Controlling ambiguity: The illusion of control in choice under risk and ambiguity

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The illusion of control occurs when individuals believe that exerting objectively meaningless control over pure chance events increases their probability of success. In economics the illusion of control has only ever been studied in choice under risk, where probability distributions are known, and has been found to have no effect. This contrasts with studies in psychology, which have found a persistent positive effect. The cause of these conflicting findings may be that the illusion of control only affects risk taking in choice under ambiguity, where probability distributions are fully or partially unknown. To address this gap in the literature, we conducted an incentive compatible laboratory experiment which induced the illusion of control in some participants. We find that the illusion of control does not affect choice under risk but increases ambiguity tolerance. These results bridge the gap between the psychology and economics literature, emphasizing the importance of distinguishing risk from ambiguity. Our results suggest that some studies may unintentionally induce an illusion of control and over-estimate ambiguity tolerance.

Keywords: illusion of control, ambiguity tolerance

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1. Introduction

Real world decision making is never as simple as choosing heads or tails in a fair coin toss. When tossing a coin, not only is there an objective probability of success, but it is obvious that the probability of success does not change depending on whether you choose heads or tails. Real world decision making does not share either of these features. Instead, there is normally some degree of ambiguity over probability distributions, and it is normally unclear just how much a single choice affects those probability distributions. Economists have spent a significant amount of time analyzing how decision making is affected by ambiguity (Knight, 1921), while psychologists have spent just as much time analyzing the 'illusion of control', which occurs when factors that have no effect on objective probabilities in pure chance tasks, such as choice, increase an individual's subjective probability of success (Langer, 1975). No previous study has sought to connect these possibly interrelated literatures.

To illustrate why the disconnect between the empirical literature on ambiguity tolerance and illusion of control is problematic, consider a modified Ellsberg urn decision task which is usually used to elicit ambiguity attitudes. Individuals are asked to choose between betting on an urn containing 50 red balls and 50 blue balls, or an urn containing 100 red and blue balls of unknown proportion. If a red ball is drawn from either urn, the individual receives $10, whereas if a blue ball is drawn, they receive nothing. Individuals are free to choose between betting on the 'risky urn', which has an objective probability of success or the 'ambiguous urn' which has no objective probability of success. Pertinent to our example is that individuals' winning color ball has already been determined. If an individual chooses the risky urn, it may not be because they are ambiguity averse, but instead because they believe the experimenter has rigged the ambiguous urn to contain fewer red balls. To dispel this potential distrust, experimenters often give participants the ability to choose which color ball they would like to be their winning color. This way experimenters do not have an ulterior motive to make any one color systematically more likely to be drawn from the ambiguous urn, as it is just as likely participants choose that color to be their winning color. However, an unintended consequence of giving participants this choice is the possibility of inducing the illusion of control. If the illusion of control does increase ambiguity tolerance, it implies that many laboratory studies which use choice as a means of dispelling participant distrust may be over-estimating ambiguity tolerance.

A puzzling finding in the illusion of control literature is the disagreement between psychology and economics. Studies in psychology found that the illusion of control increases risk taking behavior (e.g. Stefan and David, 2013), while economics found no evidence for the effect of the illusion of control in choice under risk (Charness and Gneezy, 2010, Li, 2011, Fillipin and Crosetto, 2016). The fact that no study is economics has analyzed the illusion of control in choice under ambiguity, where objective probabilities are unknown, is surprising, considering the amount of attention given to accurately estimating individuals' ambiguity tolerance. Hence, our study is motivated by the need to explain the conflict between findings in economics and psychology as well as the potential misestimation of ambiguity attitudes in many empirical studies.

The illusion of control 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, 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 (Stefan and David, 2013). It was also shown that the illusion of control had a larger effect on outcomes which measured perceptions of control rather than behavioral outcomes such as how much an individual was willing to bet.

In contrast to these 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 preferred 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 die 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 concept other 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 was 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 participants are willing to pay for. An obvious limitation of these existing studies however is that they only examined the illusion of control in the context of risky decision making, where the probability of success is objectively known to the participant. In the case of choice under ambiguity, where individuals make decisions over fully or partly unknown probability distributions, the illusion of control may have a greater effect on subjective beliefs, which in turn may lead to increased risk taking.

While the effect of the illusion of control on choice under ambiguity has not been explicitly studied in the economic literature, much research has been done regarding individuals' ambiguity tolerance more broadly. People tend to show ambiguity aversion, that is, prefer lotteries with clear probabilities of success to lotteries with ambiguous probabilities of success, 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). Regarding the effectiveness of control in dispelling participant distrust, Charness et al. (2013) show that participants may be less ambiguity tolerant when they are not able to choose their winning color. While their results support the idea that illusion of control may be driving an over-estimation of ambiguity tolerance, their experiment was designed to induce distrust in participants who could not choose their winning color. Hence, they cannot disentangle the effect of the illusion of control from the effect of distrust on ambiguity tolerance.

In contrast, we use an incentive compatible laboratory experiment which allows us to isolate the effect of the illusion of control on ambiguity tolerance by having some participants choose their winning color while others have their winning color determined by a random device. In this way, participants whose winning color is determined randomly are not induced with an illusion of control and should be equally distrustful of the experimenters as those who did get to choose their winning color. In our task participants repeatedly choose between a certain payment of $5 and a lottery with a known or unknown probability of winning. We induce 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 third-party volunteer who is unrelated to the study. The experimenter did not implement or resolve the random device, as it may in and of itself induce distrust in participants. This design allows us to test the following hypotheses based on the literature discussed above:

Hypothesis 1: Participants induced with an illusion of control in ambiguous trials will be more ambiguity tolerant than participants who are not induced with an illusion of control.

Hypothesis 2: Participants induced with an illusion of control in risky trials will be more risk tolerant than participants who are not induced with an illusion of control.

We test these hypotheses in two stages. First, we use structural modelling on the decision and individual level to see how risk and ambiguity tolerance parameters differ when participants are induced with an illusion of control. More specifically we estimate the two most common models of choice under ambiguity, the αMEU (Ghirardato et al., 2004, Olszewski, 2007) and REU (Ergin and Gul, 2003, Giraud, 2005, Halevy and Feltkamp, 2005, Klibanoff, Mariacci and Mukerji, 2005, Nau, 2006, Ahn, 2008, Seo, 2009) models. For the aggregate level analysis, we allow both the risk and ambiguity tolerance parameters to differ when the decision was and was not made under the illusion of control. For the individual level analysis, we estimate a structural model for each participant, and examine differences in the distributions of the risk and ambiguity tolerance parameters depending on whether participants were induced with an illusion of control. The second stage of our analysis is a robustness check in which we forgo the assumptions of our structural models, instead comparing the likelihood participants chose the risky or ambiguous lotteries over the certain payment when induced with an illusion of control or not.

Our results show that the illusion of control significantly increases ambiguity tolerance butnot risk tolerance. The methodological implications of our study suggest that any study which uses choice as a means of dispelling participants' distrust may be over-estimating ambiguity tolerance, and that alternative approaches may need to be developed or expanded.

2. Methods

2.1 Experimental 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 (Greiner, 2004). 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 asking to choose between two monetary options. The task was administered using a pen and paper. The questions were presented in six sets of ten 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 obtaining the reward was either 25%,

[1] A total of 227 adults participated in the study. Eight participants did not complete the task correctly and their data is omitted from the analysis. These participants either did not choose a winning color in the illusion of control treatments or changed their winning color depending on the question instead of selecting the same color for all 30 questions.

50% or 75%. The probabilities of winning were communicated via three bags full of 100 red and blue poker chips of varying proportions (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. If that chip was the participants' winning color, they would receive a monetary reward. 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 here]

2.1.3 Experimental treatment

Our experimental manipulation involves inducing in some participants an illusion of control 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.

[Table 1 here]

To induce the illusion of control (IOC) 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

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

remained the same. In the sets of questions that were used to assess risk tolerance, participants made choices between a certain amount of $5 and lotteries where the 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 tolerance, by choosing their winning color, participants were not able to affect the probability of winning over the 30 questions. The bags were prepared ahead of the experiment and participants were given no information about the content of the ambiguous bags or how they were constructed.

In our control treatments (Random Risk and Random Ambiguity), the winning color was drawn randomly by a third-party 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 chances of either color were equal. 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. Note that because the winning color was decided in both treatments before the decisions were made, this process does not generate differences across treatments that would relate to the aversion to compound lotteries.

[3] A potential confound was that in the IOC Risk treatment participants who selected blue as their winning color faced a descending order of winning probabilities and those with red as their winning color faced an 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).

[4] The third-party volunteer was either a student or an administrative member of staff and received $10 compensation.

After completing all 60 questions participants answered a psychometric survey assessing their desirability for control (Burger and Schnerring 1982) 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, the participant drew one chip from a bag with 60 chips labeled between 1 and 60, corresponding to 60 questions in which they had made decisions throughout the experiment. If in the randomly selected question the participant chose a certain amount of $5, they received it. If in 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 $22.45.

2.2 Econometric approach

2.2.1 Structural modelling

We estimate two structural ambiguity models to ensure that our results are not sensitive to model specification. We follow Ahn et al. (2014) and choose two models which encompass the two broad classes of choice under ambiguity models: the kinked specifications (αMEU, Ghirardato et al., 2004, Olszewski, 2007) and smooth specifications (REU, Ergin and Gul, 2003, Giraud, 2005, Halevy and Feltkamp, 2005, Klibanoff, Mariacci and Mukerji, 2005, Nau, 2006, Ahn, 2008, Seo, 2009).

For the kinked specification we use the general form of the αMEU (Ghirardato et al., 2004, Olszewski, 2007) model:

$$U(X) = \alpha * \max_{\pi \in \Pi} \int u(x_s) d\pi(s) + (1-\alpha) * \min_{\pi \in \Pi} \int u(x_s) d\pi(s)$$

where Π is a closed convex set of distributions over states S, $\pi(s)$ is the probability of success in state s, and $\alpha \in [0,1]$ reflects the weight assigned to the state giving the highest possible utility. The larger the value of α the greater ambiguity tolerance exhibited.

As in Ahn et al. (2014) we assume that the set of priors Π is the entire set of distributions consistent with the objective information across different ambiguity levels A. We also specify that the utility function u takes the form:

$$u(x) = x^{\rho}$$

where ρ indexes the degree of risk tolerance. This leads to the following model:

$$EU(x, A, \gamma, \alpha) = \alpha * \left[\left(0.5 + \frac{A}{2}\right) * x^{\rho}\right] + (1 - \alpha) * \left[\left(0.5 - \frac{A}{2}\right) * x^{\rho}\right]$$

The first term in square brackets corresponds to the highest expected utility of a gamble which pays reward x with ambiguity level A, while the second term in square brackets corresponds to the lowest expected utility of a gamble which pays reward X with ambiguity level A. This is because the ambiguity level A is always centred at 0.5, so the state with the lowest expected utility occurs when the total number of ambiguous chips are all opposite to the participants' winning color. For A=0.5, the state with the lowest expected utility corresponds to a probability of success equal to 0.25, since the individual knows with certainty that at least 25 of the 100 poker chips are of their winning color. α represents the degree of ambiguity tolerance because higher α corresponds to more weight placed on the state with the highest possible chance of winning.

Unlike Ahn et al. (2014), when estimating the αMEU model we do not impose a constraint on α. This is because the illusion of control may distort participants' beliefs and/or preferences in such a way that makes their choices differ fundamentally from those not under the illusion of control. That is the illusion of control may make these individuals less rational or their decision data less suitable for conventional structural modelling. As such an α less than 0 represents an individual who assigns an irrationally high weight to attaining the utility from the worst possible state. Similarly, an α greater than 1 represents an individual who assigns an irrationally high weight to attaining utility in the best possible state.

In the case of no ambiguity, with an objective probability of success p, the model simplifies to:

$$EU(x,p,\gamma) = p * x^{\rho}$$

Our smooth specification is similar to that of Ahn et al. (2014) and is derived from the recursive expected utility (REU) model (Ergin and Gul, 2003, Giraud, 2005, Halevy and Feltkamp, 2005, Klibanoff, Mariacci and Mukerji, 2005, Nau, 2006, Ahn, 2008, Seo, 2009). The general form of the REU model is:

$$EU(X) = \int_{\Delta S} \varphi\left(\int_{S} u(x_s) d\pi(s)\right) du(\pi)$$

In contrast with the α-maxmin model, the REU model is differentiable everywhere and assumes that agents have a subjective (second order) distribution μ over the possible (first order) prior beliefs π over states S. The model can be summarised in the following way: for any one possible prior belief in π, the agent calculates their expected utility which is then transformed by a concave function φ. The agent then integrates over all possible prior beliefs in π with respect to their subjective distribution μ. Risk aversion is captured by the concavity of the utility function with respect to any one possible prior belief in π. Ambiguity aversion is captured by the concavity of the transformation which occurs when integrating over all possible prior beliefs in π according to the agent's subjective beliefs captured by the distribution μ.

Following Ahn et al. (2014) we make two simplifications regarding the REU model which allows for easier comparison with the α-maxmin model. Firstly, we assume that:

$$\varphi(z) = z^{\alpha}$$

which mirrors the curvature of u and captures the concavity of the transformation over the subjective distribution μ. Secondly, we assume that μ is uniformly distributed over the set of possible priors consistent with the objective information across different ambiguity levels A. This results in the following REU parameterisation:

$$EU(x,A,\gamma,\alpha) = \int_{0.5-\frac{A}{2}}^{0.5+\frac{A}{2}} (\pi_1 * x^{\rho})^{\alpha}\, d\pi_1$$

The term inside the parentheses is the expected utility of a gamble which pays reward x with probability of success π_1. The integral ranging from $0.5-\frac{A}{2}$ to $0.5+\frac{A}{2}$ takes the expectation of these transformed expected utilities with respect to the uniform distribution for π_1. In our specification of φ, ambiguity aversion corresponds to $\alpha < 1$, ambiguity neutrality to $\alpha = 1$, and ambiguity seeking to $\alpha > 1$.

As in the kinked specification, when no ambiguity is present and there is an objective probability of success p, the model simplifies to:

$$EU(x, p, \gamma) = p * x^{\rho}$$

In both the αMEU and REU specifications we use a logistic choice function where the probability of choosing a lottery is given by:

$$P(chose\ lottery) = \frac{1}{1 + e^{(EU(X,p,A) - EU(\$5))}}$$

We use maximum likelihood estimation to fit the data using Stata following Harrison et. al. (2008).

For the aggregate level analysis, we measure the effect of the illusion of control in both the αMEU and REU specifications by allowing the risk tolerance parameter ρ and ambiguity tolerance parameter α to vary with the treatment in the following way:

$$\rho = \rho_{constant} + \rho_{IOC} I$$

$$\alpha = \alpha_{constant} + \alpha_{IOC} I$$

where ***I*** is an indicator variable equal to 1 in all decisions (risky and ambiguous) made in the illusion of control treatment and 0 otherwise. ρ_{IOC}measures the effect of the illusion of control treatment on risk tolerance and α_{IOC} the effect of illusion of control on ambiguity tolerance. All parameters are estimated jointly at the same time from all decisions made by the participant. For both the αMEU and REU specification we use the aggregate level data of 219 participants, who each made 60 decisions, leaving us with a total sample size of 13140.

In the individual level analysis, we estimate the αMEU and REU specification for each participant separately and then examine distributional differences in risk and ambiguity tolerance estimates between participants allocated into either the illusion of control or random treatments. Since all participants answered the 30 questions involving risky lotteries, we also compare the results of the αMEU and REU specifications between sequential or joint estimation of their risk and ambiguity tolerance. In sequential estimation, the first 30 questions are used to calculate participants' risk tolerance, which we then hold as constant when estimating their ambiguity tolerance in the second set of 30 questions[5]. For joint estimation, we use all 60 questions to jointly estimate participants' risk and ambiguity tolerance simultaneously.

If hypothesis 1 is true, and the illusion of control increases ambiguity tolerance, we expect a positive coefficient for α_{IOC} in the αMEU specification and a positive coefficient for α_{IOC} in the REU specification. This is because in the αMEU model, greater levels of α corresponds to more weight being assigned to the best possible state, and hence increased ambiguity tolerance, while in the REU specification, higher levels of α lead to a less concave transformation of the expected utility within any one state, representing more tolerance to mean preserving spreads and hence increased ambiguity tolerance.

2.2.2 Non-parametric analysis

To confirm that our results do not depend on the assumptions of the structural models, we calculate proportions of the lottery choices to capture how often participants selected risky and ambiguous lotteries over the certain payout of $5. 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.

3. Results

The demographic characteristics of the participants were in general well-balanced across the treatments. Participants in the Random Risk and IOC Risk conditions were not different based on gender, age, self-reported wealth, budget, number of siblings, propensity to gamble, and psychometric survey scores assessing participant's desirability for control (see Table 2). The proportion of men is slightly higher 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 gender composition in

[5] Ex-ante this approach is not appropriate because the illusion of control may affect individuals' risk tolerance. However, we proceed with this analysis because we found there was no effect of the illusion of control on risk tolerance.

Table 1). We discuss this in detail in section 3.3. On all other characteristics, there were no differences between the participants in the Random Ambiguity and IOC Ambiguity treatments (see Table 3).

[Table 2 here]

[Table 3 here]

3.1 Structural modelling

3.1.1 Aggregate level

Our aggregate level structural analysis consistently shows that participants are more ambiguity tolerant under the illusion of control (Table 4). The results are consistent across the αMEU and REU specifications. The top panel of Table 4 shows clear evidence of risk aversion ($\rho < 1$) and no evidence that the illusion of control significantly increases risk tolerance for either the αMEU or REU specification. In contrast the bottom panel of Table 4 shows that the illusion of control increases ambiguity tolerance. We find that participants are ambiguity averse under both the αMEU specification ($\alpha < 0.5$) and the REU specification ($\alpha < 1$) and that being under the illusion of control increases ambiguity tolerance for both models. In the case of the αMEU specification this corresponds to a positive coefficient on α_{IOC} (p<0.05, two-sided unpaired t-test), which represents more weight on the best possible state under the illusion of control. In the REU specification the positive coefficient on α_{IOC} (p<0.05, two-sided unpaired t-test) represents a less concave transformation of utility and hence increased tolerance to mean preserving spreads in utility.

[Table 4 here]

3.1.2 Individual level

Individual-level structural estimates support our aggregate level results. There is no significant difference in the distribution of individuals' risk tolerance parameters depending on whether they are in the IOC Risk or Random Risk treatment according to the Kolmogorov Smirnov (KS) test (p>0.1) (see Figure 2). In contrast, there is a significant difference in the distribution of participants' ambiguity tolerance depending on whether they are assigned to the IOC Ambiguity or Random Ambiguity treatment. This holds for both the sequential and joint estimation of the αMEU model (for both p<0.1, KS test) and for the sequential estimation of REU ($p<0.05$, KS test) (see Figure 3). In the joint estimation of REU model, the significance idisappears ($p>0.1$, KS test) possibly due to a reduction in sample size.[6]

[Figure 2 here]

[Figure 3 here]

3.2 Non-parametric analysis

Our non-parametric analysis based on the proportions of lottery choices is consistent with the results obtained in structural estimation.

3.2.1 Ambiguous lottery choices

Participants for whom the winning color is randomly determined by a volunteer choose the ambiguous lottery less often (55.1% of the time) than those who could pick their winning color (59.4%, $p=0.028$). Figure 4A illustrates the result. Moreover, participants in the IOC treatment select the ambiguous lottery more often on average at all ambiguity levels (see Figure 5A) and all reward levels (see Figure 6A). In Table 5 we show in a logistic regression analysis that the effect is robust to a variety of controls. Participants are more likely to choose ambiguous lotteries in the IOC treatment. This holds whether we control for a participants' risk tolerance (captured as the proportion of risky choice scenarios in which they selected the lottery instead of the safe option in Table 5 model (2)) or not (Table 5, model (1)).

[Figure 4 here]

[Figure 5 here]

[Figure 6 here]

[6] 201 participants' risk and ambiguity tolerance parameters are identified under REU model using joint estimation compared to 212 under αMEU model. The convergence is better under sequential estimation (214 participants have their risk tolerance and 213 have their ambiguity parameters identified under both ambiguity models). The results are qualitatively the same (but insignificant) when we focus on the subsample of participants for whom the risk and ambiguity tolerance parameters are identified using both the αMEU and REU models and when removing those who violated the first-order stochastic dominance or always chose risky or safe option or had multiple switching points.

[Table 5 here]

3.2.2 Risky lottery choices

Participants do not choose risky lotteries more often when they can choose their winning color versus when the winning color was randomly determined by a third-party volunteer (0.613 vs. 0.614, p=0.504; see Figure 4B). While participants on average consistently select ambiguous lotteries more often for every reward and ambiguity level (see Figure 5A and 6A), such a pattern does not emerge in questions with risky lotteries (see Figure 5B and 6B). This leads us to conclude that risk tolerance is not affected by our IOC treatment.

Since participants are well-balanced on their characteristics between the Random Risk and IOC Risk treatments (Table 2), we do not expect any confounding factors in our analysis. This is confirmed in the regression analysis presented in Table 6. Whether we control for participants' characteristics (Table 6, model 2), interact participants' characteristics with the treatment (Table 6, model 3), or do not include these control variables (Table 6, model 1), the illusion of control treatment does not affect the propensity to choose risky gambles.

3.3 Gender and illusion of control

Given that there is no evidence in the existing literature that the illusion of control is gender specific, it was not our initial intention to investigate gender. However, because the proportion of men in the Random Risk / IOC Ambiguity treatments is larger, by chance, than the proportion of men in the Random Risk / Random Ambiguity treatments (Table 3)[7] and men in our sample choose ambiguous lotteries more often than women, we conducted some robustness checks to make sure that our conclusions are not driven by differences in gender composition across treatments.

Firstly, note that if our results are driven by the larger proportion of men in in the Random Risk / IOC Ambiguity than in the Random Risk / Random Ambiguity treatment, we should see a strong IOC treatment effect in this group of men. To the contrary, across the four t-test that we conducted, one for each gender and risk treatment, we find the effect to be the weakest

[7] Note that the number of men in IOC Risk / Random Ambiguity and IOC Risk / IOC Ambiguity is the same.

in this group.[8] Secondly, our logistic regression presented in Table 5 shows that the positive effect of the illusion of control on the tendency to choose ambiguous gambles persists when we control for gender (model (3)) and that the interaction of gender and IOC Ambiguity treatment (model (4)) is not significant. In addition to the interaction between male and the IOC Ambiguity treatment, we also interacted the IOC treatment with other participants' characteristics collected in our post experimental questionnaire and found that none of these modulated the effect of the illusion of control (Table 5 model (4)), except that perhaps surprisingly those with a higher desire for control responded to the treatment less strongly.

4. Discussion

We find no effect for the illusion of control on choice under risk, but a significant increase in ambiguity tolerance under the illusion of control. The results of our non-parametric analysis align with those using structural modelling. Our structural models suggest that ambiguity tolerance is increased under the illusion of control on both the aggregate and individual level. This stark contrast in the effect of the illusion of control on choice under risk compared to choice under ambiguity can explain why economists have found no effect for the illusion of control despite the wealth of literature in psychology suggesting a positive effect on risk taking (Stefan and David, 2013). Studies in economics have only studied the illusion of control in choice under risk, whereas studies in psychology did not distinguish between risk and ambiguity. Our results suggest that the mechanisms driving the illusion of control rely on the unknown probability distributions, which have not featured in previous studies within economics.

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 his experimental manipulation does not change

[8] In Random Risk treatments men chose ambiguous lottery 62.3% under IOC versus 62.1% in Random (p=0.478) and women chose ambiguous lottery in IOC 61.5% versus 53.3% in Random (p=0.045). For completeness, we report that in the IOC Risk treatments, for men these numbers are 59.7% versus 55.7% (p=0.181) and for women 54.5% versus 51.8% (p=0.270). While not statistically significant in all analyses, the effect of the illusion of control on the proportion of times men and women chose the ambiguous lotteries is always positive.

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). Our experimental findings are not consistent with the source preference explanation. If our participants exhibited source preference and assuming that source preference is the same for ambiguous and risky lotteries, 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 lotteries, but not risky lotteries intuitively fits with the distortion of beliefs explanation. In ambiguous lotteries, the probability of winning is presented as a range of possible winning probabilities leaving participants more freedom in choosing their own winning probability. In contrast, for the illusion of control to work in risky lotteries, it would have to be that participants believe 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 outcome 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 also cannot explain our findings.

Given that the distortion of beliefs seems to best explain the effect of the illusion of control in our study, we are left asking how this explanation fits within our structural models. In both the αMEU and REU models we assume for the sake of identification of individuals' ambiguity tolerance that their set of possible prior beliefs are consistent with the objective information presented. This leads to a different interpretation of the ambiguity tolerance parameter, and therefore the effect of the illusion of control, in both models. In the αMEU model, the positive effect of the illusion of control on ambiguity tolerances corresponds to an individual assigning more weight to the best possible state, whereas in the REU model it corresponds to a less concave transformation of utility within a given state. When this identifying assumption is relaxed, we cannot separate individuals' ambiguity tolerance from the ambiguity they perceive in the decision problem. If we instead allow individuals' priors to vary, the ambiguity tolerance parameter reflects the degree of optimism. This interpretation of the ambiguity tolerance parameter is more congruent with the illusion of control distorting individuals' subjective beliefs, as it suggests that under the illusion of control individuals become more optimistic about their probability of success, rather than changing the utility they receive from ambiguous states.

Regardless of how this effect is interpreted, of primary methodological concern is that the illusion of control does increase ambiguity tolerance. This is an important methodological result as it suggests that studies which use choice as a means of dispelling participant distrust are over-estimating individuals' true ambiguity tolerance. In our study, participants who did not get to choose their winning color poker chip had it randomly determined by a third-party volunteer unrelated to the study. These participants were not induced with an illusion of control and should have been equally distrustful of the experimenters, since there was no way the experimenters could alter the ambiguous bags after their winning color was determined. The results of our study suggest that such a random device should be implemented when possible to avoid inducing an illusion of control. Future research should consolidate this notion by investigating whether other skill-based characteristics known to induce the illusion of control, and commonly featured in choice under ambiguity tasks, such as involvement, familiarity, practice and competition (Langer, 1975), increase ambiguity tolerance in a similar way.

The real-world applications of our results extend most obviously to the gambling literature, where the effect of illusory control on risk taking behavior has been consistently observed. In the case of electronic gambling machines (EGMs), where the probability of success is usually unknown to individuals, the addition of so-called "skill" components[9] to pure games of chance have been found to induce erroneous cognitions about their function and their effect on individuals' probability of success (Dixon et al. 2018). Our findings suggest that such illusory

[9] These skill components, such as stop buttons, are not expected to affect the likelihood of winning in EGMs.

skill components increase individuals' likelihood to engage in risk-taking behavior due to a distortion of beliefs when the probability of success is unclear. These implications may extend into emerging research into skill-based gambling machines (SGMs) where legitimate skill components offer individuals trivial rewards, improved probabilities of success, or greater payoffs (Pickering, Philander, and Gainsbury 2020). Giving individuals control over some aspect of their bet may create an illusion of control over other aspects as well. As long as the probability of success is unclear in SGMs, this illusory control may, in a similar way as EGMs, increase individuals' propensity to engage in gambling.

5. Conclusion

The implications of our study are clear. The illusion of control does not increase risk taking when probability distributions are known but increases risk taking when probability distributions are unknown. It is most likely that this occurs due a distortion of beliefs when under the illusion of control. As a result, individuals should be mindful when exposed to skill-based characteristics in pure chance tasks to avoid engaging in risk taking behavior when they otherwise wouldn't. Similarly, when designing decision tasks to estimate individuals' ambiguity tolerance, experimenters should avoid using choice as a means of inducing the illusion of control.

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Figures

Figure 1 Images used to communicate the probability of winning in the questions used to assess A: risk and B: ambiguity tolerance. 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.

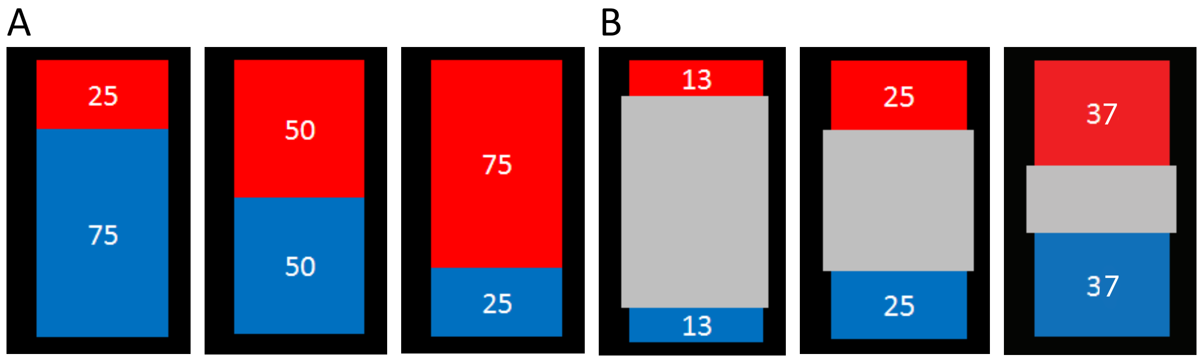


Figure 2 Distribution of participants' risk tolerance parameter ρ by ambiguity model, estimation method, and treatment. Note that since both models simplify to the same functional form under no ambiguity, the ρ distributions are exactly the same under sequential estimation.

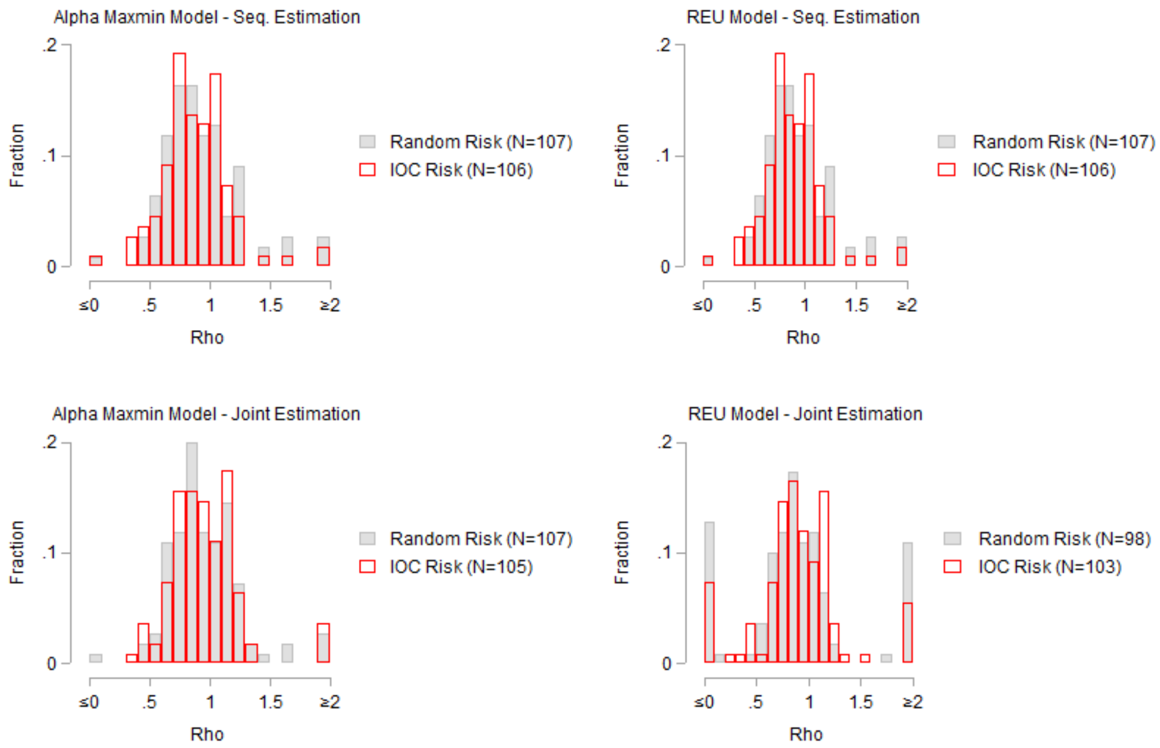


Figure 3 Distribution of participants' ambiguity tolerance parameter α by ambiguity model, estimation method, and treatment.

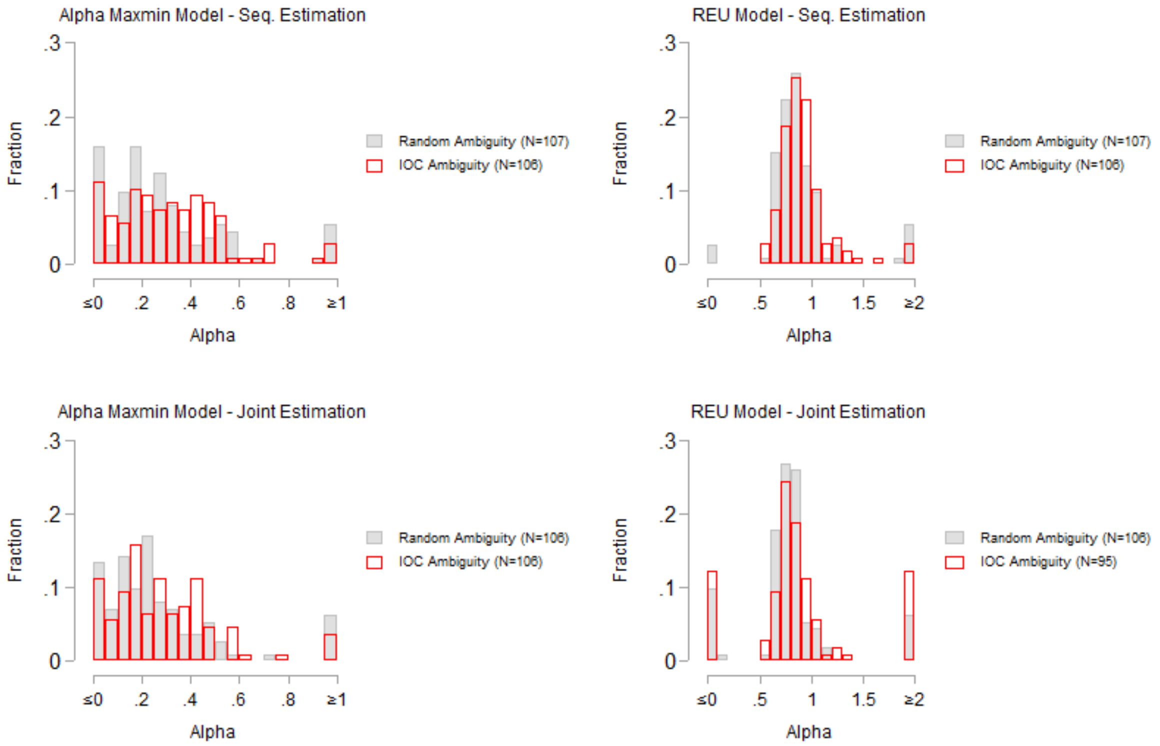


Figure 4 The effect of the illusion of control on participants' willingness to choose lotteries with A: ambiguous and B: known probability of winning. Error bars are 95% confidence intervals.

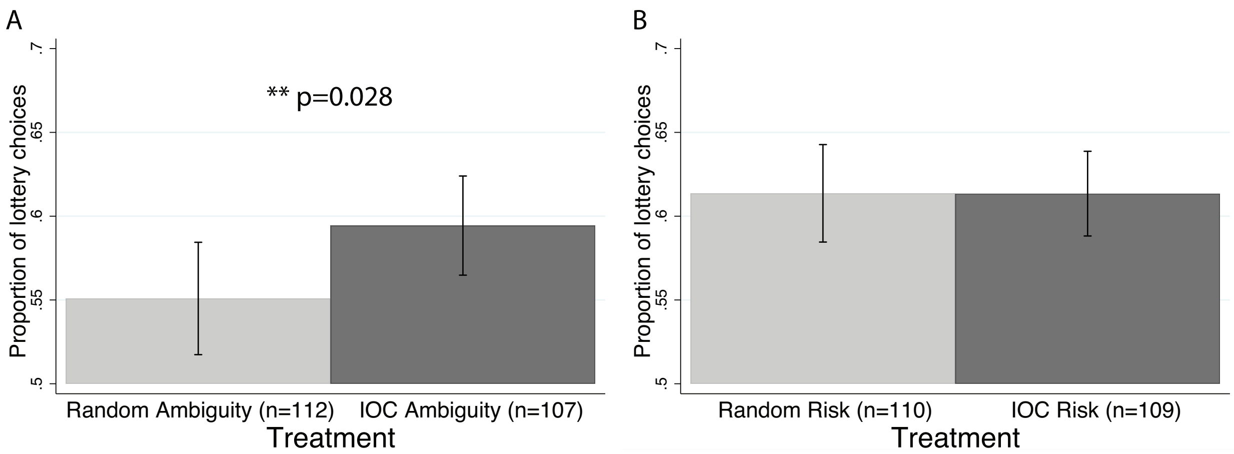


Figure 5 Illusion of control by A: ambiguity level and B: probability of winning.

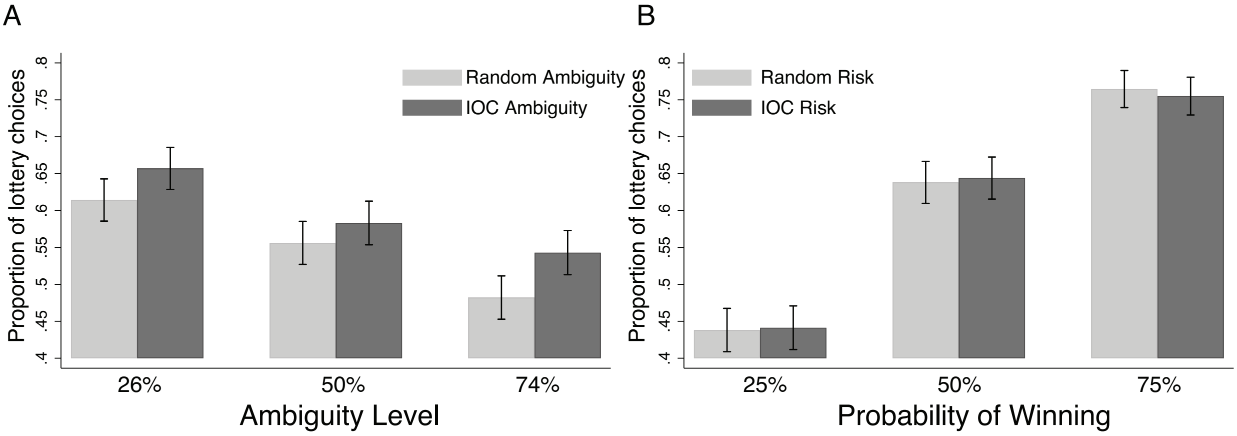
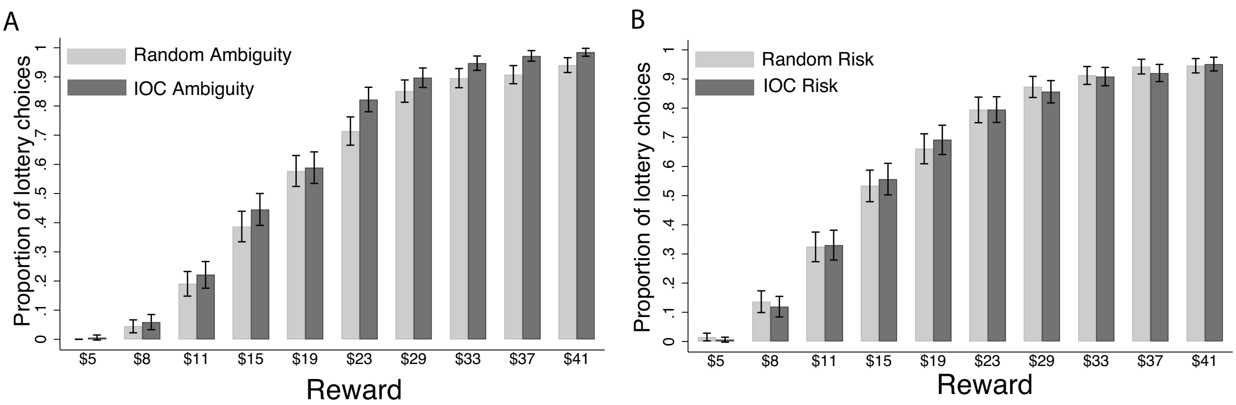


Figure 6 Illusion of control by reward size in questions with A: ambiguous probability of winning B: known probability of winning.



Tables

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 (in that order).

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

N=219	**Random Risk**	**IOC Risk**
male	0.491	0.459
	(0.048)	(0.048)
age	22.755	22.092
	(0.413)	(0.323)
wealth	3.172	3.046
	(0.051)	(0.063)
budget	70.573	80.133
	(6.341)	(9.821)
siblings	1.300	1.193
	(0.108)	(0.129)
gambler	0.364	0.266
	(0.046)	(0.043)
DOC Scale	97.118	96.982
	(1.086)	(1.125)

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

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

Table 4: Illusion of control - aggregate level structural model estimates

	αMEU		REU	
	(1)	(2)	(3)	(4)
$\boldsymbol{\rho - risk\ tolerance}$				
ρ_{IOC}		-0.017		-0.017
		(0.024)		(0.027)
$\rho_{constant}$	0.793***	0.802***	0.797***	0.805***
	(0.014)	(0.019)	(0.016)	(0.021)
$\boldsymbol{\alpha - ambiguity\ tolerance}$				
α_{IOC}		0.058**		0.049**
		(0.026)		(0.021)
$\alpha_{constant}$	0.2666***	0.240***	0.843***	0.820***
	(0.014)	(0.018)	(0.012)	(0.016)
N	13140	13140	13140	13140

Standard errors clustered on the participant level and shown in parentheses.
* p<0.1, ** p<0.05, *** p<0.01

Table 5 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. Only decisions with ambiguous lotteries are included.

	(1)	(2)	(3)	(4)
IOC ambiguity	0.374*	0.315*	0.320*	3.948*
	(0.192)	(0.169)	(0.192)	(2.251)
male			0.427**	0.430
			(0.197)	(0.317)
age				0.061*
				(0.031)
no. of siblings				0.082
				(0.103)
no. of younger siblings				-0.063
				(0.155)
wealth				0.385
				(0.253)
gambler				-0.217
				(0.319)
desire for control				0.018
				(0.013)
IOC x male				-0.029
				(0.385)
IOC x age				-0.066
				(0.045)
IOC x siblings				-0.108
				(0.152)
IOC x siblings younger				-0.087
				(0.206)
IOC x wealth				-0.19
				(0.321)
IOC x gambler				-0.048
				(0.385)
IOC x desire for control				-0.018
				(0.017)
IOC x risky lotteries				0.659
				(1.511)
prop. risky lotteries		7.804***		7.195***
		(0.924)		(1.489)
reward	0.199***	0.199***	0.200***	0.244***
	(0.011)	(0.011)	(0.011)	(0.015)
ambiguity level	-0.022***	-0.022***	-0.022***	-0.027***
	(0.002)	(0.002)	(0.002)	(0.003)
constant	-2.767***	-2.767***	-2.964***	-12.224***
	(0.193)	(0.193)	(0.221)	(1.643)
no. of observations	6570	6570	6570	6570

Standard errors clustered on the participant level and shown in parentheses.
* p<0.1, ** p<0.05, *** p<0.01

Table 6 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.

	(1)	(2)	(3)
IOC risk	-0.002	0.094	2.305
	(0.171)	(0.176)	(2.072)
male		0.138	0.168
		(0.185)	(0.259)
age		0.081***	0.089***
		(0.025)	(0.033)
no. of siblings		-0.023	-0.090
		(0.064)	(0.114)
no. of younger siblings		0.046	0.157
		(0.101)	(0.202)
wealth		0.208	0.419*
		(0.146)	(0.231)
gambler		0.124	0.312
		(0.193)	(0.256)
desire for control		0.001	0.004
		(0.008)	(0.011)
IOC x male			-0.009
			(0.374)
IOC x age			-0.016
			(0.048)
IOC x siblings			0.108
			(0.140)
IOC x siblings younger			-0.221
			(0.230)
IOC x wealth			-0.390
			(0.287)
IOC x gambler			-0.485
			(0.393)
IOC x desire for control			-0.005
			(0.016)
reward	0.198***	0.202***	0.203***
	(0.011)	(0.011)	(0.011)
winning probability	0.055***	0.056***	0.057***
	(0.004)	(0.004)	(0.004)
constant	-6.073***	-8.896***	-10.082***
	(0.342)	(1.196)	(1.706)
no. of observations	6570	6570	6570

Standard errors clustered on the participant level and shown in parentheses.
* p<0.1, ** p<0.05, *** p<0.01

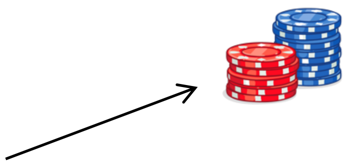
Supplementary Materials for "Controlling uncertainty: The illusion of control in choice under risk and ambiguity" by Alex Berger

Appendix A Experimental instructions

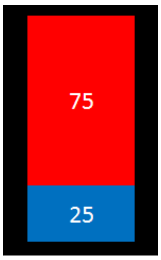
Welcome to our decision-making study!!!

Thank you for helping us understand how people make decisions!

(Please do not write on these instructions. We re-use them.)



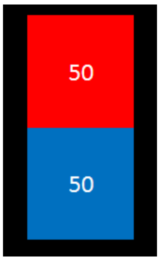
In the task you are going to see pictures of bags of chips. Each bag is filled with 100 chips and corresponds to one, real bag of chips that the researcher has with them. Some of the chips in the bags are red and some of them are blue. For example:



In this bag 75 chips are red and 25 are blue.

We are using 6 bags with different quantities of red and blue chips in the study. You will make 10 decisions for each bag. At the end of the study, you will pick **one** chip from a bag and its colour will determine your payment. Keep on reading the instructions to understand how it all works.

Here is an example of just one decision that you will have to make:



Decision number		Option A			Option B
8		Red pays $5 Blue pays $5	or		Red pays $33 Blue pays $0

There are 50 red and 50 blue chips in this bag. Imagine that you are to pick one chip from this bag without looking. Do you prefer:

Option A which pays you $5 independent of the colour you pick, or

Option B which pays you $33 if you pick red chip but nothing if you pick a blue one? In option B your payment is determined by chance - you can’t be sure about the colour of the chip that you will pick.

You will let us know which option you prefer by putting a tick in the empty box to the left of it. For example, if you prefer option A you will mark it this way:

18	✓	Red pays you $5 Blue pays you $5	or		Red pays you $33 Blue pays you $0

And if you prefer option B you will mark it this way:

18		Red pays you $5 Blue pays you $5	or	✓	Red pays you $33 Blue pays you $0

In the study you will see tables like the one below. You are supposed to make one decision in each row by drawing a tick next to your preferred option. (Please do not complete the table below. It is just an example.)

Decision number		Option A			Option B
1		Red pays $5 Blue pays $5	or		Red pays $5 Blue pays $0
2		Red pays $5 Blue pays $5	or		Red pays $8 Blue pays $0
3		Red pays $5 Blue pays $5	or		Red pays $11 Blue pays $0
4		Red pays $5 Blue pays $5	or		Red pays $15 Blue pays $0
5		Red pays $5 Blue pays $5	or		Red pays $19 Blue pays $0
6		Red pays $5 Blue pays $5	or		Red pays $23 Blue pays $0
7		Red pays $5 Blue pays $5	or		Red pays $29 Blue pays $0
8		Red pays $5 Blue pays $5	or		Red pays $33 Blue pays $0
9		Red pays $5 Blue pays $5	or		Red pays $37 Blue pays $0
10		Red pays $5 Blue pays $5	or		Red pays $41 Blue pays $0

There are no wrong decisions. Everybody prefers something else, so pick the option you like more.

Once you finish the task, you should have one tick in each row in each table. It is important that you don't miss any rows. If you miss a decision, you risk not getting paid.

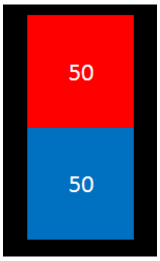
Each of the bag images that you will see corresponds to exactly one bag of poker chips. The experimenter has all the bags with them here today.

Payment

At the end of the study, you will pick a chip from a different bag that contains 60 chips numbered from 1 to 60. The number on this chip will determine which decision you are paid for. You will receive your earnings in cash at the end of the study.

Independent of your choice, you will receive $10 for participation. If you did not make a choice in the 'payment decision' then you will get only $10 for participation.

Example: Suppose that you picked a chip with number 18 and so this is the decision that you are paid for. Suppose that you picked Option B.



18		Red pays you $5 Blue pays you $5	or	✓	Red pays you $33 Blue pays you $0

For sure you will receive $10 for participation. Then you will pick one chip from a bag that has 50 red and 50 blue chips. If the chip you pick is red, you will get extra $33. If the chip you pick is blue you don't get anything extra.

[In Illusion of Control Treatments: In this experiment you will choose which colour of the poker chip you would like to be your winning colour. You will be asked to make this choice twice. You can choose the same, or a different winning colour poker chip each time you are asked.]

[In Control Treatments: To determine what colour of poker chip will be your winning colour poker chip, a student volunteer, who is not a part of the research team, will randomly draw a poker chip from a bag containing 2 red and 2 blue poker chips. The colour poker chip drawn from the bag will be your winning colour poker chip. If the student volunteer randomly draws a red poker chip from the bag, then your winning colour poker chip will be red. If the student volunteer randomly draws a blue poker chip from the bag, then your winning colour poker chip will be blue.]

This is the end of instructions.

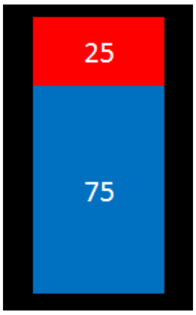
If you have any questions about the task please raise your hand and one of the researchers will come over to help you.

If you understand the task, you can start making your decisions using the provided decision sheets.

Appendix B Experimental task (IOC Risk IOC Ambiguity Treatment)

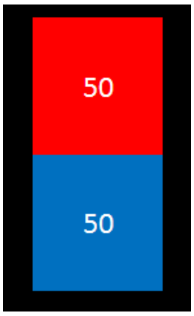
Before you continue to choose, please choose one colour that you would like to be the winning colour in Option 2 for all questions on pages 1, 2, and 3. Then if you draw your colour from the bag, you win the specified amount of money and if the other colour is drawn from the bag you get $0.

I choose my winning colour for pages 1, 2 and 3 to be: RED / BLUE (circle one)



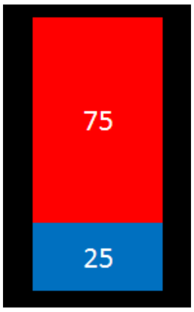
There are 25 red and 75 blue chips in this bag. Which option do you prefer?

Decision number		Option 1			Option 2
1		Red pays you $5 Blue pays you $5	or		Your colour pays you $5 Other colour pays you $0
2		Red pays you $5 Blue pays you $5	or		Your colour pays you $8 Other colour pays you $0
3		Red pays you $5 Blue pays you $5	or		Your colour pays you $11 Other colour pays you $0
4		Red pays you $5 Blue pays you $5	or		Your colour pays you $15 Other colour pays you $0
5		Red pays you $5 Blue pays you $5	or		Your colour pays you $19 Other colour pays you $0
6		Red pays you $5 Blue pays you $5	or		Your colour pays you $23 Other colour pays you $0
7		Red pays you $5 Blue pays you $5	or		Your colour pays you $29 Other colour pays you $0
8		Red pays you $5 Blue pays you $5	or		Your colour pays you $33 Other colour pays you $0
9		Red pays you $5 Blue pays you $5	or		Your colour pays you $37 Other colour pays you $0
10		Red pays you $5 Blue pays you $5	or		Your colour pays you $41 Other colour pays you $0



There are 50 red and 50 blue chips in this bag. Which option do you prefer?

Decision number		Option 1			Option 2
1		Red pays you $5 Blue pays you $5	or		Your colour pays you $5 Other colour pays you $0
2		Red pays you $5 Blue pays you $5	or		Your colour pays you $8 Other colour pays you $0
3		Red pays you $5 Blue pays you $5	or		Your colour pays you $11 Other colour pays you $0
4		Red pays you $5 Blue pays you $5	or		Your colour pays you $15 Other colour pays you $0
5		Red pays you $5 Blue pays you $5	or		Your colour pays you $19 Other colour pays you $0
6		Red pays you $5 Blue pays you $5	or		Your colour pays you $23 Other colour pays you $0
7		Red pays you $5 Blue pays you $5	or		Your colour pays you $29 Other colour pays you $0
8		Red pays you $5 Blue pays you $5	or		Your colour pays you $33 Other colour pays you $0
9		Red pays you $5 Blue pays you $5	or		Your colour pays you $37 Other colour pays you $0
10		Red pays you $5 Blue pays you $5	or		Your colour pays you $41 Other colour pays you $0

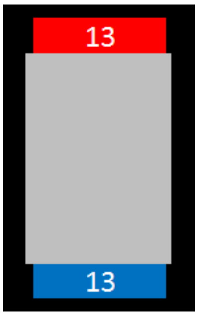


There are 75 red and 25 blue chips in this bag. Which option do you prefer?

Decision number		Option 1			Option 2
1		Red pays you $5 Blue pays you $5	or		Your colour pays you $5 Other colour pays you $0
2		Red pays you $5 Blue pays you $5	or		Your colour pays you $8 Other colour pays you $0
3		Red pays you $5 Blue pays you $5	or		Your colour pays you $11 Other colour pays you $0
4		Red pays you $5 Blue pays you $5	or		Your colour pays you $15 Other colour pays you $0
5		Red pays you $5 Blue pays you $5	or		Your colour pays you $19 Other colour pays you $0
6		Red pays you $5 Blue pays you $5	or		Your colour pays you $23 Other colour pays you $0
7		Red pays you $5 Blue pays you $5	or		Your colour pays you $29 Other colour pays you $0
8		Red pays you $5 Blue pays you $5	or		Your colour pays you $33 Other colour pays you $0
9		Red pays you $5 Blue pays you $5	or		Your colour pays you $37 Other colour pays you $0
10		Red pays you $5 Blue pays you $5	or		Your colour pays you $41 Other colour pays you $0

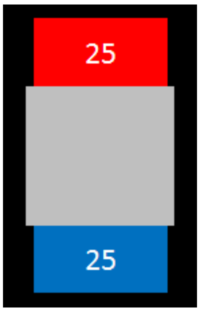
Before you continue to choose, please choose one colour that you would like to be the winning colour in Option 2 for all questions on pages 4, 5, and 6. Then if you draw your colour from the bag, you win the specified amount of money and if the other colour is drawn from the bag you get $0.

I choose my winning colour for pages 4, 5 and 6 to be: RED / BLUE (circle one)



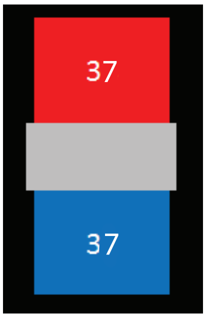
There are 100 chips in this bag. At least 13 are red and at least 13 are blue. The remaining 74 chips hidden behind the grey bar are of some unknown combination of red and blue. So you don't know whether there is more of red or more of blue colour in this bag. Which option do you prefer?

Decision number		Option 1			Option 2
1		Red pays you $5 Blue pays you $5	or		Your colour pays you $5 Other colour pays you $0
2		Red pays you $5 Blue pays you $5	or		Your colour pays you $8 Other colour pays you $0
3		Red pays you $5 Blue pays you $5	or		Your colour pays you $11 Other colour pays you $0
4		Red pays you $5 Blue pays you $5	or		Your colour pays you $15 Other colour pays you $0
5		Red pays you $5 Blue pays you $5	or		Your colour pays you $19 Other colour pays you $0
6		Red pays you $5 Blue pays you $5	or		Your colour pays you $23 Other colour pays you $0
7		Red pays you $5 Blue pays you $5	or		Your colour pays you $29 Other colour pays you $0
8		Red pays you $5 Blue pays you $5	or		Your colour pays you $33 Other colour pays you $0
9		Red pays you $5 Blue pays you $5	or		Your colour pays you $37 Other colour pays you $0
10		Red pays you $5 Blue pays you $5	or		Your colour pays you $41 Other colour pays you $0



There are 100 chips in this bag. At least 25 are red and at least 25 are blue. The remaining 50 hidden behind the gray bar are of some unknown combination of red and blue. So you don't know whether there is more of red or more of blue colour in this bag. Which option do you prefer?

Decision number		Option 1			Option 2
1		Red pays you $5 Blue pays you $5	or		Your colour pays you $5 Other colour pays you $0
2		Red pays you $5 Blue pays you $5	or		Your colour pays you $8 Other colour pays you $0
3		Red pays you $5 Blue pays you $5	or		Your colour pays you $11 Other colour pays you $0
4		Red pays you $5 Blue pays you $5	or		Your colour pays you $15 Other colour pays you $0
5		Red pays you $5 Blue pays you $5	or		Your colour pays you $19 Other colour pays you $0
6		Red pays you $5 Blue pays you $5	or		Your colour pays you $23 Other colour pays you $0
7		Red pays you $5 Blue pays you $5	or		Your colour pays you $29 Other colour pays you $0
8		Red pays you $5 Blue pays you $5	or		Your colour pays you $33 Other colour pays you $0
9		Red pays you $5 Blue pays you $5	or		Your colour pays you $37 Other colour pays you $0
10		Red pays you $5 Blue pays you $5	or		Your colour pays you $41 Other colour pays you $0



There are 100 chips in this bag. At least 37 are red and at least 37 are blue. The remaining 26 chips hidden behind the grey bar are of some unknown combination of red and blue. So you don't know whether there is more of red or more of blue colour in this bag. Which option do you prefer?

Decision number		Option 1			Option 2
1		Red pays you $5 Blue pays you $5	or		Your colour pays you $5 Other colour pays you $0
2		Red pays you $5 Blue pays you $5	or		Your colour pays you $8 Other colour pays you $0
3		Red pays you $5 Blue pays you $5	or		Your colour pays you $11 Other colour pays you $0
4		Red pays you $5 Blue pays you $5	or		Your colour pays you $15 Other colour pays you $0
5		Red pays you $5 Blue pays you $5	or		Your colour pays you $19 Other colour pays you $0
6		Red pays you $5 Blue pays you $5	or		Your colour pays you $23 Other colour pays you $0
7		Red pays you $5 Blue pays you $5	or		Your colour pays you $29 Other colour pays you $0
8		Red pays you $5 Blue pays you $5	or		Your colour pays you $33 Other colour pays you $0
9		Red pays you $5 Blue pays you $5	or		Your colour pays you $37 Other colour pays you $0
10		Red pays you $5 Blue pays you $5	or		Your colour pays you $41 Other colour pays you $0

Appendix C Demographic questions

1. I am (circle the right answer): male female other
2. I was born on ……………………………………………… (day/month/year)
3. I am ………………….. years old
4. How many years has it been since you graduated from high school? ……………………………
5. Are you a university student (YES/NO)? …………………………..
6. How many years has it been since you started university? …………………………..
7. Are you a masters or HDR student (YES/NO)?..................
8. How many siblings do you have? …………………………..
9. How many younger siblings do you have? …………………………..
10. I consider myself (circle one):
    - Very wealthy
    - Wealthy
    - Neither poor nor wealthy
    - Poor
    - Very poor
11. What is your weekly budget to spend on entertainment (in Australian dollars)?
    - ………………………………………..
12. In the last 12 months did you partake in any of the following or similar activities: state lotteries, raffles, poker machines/keno, gambling in a casino, online gambling or other online games involving risks with monetary outcomes?
    - Yes
    - No
13. (skip if you answered no to question 12)
    If you answered yes to question 12, which statement best describes how frequently you engaged in these activities?
    - Once every 12 months
    - Once every 6 months
    - Once every 3 months
    - Once a month
    - Once a fortnight
    - Once a week
    - More than once a week
14. What do you think the experiment was about?