equal to 1 if the participant selected a lottery and equal to 0 if the participant selected \$5. We cluster standard errors in the logistic regressions on the level of participant.

Next, to estimate the effect size of the illusion of control on ambiguity tolerance in a way that makes it comparable to other studies, we estimate a structural model of decision-making under risk and ambiguity based on Gilboa and Schmeidler (1989) allowing its parameters to depend on the illusion of control treatment. In this structural model, an individual's expected utility from choosing a lottery ***(x, p, a)*** that pays reward ***x***, with probability ***p*** and ambiguity about that probability ***a***, is given by:

$$\boldsymbol{EU(x,p,a) = \left(p + \beta \frac{a}{2}\right) x^{\alpha}}$$

$\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are the parameters of interest. $\boldsymbol{\alpha}$ captures an individual's risk tolerance. If $\boldsymbol{\alpha} = 1$ (*<1; >1*) the individual is risk-neutral (risk-averse; risk-seeking). $\boldsymbol{\beta}$ captures an individual's ambiguity tolerance. Ambiguity neutral individuals would view the chance of winning in the ambiguous lottery as 50-50 since the ambiguity is centered around 50% and would thus have $\boldsymbol{\beta} = 0$. Ambiguity averse individuals would perceive the chance to win to be lower ($\boldsymbol{\beta}<0$) and ambiguity seeking participants would perceive it to be higher ($\boldsymbol{\beta} >0$) than 50%.

We allow for stochasticity in choice by using a logistic choice function with a noise term, $\boldsymbol{\gamma}$, controlling for the slope of the choice function where the probability of choosing a lottery is given by:

$$\boldsymbol{P(chose\ lottery) = \frac{1}{1 + e^{(EU(x,p,a) - EU(\$5))/\gamma}}}$$

.

We use maximum likelihood estimation to fit the data using Stata following Harrison (2008). We measure treatment effect on risk (***α***) and ambiguity (***β***) parameter estimates by allowing for these parameters to vary with the treatment in the following way:

$$\boldsymbol{\alpha} = \boldsymbol{\alpha_{constant}} + \boldsymbol{\alpha_{IOC}} \text{ and } \boldsymbol{\beta} = \boldsymbol{\beta_{constant}} + \boldsymbol{\beta_{IOC}}$$

$\boldsymbol{\alpha_{IOC}}$ is equal to 1 in all decisions (risky and ambiguous) with the illusion of control treatment and 0 otherwise. $\boldsymbol{B_{IOC}}$ is equal to 1 in all ambiguous decisions with the illusion of control treatment and 0 otherwise.

3. Results

The demographic characteristics of the participants were generally well-balanced across the treatments. Participants in the Random Risk and IOC Risk conditions did not differ in gender, age, self-reported wealth, budget, siblings number, propensity to gamble, and psychometric survey scores assessing participant's desirability for control (Table 2). There were slightly more men in the IOC Ambiguity treatment than in the Random Ambiguity treatment (0.542 vs. 0.411), a difference significant at the 10% level in an unpaired two-sided t-test and present only in the Random Risk treatments (see male composition for each of the treatments in Table 1). On all other characteristics, there were no differences between the participants in the Random and IOC Ambiguity treatments (Table 3).

N=219	**Random Risk**	**IOC Risk**
male	.491 (0.048)	.459 (0.048)
age	22.755 (0.413)	22.092 (0.323)
wealth	3.172 (0.051)	3.046 (0.063)
budget	70.573 (6.341)	80.133 (9.821)
siblings	1.3 (0.108)	1.193 (0.129)
gambler	0.364 (0.046)	0.266 (0.043)
DOC Scale	97.118 (1.086)	96.982 (1.125)

Table 2 Demographic characteristics across treatments in the sets of risky lotteries. Standard errors are reported in parentheses. If there is a significant difference in an unpaired two-sided t-test between Random and IOC treatments it is indicated with * for p<0.1, ** for p<0.05, *** for p<.01.

N=219	Random Ambiguity	IOC Ambiguity
male*	0.411* (0.047)	0.542* (0.048)
age	22.464 (0.396)	22.383 (0.344)
wealth	3.071 (0.056)	3.150 (0.059)
budget	72.277 (6.586)	78.528 (9.764)
siblings	1.223 (0.123)	1.271 (0.114)
gambler	0.313 (0.044)	0.318 (0.045)
DOC Scale	96.795 (1.040)	97.318 (1.172)

Table 3 Demographic characteristics across treatments in the sets of ambiguous lotteries. Standard errors are reported in parentheses. If there is a significant difference in an unpaired two-sided t-test between Random and IOC treatments it is indicated with * for p<0.1, ** for p<0.05, *** for p<.01.

3.1 The effect of the illusion of control on the preference for ambiguous gambles

Result 1*: When given an illusion of control over the chances of winning in a lottery, participants choose lotteries with ambiguous probability of winning more often.*

In line with our hypothesis, we found that participants in the illusion of control treatment were more likely to choose ambiguous gambles. Participants for whom the winning color was determined by a volunteer chose the ambiguous lottery 55.1% of the time and those who could pick their winning color by themselves chose it 59.4% of the time, a statistically significant difference (p=0.028). Figure 2 illustrates the result. The result is not specific to some levels of reward or probability. For all reward levels (see Figure 3A) and for all ambiguity levels, (see Figure 4A) participants in the illusion of control treatment selected the ambiguous lottery more often on average.

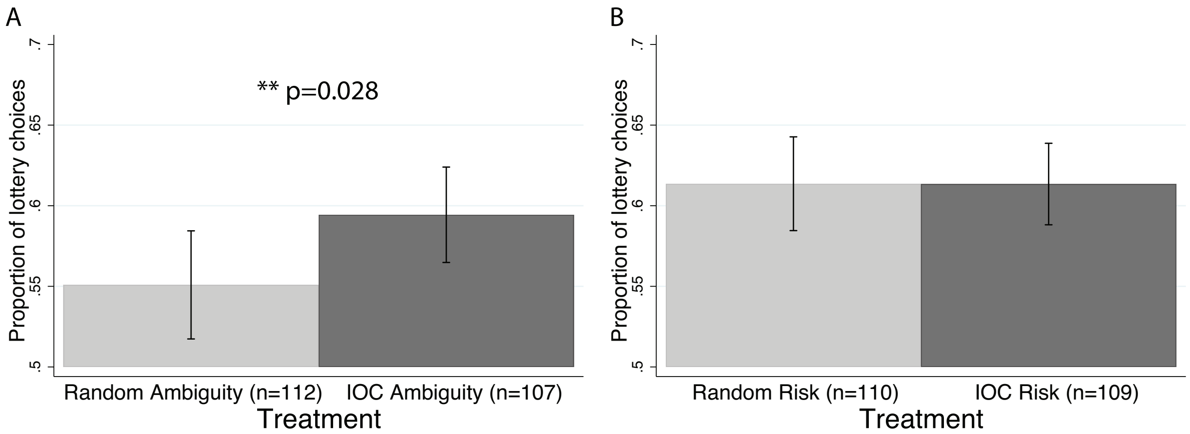

Figure 2 The effect of the illusion of control on participants' willingness to choose lotteries with A: ambiguous and B: known probability of winning. Error bars are 95% confidence intervals.

We should be cautious in interpreting this result because in the Random Risk treatments, our sample in the IOC Ambiguity treatment has slightly more men than our sample in Random Ambiguity treatment. If men are more ambiguity tolerant (and our analysis reveals that they are) and there were more men in our illusion of control treatment, then the real reason why we see ambiguous lotteries being selected more often in the illusion of control treatment could be not because the treatment worked but because there were more men in that treatment. To assess this possibility, we first ran a set of logistic regressions with a binary dependent variable that captures whether the participant selected an ambiguous lottery or a certain payout of $5. We ran these regressions with and without gender controls. As shown in Table 4 (models (2) and (5)), male participants were indeed more likely to choose ambiguous gambles. Nevertheless, the coefficient on the *IOC ambiguity* binary variable that captures whether participants were in the illusion of control treatment or not is positive both without any controls (model (1)) and when we control for gender (model (2) and (5)). When we include all of the participants' characteristics as control variables, the treatment effect goes away (model (3)) and when we include all controls except the gender, the treatment effect is significant again (model (4)). To further check whether the unbalanced gender composition in the Random Risk treatments is driving our result, we next focused on these treatments (top row of Table 1) and checked for the illusion of control effects separately for each gender. The results do not support the idea that our results can be explained simply by the higher number of male participants. While women were more likely to choose ambiguous lotteries under the IOC Ambiguity treatment than under Random Ambiguity treatment (61.5% versus 53.3%, p=0.045), for men the propensity to choose ambiguous lotteries was not affected by the treatment (62.3% versus 62.1%, p=0.478). Moreover, in Random Risk treatment, men and women choose the ambiguous lottery equally often under the illusion of control (62.3% versus 61.5%, p=0.863 two-sided), reinforcing that gender composition is not a confounding factor in our analysis.

Finally, we interacted the illusion of control treatment with participants' characteristics to investigate whether the illusion of control had a stronger effect on the propensity to choose ambiguous gambles for men, older participants, participants with more siblings, wealthier participants, gamblers or those with more desire for control. None of these modulated the effect of the illusion of control (Table 4 model (5)), except that those with a higher desire for control responded to the treatment less strongly.

3.2 The effect of the illusion of control on the preference for risky gambles

Result 2*: When given an illusion of control over the chances of winning in a lottery, participants do not choose lotteries with known probability of winning more often.*

In line with our hypothesis based on pervious literature, we found that participants did not choose lotteries with a known probability of winning more often when they could choose their winning color versus when the winning color was selected by a student volunteer (0.613 vs. 0.614, p=0.504; see Figure 2B). While in questions with ambiguous lotteries, participants on average consistently selected lotteries more often for every reward and ambiguity level (see Figure 3A and 4A), such pattern did not emerge in questions with risky lotteries (see Figure 3B and 4B). This leads us to conclude that risk attitudes were not affected by our illusion of control treatment.

Since participants were well-balanced on their characteristics between the Random Risk and IOC Risk treatments (see Table 2), we did not expect any confounding factors in our analysis. This is confirmed in the regression analysis presented in Table 5. Whether we control for participants' characteristics (Table 5, model (2)), interact participants' characteristics with the treatment (Table 5, model (3)), or do not include these control variables (Table 5, model (1)), the illusion of control treatment has no effect on the propensity to choose risky gambles.

	(1)	(2)	(3)	(4)	(5)
IOC ambiguity	0.3736*	0.3203*	0.3101	0.3638*	6.0784**
	(0.1917)	(0.1923)	(0.1889)	(0.1890)	(2.4604)
male		0.4272**	0.4471**		0.5110
		(0.1968)	(0.2278)		(0.3207)
age			0.0859***	0.0840***	0.0955***
			(0.0240)	(0.0231)	(0.0287)
no. of siblings			0.0291	0.0644	0.0488
			(0.0755)	(0.0751)	(0.1056)
no. of younger siblings			-0.1096	-0.1280	0.0404
			(0.1143)	(0.1174)	(0.1622)
wealth			0.3815**	0.3708**	0.6277**
			(0.1726)	(0.1807)	(0.3190)
gambler			-0.1620	-0.0334	-0.3226
			(0.2292)	(0.2050)	(0.3320)
desire for control			0.0065	0.0097	0.0270*
			(0.0097)	(0.0093)	(0.0148)
IOC x male					-0.1125
					(0.4387)
IOC x age					-0.0278
					(0.0539)
IOC x siblings					-0.1375
					(0.1623)
IOC x siblings younger					-0.1662
					(0.2317)
IOC x wealth					-0.4505
					(0.3744)
IOC x gambler					0.4283
					(0.4517)
IOC x desire for control					-0.0365*
					(0.0186)
reward	0.1988***	0.2003***	0.2060***	0.2045***	0.2096***
	(0.0108)	(0.0110)	(0.0115)	(0.0112)	(0.0114)
ambiguity level	-0.0220***	-0.0222***	-0.0228***	-0.0227***	-0.0232***
	(0.0022)	(0.0023)	(0.0023)	(0.0023)	(0.0024)
constant	-2.7666***	-2.9642***	-6.7065***	-6.8019***	-9.8074***
	(0.1934)	(0.2211)	(1.1596)	(1.1359)	(1.8410)
no. of observations	6570	6570	6570	6570	6570

Table 4 Illusion of control for ambiguous lotteries. Logistic regression with dependent variable equal to 1 if participant selected an ambiguous gamble and equal to 0 if participant selected $5.

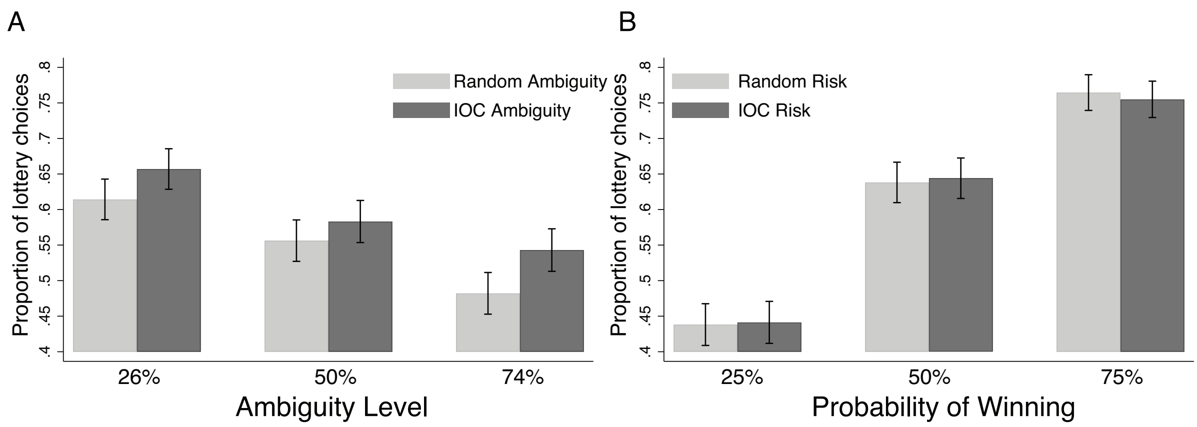

Figure 3 Illusion of control by A: ambiguity level and B: probability of winning.

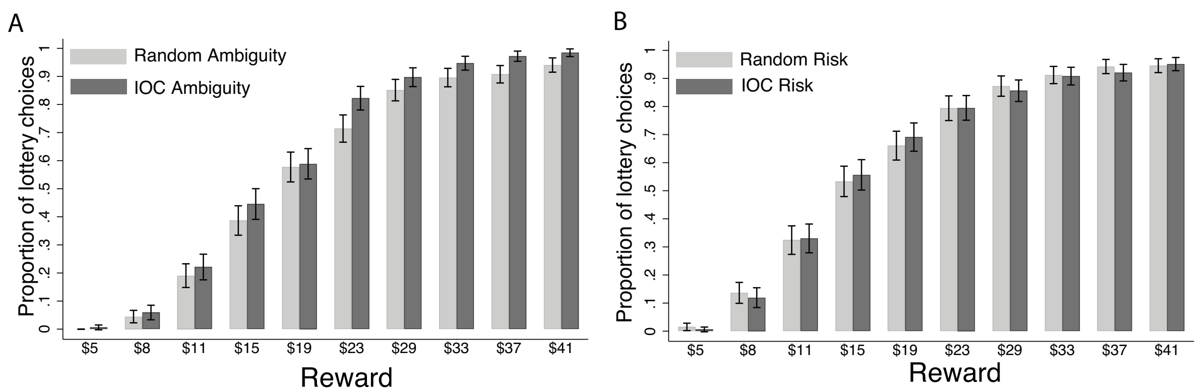

Figure 4 Illusion of control by reward size in questions with A: ambiguous probability of winning B: known probability of winning.

	(1)	(2)	(3)
IOC risk	-0.0016	0.0944	2.3052
	(0.1706)	(0.1760)	(2.0716)
male		0.1378	0.1683
		(0.1848)	(0.2585)
age		0.0808***	0.0885***
		(0.0246)	(0.0333)
no. of siblings		-0.0227	-0.0902
		(0.0635)	(0.1141)
no. of younger siblings		0.0463	0.1573
		(0.1014)	(0.2017)
wealth		0.2080	0.4186*
		(0.1455)	(0.2313)
gambler		0.1237	0.3124
		(0.1926)	(0.2560)
desire for control		0.0010	0.0035
		(0.0078)	(0.0106)
IOC x male			-0.0088
			(0.3737)
IOC x age			-0.0155
			(0.0479)
IOC x siblings			0.1078
			(0.1403)
IOC x siblings younger			-0.2214
			(0.2301)
IOC x wealth			-0.3899
			(0.2867)
IOC x gambler			-0.4852
			(0.3930)
IOC x desire for control			-0.0051
			(0.0164)
reward	0.1978***	0.2015***	0.2026***
	(0.0109)	(0.0114)	(0.0114)
winning probability	0.0551***	0.0562***	0.0565***
	(0.0035)	(0.0037)	(0.0036)
constant	-6.0725***	-8.8955***	-10.0817***
	(0.3419)	(1.1960)	(1.7059)
no. of observations	6570	6570	6570

Table 5 Illusion of control for risky gambles. Logistic regression with dependent variable equal to 1 if participant selected an ambiguous gamble and equal to 0 if participant selected $5.

3.3 Structural estimation

Our structural model estimation presented in Table 6 (model (1)) yields reasonable estimates with alpha=0.77 indicating risk aversion and beta=-0.45 indicating ambiguity aversion. Consistent with our previous analysis, in the illusion of control treatment ambiguity tolerance is significantly higher but there is no such effect on risk tolerance (Table 6 model (2)). The difference in tolerance to ambiguity across treatments is sizeable, -0.386 in the IOC Ambiguity treatments and -0.497 in Random Ambiguity treatments, a drop in the estimate of 28.76%.

	(1)	(2)
alpha - risk tolerance		
$alpha_{IOC}$		0.0007
		(0.0258)
$alpha_{constant}$	0.7699***	0.7694***
	(0.0168)	(0.0221)
beta - ambiguity tolerance		
$beta_{IOC}$		0.1110*
		(0.0597)
$beta\_{constant}$	-0.4451***	-0.4965***
	(0.0250)	(0.0344)
noise		
constant	0.8993***	0.8966***
	(0.0507)	(0.0504)
no. of observations	13140	13140

Table 6 Structural model estimates of the illusion of control.

4. Conclusions

We found evidence for the illusion of control in choice under ambiguity and in line with the previous literature in economics, we found that the illusion of control does not affect individuals' propensity to choose risky gambles with known probabilities of winning. Our work extends the previous research, by additionally examining the effect of the illusion of control on the attitudes towards ambiguous gambles with unknown risks. We found that people under the illusion of control treatment (that does not affect the probability of winning) are significantly more likely to choose ambiguous lotteries than those who had their winning color selected for them by a random process implemented by a volunteer. Our finding can help reconcile the evidence from psychology where many studies have found the illusion of control to be effective (Stefan and David, 2013) and economics where the induction of the illusion of control has been generally unsuccessful in reducing risk aversion (Charness and Gneezy, 2010; Filippin and Crosetto, 2016; Li, 2011).

Possible explanations for the illusion of control suggested in the literature are the distortion of beliefs and source preference (Abdellaoui et al., 2011; Hong and Sagi, 2006; Tversky and Wakker, 1995). Li (2011) presented evidence that in risky choice the illusion of control is not consistent with the distortion of beliefs as her experimental manipulation does not change people's perception of winning probability. Therefore, Li (2011) argued that the effect should be attributed to source preference, that is preferring one source of uncertainty (e.g., choosing numbers herself) to another (e.g., numbers randomly generated by the computer). In contrast with Li (2011), in our experiment, we do not find evidence consistent with source preference. If our participants exhibited source preference, we should observe the effects of the illusion of control both in risky and ambiguous choice but we do not. Our finding that the experimentally induced illusion of control increases the uptake of ambiguous gambles but not risky gambles intuitively fits with the distortion of beliefs explanation. In ambiguous gambles, the probability of winning is presented as a range of possible winning probabilities leaving participants more freedom in choosing their own winning probability. On the other hand, in risky gambles for the manipulation of the illusion of control to work, it would have to be that the participants believe that the odds of winning are not the ones communicated by the experimenter.

Langer in her original study (1975) proposed the skill confusion hypothesis which suggests that the illusion of control occurs because people mistake chance situations for skill situations due to similar task characteristics. It is hard to reconcile this explanation with our results though because in both the ambiguous and risky conditions the illusion of control is induced via the same task (picking a winning color) but the results differ across these two settings. Finally, the control heuristic theory (Thompson et al., 2007) which consolidates upon Langer's skill confusion hypothesis does not apply to our setting. The theory suggests that when people see a connection between their actions and the outcome of the task they're involved in, and the outcomes of the task is one they intended, they will have higher perceptions of control. In our task the realization of participants actions did not occur until after all questions were answered, meaning that the control heuristic theory cannot explain our findings as well.

The remaining question is why people are affected by the illusion of control under ambiguity. From a normative perspective, why did we evolve to have such preferences? Although the illusion of control is usually perceived as suboptimal behavioral bias, Gossner and Steiner (2018) have shown that under some conditions the illusion of control can be optimal. In particular, they show that if cognitive constraints imply that individuals over time lose some of the accumulated information about payoff-relevant parameters, then it is under some conditions optimal to exhibit some illusion of control, as well as overconfidence, and optimism. Although this theoretical work does not map precisely to our experimental setup, it sheds some light on the normative origins of the illusion of control in an economic framework.

Finally, our paper makes a methodological point. One of the major concerns when asking study participants to make choices among options that involve ambiguous probabilities is that the participants may suspect that the experimenter manipulated the chances of winning against the participant, for example, to save on the participant payments in the experiment. To avoid this concern, experimenters designed a range of techniques to convince the participants that the ambiguous options are not manipulated towards unfavorable odds of winning or losing. In one of the frequently used methods, the participants are given some control over the resolution of uncertainty, for example, by choosing their own winning color. If the uncertainty is resolved by picking a colored chip from a physical urn which contents cannot be manipulated by the experiment after the participant makes their selection, then the participant can no longer rationally believe that the odds were skewed against them. Our results suggest that the estimated ambiguity aversion parameters from studies using such methodology can be inflated by as much as 29%.

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