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Comparing Small-Group and Individual Behavior in Lottery-Choice Experiments

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Abstract: Lottery-choice experiments are conducted to compare risk preferences revealed by three-person groups versus isolated individuals. A lottery-choice experiment consists of a menu of paired lottery choices structured so that the crossover point from a low-risk to a high-risk lottery can be used to infer the degree of risk aversion. The data from a between-subjects experiment indicate that the difference in the average crossover point for groups versus individuals is not significant, but groups tend to make decisions that are more consistent with risk-neutral preferences in the lowest and highest risk lotteries. The data from a three-phased individual-group-individual sequenced experiment indicate that groups choose significantly more low-risk lotteries than the mean choice of the individual group members. Also, making a phase-two group decision influences the subsequent phase-three individual decisions toward the group decision relative to the initial phase-one (individual) decisions.

Keywords: experiments, group behavior, lottery-choice

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Comparing Small-Group and Individual Behavior in Lottery-Choice Experiments

Group decision-making plays an important role in economic policy. From the Open Market Committee of the Federal Reserve, to family expenditures, to the management of mutual funds, important decisions are made by groups. [1] While there is a long history in social psychology of studying the effects of group discussion on decision making, research addressing when and how group decisions differ from individual decisions in economic contexts with salient cash rewards has only recently appeared in the economics literature. [2] This study builds on this nascent literature by reporting the results of a series of lottery-choice experiments following the Holt-Laury (2002) format. The goal of this study is to compare the inferred risk preferences measured by the lottery-choices of three-person groups and individuals in an environment where group members must unanimously agree on the group decision after a period of unstructured discussion.

This study consists of experiments in two formats: non-sequenced (between-subjects) experiments that generate independent individual-choice and group-choice samples and sequenced (within-subjects) individual-group-individual experiments. The non-sequenced experiments measure whether groups, on average, make significantly different choices than individuals. The sequenced experiments investigate how individual choices are aggregated into the group choice and examine whether participating in group discussion immediately impacts subsequent individual decisions.

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[1] Bliss, Potter, and Schwarz (2008) compare the performance of team and individually managed mutual funds. They find no significant difference in fund performance, but team managed funds are significantly less risky and have lower management fees than individually managed funds.

[2] See Kerr, MacCoun, and Kramer (1996) for an excellent review of the social psychology literature on group versus individual decision making. This experimental literature is primarily based on choice-dilemma questionnaires where subjects made decisions based on hypothetical situations in the absence of a salient reward structure. Kerr et al. concluded “there are several demonstrations that group discussion can attenuate, amplify, or simply reproduce the judgmental biases of individuals” and “research conducted to date indicates that there is unlikely to be any simple, global answer to the question (p. 693).” An excellent summary of the small pre-2005 economics literature on group versus individual decision making is contained in Kocher and Sutter (2005).

Similar to previous research, the findings of this study show that subject composition (individual or group decision makers) does influence experimental outcomes. Specifically, while there is not a significant difference in the total number of safe-lottery choices based on subject composition in the non-sequenced experiment, lottery choice is affected by a significant interaction between subject composition and the lottery winning percentage, defined here as the probability of attaining the high-payoff outcome in the lottery. Groups appear to deviate less from the risk-neutral set of choices in the lowest (10%-30%) and highest (80%-100%) winning-percentage lotteries. The sequenced experiments show that a group shift occurs such that the total number of safe-lottery choices by the group is significantly greater than the mean total safe choices of group members. Further, unstructured group discussion significantly impacts subsequent individual decisions.

The paper proceeds as follows: Section 2 summarizes recent related research exploring risk preferences of individuals and groups using lottery-valuation or lottery-choice experiments; the experimental procedures for the lottery-choice experiments utilized here are explained in Section 3; Section 4 presents the experimental results; and a summary of conclusions is offered in Section 5.

Section 2: Overview of Recent Related Lottery Experiments

Recent studies using lotteries to elicit risk preferences have been conducted by Holt and Laury (2002), Harrison, Lau et al. (2005), Colombier et al. (2006), and Shupp and Williams (2008).[3] Holt and Laury elicited individual risk preferences using a four-phase lottery-choice experiment with probabilities of obtaining the higher monetary payoff ranging from 10% to 100%. Each phase differed by the monetary payoffs of the lotteries and whether or not subjects

[3]Previous experimental research finds that individuals are sensitive to the institution used to elicit the risk-preference measure. Isaac and James (2000) and Berg, Dickhaut, and McCabe (2005) present a within-subjects design using a variety of auction formats (first price, Becker-Degroot-Marshak, English Clock) that provide inconsistent estimated coefficients of relative risk aversion for the same subject across the institutions. A recent working paper by Dave et al. (2008) reveals a similar result comparing estimated coefficients of relative risk aversion elicited through Binswanger and Holt-Laury lottery choice procedures. Whether group decisions exhibit this characteristic is a topic for further research.

were paid based on their decisions.[4] Their experimental results showed that subject decisions at baseline payoff levels were consistent with risk aversion (indicated by the number of safe lottery choices), there was no difference in inferred risk preferences between baseline payoffs and high-hypothetical payoffs, and the magnitude of inferred risk aversion increased from baseline to high-real payoffs. Increased risk aversion persisted as the payoffs continued to be scaled upward; however, risk preferences in the high-payoff lotteries were not consistent with those in the hypothetical high-payoff lotteries. Finally, risk preferences in baseline-payoff lotteries conducted after the high-payoff lottery phase remained consistent with the baseline-payoff lotteries conducted prior to the high-payoff lottery phase.

In a comment on the Holt and Laury (2002) paper, Harrison, Johnson et al. (2005) noted that an order effect existed in the Holt-Laury lottery-choice experiments. Holt and Laury (2005) reported new data to address the magnitude of the order effect; their original conclusions were supported by the new data.

Harrison, Lau et al. (2005) analyzed social preferences in a lottery-choice experiment. Individuals were assigned to anonymous three-person groups and the group decision was determined by majority rule. Group members were not allowed to communicate with one another. Controlling for order effects and subject demographics, the interval regression and random-effects panel-data estimates reported found no evidence of differences in the choices of individuals and three-person majority-rule groups.

Shupp and Williams (2008) conducted lottery-valuation experiments to compare the risk preferences revealed by individuals relative to three-person groups and to analyze how individual decisions are aggregated to form a group decision. Instead of using a lottery-choice procedure, Shupp and Williams elicited maximum willingness-to-pay bids to play each of nine lotteries with varying probabilities (10% to 90%) of winning $20 ($60 for groups) or nothing. Individuals were

[4] Monetary payoffs for the baseline treatment were $3.85 and $0.10 for the risky lottery and $2.00 and $1.60 for the safe lottery. Payoffs were scaled by factors of 20, 50 and 90 from the baseline levels.

endowed with $20 (groups with $60) to cover their bids. Group decisions were formed by unanimous consent after an unstructured period of face-to-face discussion.

Shupp and Williams analyzed their results using a certainty-equivalent ratio (CER) defined as the reported maximum willingness to pay divided by the expected value of the lottery. Thus a CER = 1 was consistent with risk-neutral preferences, a CER > 1 was consistent with risk-seeking preferences, and CER < 1 was consistent with risk-averse preferences. For example, in a lottery with a 50% probability of winning $20, the expected value of the lottery is $10. If a subject reported a maximum willingness to pay of $10, this person would be classified as risk neutral (with a CER of 1). In contrast, if a subject reported a maximum willingness to pay of $7 (less than the expected value of the lottery) this person would be classified as risk averse (with a CER of 0.7). Elicited CERs showed a significant interaction between subject composition (individual or group) and the lottery win percentage. For the lowest-risk lotteries (win percentage of at least 80%) the average group CER was near the risk-neutral benchmark and slightly greater than the average individual CER. For the highest-risk lotteries (win percentage of at most 40%) the average group CER revealed substantial risk aversion and was significantly smaller than the average individual CER. For lotteries with a winning percentage of 50%-70%, average group and individual CERs were consistent with risk aversion and not significantly different.

Shupp and Williams also conducted a follow-up experiment employing individual-then-group sequenced decisions that was designed to test the robustness of their initial (independent samples) results and to explore how individuals form a group decision. These data confirmed that group discussion led to a significant shift of the group CER away from the mean individual group-member CER toward more risk aversion in the four highest-risk lotteries. No significant individual-versus-group difference was found in the five lowest-risk lotteries.

In a recent working paper, Colombier, et al. (2006) report individual and three-person group lottery-choice experiments where group members can not directly communicate, as in Harrison, Lau, et al. (2005), but must come to a unanimous group decision through an iterative voting process or have a random decision imposed on the group. They interpret their results as being inconsistent with the findings of Harrison, Lau et al. (2005) (significant differences are reported for individual versus group decisions) and generally consistent with implications derived from the Shupp-Williams lottery-valuation research and the research reported here.

Section 3: Experimental Procedures

The experimental procedure followed Holt and Laury (2002), Holt and Laury (2005), and Laury (2002). Subjects were presented with a menu of ten lottery-choice decisions. Each decision represented a choice between a relatively "safe" lottery (with a small difference between the low-payoff and high-payoff outcome) and a more "risky" lottery (with a larger difference between the low-payoff and high-payoff outcome). Payoffs were identical in all 10 decisions, however the probability of the high-payoff outcome increased in 10% increments from 10% in the first decision to 100% in the last decision. In each decision, the subject was asked to choose which lottery he preferred to play. One of these decisions was randomly chosen for payment by throwing a ten-sided die, with the outcome of the lottery determined by a second throw. Instructions and decision sheets are included in the Appendix.

As in Holt and Laury (2002), the total number of safe lottery choices was used as a measurement of subject risk preferences. A subject acting as if risk-neutral would choose the lottery with the highest expected monetary payoff for all winning probabilities: he would choose the safe lottery for winning probabilities $p \in [10\%, 40\%]$ and then switch to the risky lottery for the winning probabilities $p \in [50\%, 100\%]$.[5] A subject acting as if risk averse would choose the safe lottery for $p \in [10\%, M]$ where $M > 40\%$. A subject acting as if risk seeking would choose the safe lottery for $p \in [10\%, M]$ where $M < 40\%$.

In each session subjects participated in either an individual-choice task or a group-choice task (or both). In the individual-choice task, subjects were seated in a lab and were visually

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[5] The risk-neutral set of lottery choices is optimal for risk preferences in the interval of (-0.15,0.15) for the Constant Relative Risk Aversion model with utility for money x of $u(x) = x^{1-r}$.

isolated from one another when they made their lottery-choice decisions. In the group-choice task, each group (consisting of three subjects) was placed into a separate room near the lab to ensure that between-group communication did not occur. Subjects were told to reach a unanimous decision for all group choices. They indicated their agreement with the group choices by signing a statement sheet. If subjects could not reach a unanimous agreement, they were told a majority rule would be used in determining the group decision. However, all groups were able to reach a consensus and the majority rule was never used.[6]

All sessions were conducted at Georgia State University, the same subject population used in Holt and Laury (2002).

The results from two treatments are reported here. In the first treatment, data generated from a between-subjects design are examined: 30 subjects completed the individual-choice task only and 45 subjects (15 groups) completed the group-choice task only. In the second treatment, sequenced data from a within-subjects design are examined: 45 subjects participated in an individual-choice task, followed by a group-choice task, and then a final individual-choice task. These two treatments are summarized in Table 1 and are described below.

3.A: Non-Sequenced Treatment

In the individual-task sessions[7] (Ind 10X), subjects entered the lab and were seated at individual desks. They started by completing a hypothetical trial lottery-choice task with different payoffs than those used in the actual experiment in order to become familiar with the procedures.[8] Next, they completed ten lottery-choice decisions; payoffs were ten-times those used in the baseline Holt and Laury treatment. The payoffs for the safe option (labeled "Option A" on the decision-sheet) were $20 or $16, while the payoffs from the risky option (labeled

[6] Knowing that a majority rule would be used in case of disagreement, subjects could have invoked this rule on their own to make their group decisions. In fact, 142 of 150 (94.7%) group decisions in phase 2 of the sequenced experiment are consistent with a majority rule according to group members' choices in phase 1.

[7] The individual-task sessions were completed approximately one year prior the group-task sessions. The individual-task data were originally analyzed in Laury (2002). Different subjects from those who completed the individual-task sessions were used in the group-task sessions.

[8] Option A was $3 with certainty and Option B was either $6 or $1.

"Option B") were \$38.50 or \$1.   Table 2 displays the expected value for each lottery used in this treatment.

In the group-task sessions (Group 10X), subjects entered the experimental laboratory and were seated at individual desks. Each desk contained a post-it note with a number on it. Subjects were later told that the number represented the group they would participate with during the session. The desks were numbered such that subjects seated next to each other were placed in different groups in order to minimize the probability that friends would be placed in the same group.

As in the individual-task sessions, all subjects first participated in a hypothetical trainer task to familiarize them with the procedures. Next, subjects broke into groups to complete the menu of lottery choices. All payoffs were three-times higher than in the individual-choice task, and subjects were told that the earnings would be equally divided among all three group members (so that individual payoffs were identical to those in the individual-choice task). As in the other treatments, subjects were told that just one of the ten lotteries would be randomly chosen *ex post* for payment. When a group returned from making their choices, a ten-sided die was rolled twice to determine the played lottery and the lottery outcome.

3.B: Sequenced Treatment

A sequenced individual-group-individual (sequenced IGI) treatment was also performed. The payoffs in this treatment were identical to the Holt and Laury baseline payoff level; as in the non-sequenced group sessions, the group's payoff was three-times higher than the individual payoff so that the individual payoffs were identical between group and individual tasks. Table 3 displays the expected value for all ten lotteries in this treatment. As in the non-sequenced sessions, all tasks were preceded by a hypothetical lottery choice task that trained subjects on the procedures.

The sequenced IGI experiment consisted of three phases. Subjects were not told about any future tasks until they took place and did not know in advance how many decision-making tasks would be completed during the experiment. In phase 1 subjects first made lottery choices individually in the experimental laboratory. In phase 2 subjects then repeated the experiment as part of a randomly composed three-person group.[9] After completing the experiment as a group, subjects returned to the experimental laboratory and again repeated the experiment individually in phase 3. After subjects completed all three phases, a ten-sided die was rolled for each group and individual to determine the lottery outcomes for each phase. Payoffs were determined in this way to control for wealth effects (e.g. the phase 2 decision was not affected by the monetary outcome from the phase 1 decision).

Section 4: Experimental Results

The experimental results are analyzed in the following ways. First, the impact of subject demographics (e.g. race, gender, etc.) on individual lottery-choice decisions is examined. If demographics play an important role in explaining differences in individual decisions, then group composition should be taken into account when studying group decisions. To examine the role of subject demographics, a count-data Poisson regression model is estimated using the individual 10X (Ind 10X) and phase 1 sequenced IGI data, where the count of safe-lottery choices is the dependent variable. Second, group and individual decisions from the non-sequenced between-subjects treatment are compared for differences in the total number of safe lottery choices through a count-data regression. Further, the potential interaction between subject composition and lottery win percentage found by Shupp and Williams (2008) is investigated via a clustered-logit regression using the binary lottery choice (safe or risky) as the dependent variable. Finally, the results from the sequenced IGI experiment are examined to explore how individual decisions are aggregated to form a group decision and the impact of group decisions on subsequent individual lottery-choice decisions.

[9] Like the non-sequenced sessions, subjects were assigned to groups based on the number on the post-it note on their desk.

4.A: Subject Demographics

Demographic information was gathered by having subjects complete a survey following the lottery-choice experiment. Demographic effects are measured by a Poisson regression model using data from the Ind 10X experiment and phase 1 of the sequenced IGI experiment.[10] The dependent variable is the count of safe lottery choices, which serves as an indicator of risk preference.[11,12] The independent variables include dummies for Ind 10X, race (white=1, other=0), gender (male=1, female=0), income (low income of less than $5,000=1, income at least $5,000=0), student status (undergraduate=1, graduate=0), and major (mathematical=1, else=0).[13] Table 4 displays the regression results. A convenient way to interpret the regression coefficients in the Poisson model is to examine incidence-rate ratios (IRR), where $\mathrm{IRR} = e^{\beta_i}$. IRRs reveal the percentage change in the expected count of the number of safe lottery choices due to a change in the treatment condition, holding all other independent variables constant. For example, in Table 4, the Ind 10X treatment changes the expected frequency of safe lottery choices by a multiple of 0.992 compared to the phase 1 sequenced IGI treatment, a 0.8% decrease [i.e. 100*(IRR – 1)]. The null hypothesis of the data having a Poisson distribution is not rejected according to Pearson's chi-square goodness-of-fit test (p = 0.9886). Further, the overall regression is not significant (p = 0.7786). Thus, subject demographics are not likely to explain differences in the number of safe lotteries chosen by individuals. Also of interest, the regression does not support the payoff effect (larger lottery payoffs induce more risk aversion) found in the Holt and Laury

[10] See Cameron and Trivedi (2005, Chapter 20) and Long (1997, Chapter 8) for details on the Poisson regression model.

[11] Of course, decision errors or motivations other than maximization of expected utility from lottery payoffs could influence lottery choices. For example, subjects might derive some nonmonetary utility from the excitement of playing the risky lottery or from submitting choices that would please the experimenter. Furthermore, the effects of such anomalies might not be symmetric across individuals and groups.

[12] All results are also supported using only data where subjects made choices with a single switch point from the safe to the risky lottery. Four of 30 subjects in Ind 10X and nine of 45 subjects in phase 1 sequenced IGI submitted choices that contained more than one switch point and thus were not consistent with expected utility theory.

[13] Subjects majoring in a mathematical based discipline are more likely to be exposed to calculating expected values and using these calculations to guide their lottery-choice decisions. Mathematical majors considered here are Business, Accounting, Management, Marketing, Math, Economics, Risk Management, Engineering, and MBA students.

(2002) experiments. Raising the relatively small baseline lottery payoffs by a factor of 10 is apparently insufficient to raise inferred risk aversion levels in subjects.

4.B: Non-Sequenced Treatment

Table 5 and Figure 1 summarize the results of the Group 10X and Ind 10X lottery-choice experiments. The Group 10X data offers a cleaner picture of risk preferences than the Ind 10X data in that no group switches back to the safe lottery once they choose a risky lottery. Table 5 shows the average number of safe choices of both Ind 10X and Group 10X to be greater than four, the number consistent with risk-neutral preferences, with the Group 10X choices exhibiting slightly lower dispersion. This observation is confirmed by a sign test ($p < 0.01$) for both Ind 10X and Group 10X. A Poisson regression model is again used to examine variation in the number of safe-lottery choices, which is the dependent variable. The independent variables are dummies indicating Ind 10X and phase 2 sequenced IGI observations, where the latter captures the joint effect in the group-choice data of changing payoffs and any pure-sequencing effect associated with phase 2 decisions. The results of this regression are displayed in Table 6. The null hypothesis of the data having a Poisson distribution is not rejected by the Pearson chi-square goodness-of-fit test ($p = 0.9635$). The overall regression is not significant ($p = 0.966$). Therefore, there is no significant difference in total safe-lottery choices between groups and individuals and no payoff/sequencing effect for groups.[14]

Although, on average, there is no significant difference in the total count of safe-lottery choices, Figure 1 indicates a possible interaction effect of subject composition and lottery winning percentage on the probability of choosing the safe lottery. Even though the percentage of groups choosing the safe lottery is higher than the percentage of individuals in the 50%-60% lotteries, fewer groups than individuals deviate from the choice consistent with risk-neutral preferences in the highest-risk (10%-30%) and lowest-risk (80%-100%) lotteries. This possible interaction is similar to Shupp and Williams (2008) and Colombier et al. (2006). Recall the

[14] This result is also supported by a Wilcoxon rank-sum test ($p = 0.885$) using the total safe lottery choices of a subject as an observation.

finding of Shupp and Williams that group CERs were significantly lower than individual CERs in the lotteries with the lowest winning percentages (highest risk). For the highest winning-percentage (lowest-risk) lotteries, group CERs approached risk neutrality.[15] Colombier et al. (2006) also find a greater percentage of groups choose the safe lottery than individuals in the 50%-60% lotteries, consistent with more risk-averse preferences relative to individuals for those lotteries. When the lottery winning percentage is further increased, group choices are more consistent with risk neutrality than individuals.

To investigate the relationship between subject composition and lottery winning percentage, a logit regression is performed using the binary indicator of a safe choice as the dependent variable (safe=1, risky=0) with the independent variables consisting of a subject composition dummy (group=1, individual=0), the lottery winning percentage, and an interaction term. To account for the lack of independence across the ten lottery choices made by each individual or group, clustered-robust standard errors are utilized.[16] For the logit regression to be consistent with Figure 1, the coefficient on the lottery winning percentage is expected to be negative, because Figure 1 shows the average number of safe-lottery choices decreasing as the lottery winning percentage increases. The coefficient on the interaction term is expected to be negative. A negative interaction coefficient suggests that, as the winning-percentage increases, groups are less likely than individuals to choose the safe lottery. Finally, Figure 1 does not imply any specific sign on the group-decision dummy variable.

Table 7 presents the results of the clustered-logit regression. The regression coefficients match their expected signs, and all independent variables are significant. To further explain how

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[15] It must be noted that willingness to pay (WTP) differentials may exist between groups and individuals in this study, but are not captured by the lottery-choice method. Assuming a safe lottery choice means WTP safe > WTP risky, groups and individuals could have significant differences in WTP, but choose the same lottery. Holding the CER fixed across the lottery choices would result in choices consistent with risk-neutral preferences in this study no matter whether the CER is consistent with risk-averse or risk-preferring preferences.

[16] For a detailed discussion of the heteroskedasticity-robust Huber/White sandwich estimator of variance in clustered samples see, for example, Cameron and Trivedi (2005, Chapter 24, Section 24.5). The specific implementation utilized here is documented in Rogers (1993).

the independent variables influence the probability of choosing the safe lottery, Figure 2 displays the regression's predicted probability of choosing the safe lottery for different values of the independent variables. To examine whether the predicted probabilities for the group-interaction line are significantly different than the predicted probabilities for the individual line, a Wald test is conducted. The joint null hypothesis is that both the group dummy and interaction regression coefficients equal zero. The null hypothesis is rejected ($p = 0.018$) indicating that, similar to Shupp and Williams (2008), a significant interaction between group-versus-individual decision making and lottery winning percentage exists.[17]

4.C: Sequenced Individual-Group-Individual Treatment

In order to examine how individual decisions are aggregated to form a group decision and if interacting in a group immediately impacts subsequent individual decisions, a sequenced individual-group-individual experiment was conducted. The results from the sequenced experiment also offer a robustness check on the results from the non-sequenced experiment.

Figure 3 and Table 8 summarize the results of the sequenced IGI experiment. Again the group data is "cleaner" in that all groups submit choices that are consistent with expected utility theory in the sense that there is a unique switch point from the safe to the risky lottery.[18] Sign tests in each phase of the sequenced experiment (phase 1: $p = 0.0025$, phase 2: $p = 0.0010$, phase 3: $p = 0.0000$) indicate that subject choices in the sequenced experiment are, on average, consistent with risk aversion.

The analysis now turns to comparing the lottery decisions across each phase. Table 9 displays the number of safe choices for each group member and the mean number of safe choices of group members in phases 1 and 3, as well as the phase 2 group number of safe choices. Comparing phases 1 and 2, ten of fifteen groups choose more safe lotteries than the mean of its

[17] Significant differences for specific lottery pairings were examined via binomial tests and 95% confidence bands around logit predicted probabilities. Given the small sample sizes, the null of homogeneity between group and individual safe choices can not be rejected in 8 of 10 lotteries.

[18] Only 3 of 45 individuals in phase 3 submitted choices that were not consistent with expected utility theory, compared with 9 of 45 individuals in phase 1. The group discussion in phase 2 appears to increase the likelihood of individuals submitting a unique switch point.

members, two groups choose fewer safe lotteries than their member mean, and three groups choose the same number of safe lotteries as their member mean. A Wilcoxon signed-ranks matched-pairs test rejects the null hypothesis of equal population counts of safe choices between the phase-1 group-member mean and the phase-2 group decision ($p = 0.0342$).[19,20]

Figure 3 illustrates that phase-3 individual decisions appear to gravitate toward the phase-2 group decisions. To more formally examine the potential impact of group decisions on group members' subsequent individual decisions, an ordinary least-squares regression is conducted where the dependent variable is the change in an individual's safe-lottery count from phase 1 to phase 3 (phase 3 – phase 1). The independent variable is the difference between an individual's phase-1 safe-lottery count and the relevant group's safe-lottery count (phase 2 – phase 1). Clustered robust standard errors are estimated where clustering is by membership in a specific three-person group to account for the lack of independence in group members' phase-3 decisions following verbal interaction in phase 2. The coefficient of this regression is positive ($b = 0.6663$) and significant ($p = 0.001$), indicating that each positive difference in the number of safe choices the group made in phase 2 from the group member in phase 1 increases the change in the number of safe choices made by the group member in phase 3 from phase 1 by 0.67. Therefore, participating in phase 2 has a significant, positive impact on subjects' safe-lottery choices in phase 3.

Figure 3 also suggests the presence of an interaction effect of subject composition and winning percentage on the probability of choosing the safe lottery. Phase-2 groups appear to be deviating from the risk-neutral set of choices less than phase-1 individuals in the lowest and highest winning-percentage lotteries, but the reverse is true for the 50%-60% winning-percentage lotteries. The clustered-logit regression used to analyze the non-sequenced between-subject data

[19] After subjects interact in phase-2 groups it can not be assumed that the phase-3 individual decisions represent independent observations. Thus, matched-pairs tests employing phase-3 data are not reported.
[20] The same result is reached using the median as the group member average. However, it must be noted that the Wilcoxon signed-ranks matched-pairs test drops pairs that are equal, which occurs in 6 of the 15 phase median pairings in phases 1 and 2.

is also used to analyze the sequenced within-subject IGI data. The results appear in Table 10.[21] The winning-percentage coefficient is significantly negative, the group-decision phase-2 dummy coefficient is significantly positive, and the interaction coefficient is significantly negative. The regression's predicted probabilities of choosing the safe lottery calculated at various values of the independent variables are shown in Figure 4. A Wald test is again conducted to test whether or not a significant difference exists between the predicted probabilities shown in the phase-1 line and the phase-2 with interaction line. The joint null hypothesis that the phase-2 dummy and interaction regression coefficients equal zero is rejected (p = 0.02). Therefore, similar to the results from the non-sequenced sessions, a significant interaction exists between group-versus-individual decision making and lottery winning percentage.[22]

Section 5: Summary and Directions for Future Research

A lottery-choice experiment introduced by Holt and Laury (2002) is conducted where subjects choose between playing two lotteries, one "safe" (little monetary difference in lottery payoffs) and one "risky" (large monetary difference in lottery payoffs), with varying probabilities of receiving the higher monetary payoff. A decision maker's risk preference is inferred by comparing the actual count of safe lottery choices to the risk-neutral benchmark of always choosing the lottery with the highest expected monetary payoff. The research reported here examines whether three-person group decisions submitted after unstructured discussion among group members differ significantly from decisions submitted by isolated individuals. The experimental design also addresses whether making decisions as a group impacts subsequent individual behavior. It is found that, consistent with the results reported in previous experimental research, individual lottery-choice decisions tend to exhibit risk aversion as revealed by the count of safe lotteries chosen. This basic risk-aversion result is found to extend to three-person group decisions.

[21] For the sequenced-decisions clustered-logit results to be compared with the non-sequenced results, it is assumed that the phase-1 individual decisions and phase-2 group decisions are independent.
[22] Again, the null hypothesis of homogeneity between group and individual decisions for specific lottery pairings can not be rejected for each of the 10 lotteries.

Using payoff levels ten times the baseline of Holt and Laury (2002), Poisson regression analysis reveals that gender, race, educational indicators, and other demographic factors do not significantly influence the (nonnegative integer count of) safe-lottery choices by isolated individuals. Independent samples of three-person group versus individual lottery-choice decisions compared using Poisson regression reveal that there is not a significant difference in the average number of safe lotteries chosen. However, a logit regression model utilizing clustered-robust standard errors reveals that the probability of choosing the safe lottery is significantly affected by an interaction between subject composition (group or individual) and the lottery winning percentage. Relative frequency plots of safe-lottery choices for each lottery pairing illustrate that groups tend to deviate less frequently than individuals from the risk-neutral lottery choice in the lowest winning-percentage (10%-30%) lottery pairs (the safe lottery) and the highest winning-percentage (80%-100%) lottery pairs (the risky lottery). However, focusing on the small sample of data from a single win-percentage lottery, the difference in safe-lottery choice frequency tends not to be statistically significant. An interaction between subject composition and lottery winning percentage was previously reported by Shupp and Williams (2008) using a maximum willingness-to-pay risk-preference measure that is quite different than the lottery-choice procedure utilized here. In a recent working paper, Colombier, et al. (2006) also interpret their lottery-choice experiments as being generally consistent with the results reported by Shupp and Williams.

Data from a three-phased sequenced individual-group-individual experiment reveal that, using a Wilcoxon matched-pairs test, the count of safe-lottery choices submitted by three-person groups (in phase 2) is significantly greater than the mean of the group members (in phase 1). Further, an OLS regression model reveals that participating in the phase-2 unstructured group discussion appears to have a significant impact on the subsequent (phase 3) individual group-member decision relative to the original pre-discussion (phase 1) individual decision. Post-discussion individual decisions tend to move toward the group decision. Finally, consistent with the non-sequenced between-subjects data, relative frequency plots supported by a logit regression model with robust-clustered standard errors suggest that the phase-1 (individual) and phase-2 (group) sequenced lottery-choice data are influenced by a significant interaction between subject composition (group or individual) and the lottery winning percentage.

Further research addressing the existence of risk-preference differentials revealed by small-groups versus isolated individuals can address a variety of interesting issues. Obviously, larger sample sizes and careful replication by other researchers using different participant populations is always useful to nail down empirical stylized facts. Beyond pure replication, additional sequenced experiments using either a lottery-choice procedure or a lottery willingness-to-pay elicitation procedure are needed to investigate the existence and importance of pure order effects. In particular, a series of at least three decisions by isolated individuals would be an interesting exploration of learning and the stability of various risk-preference measurements. Individual choice variation or convergence patterns over time could be contrasted with similar experiments using groups of various sizes and various rules for coming to a group decision. While sequenced experiments examining individual, group, and subsequent individual or group decisions are also important, the independence issues raised for decision data subsequent to having participants freely interact in groups are problematic. Also, it remains to be seen whether the payoff-magnitude effects reported by Holt and Laury (2002), where larger payoffs tend to result in more risk-averse decisions, will extend to small-groups and risk-preference measurement procedures other than the Holt-Laury lottery choice game.

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Table 1: Summary of Experimental Sessions

Treatment	# of Sessions	# of Subjects	Mean Earnings	Minimum Earnings	Maximum Earnings
Ind 10X	2	30	$14	$1	$16
Group 10X	2	45	$24.83	$16	$38.50
Sequenced IGI	3	45	$6.91	$3.70	$11.55

Note: An unrelated dictator/charitable giving experiment was conducted after the lottery-choice experiment in all sessions. The amount used in this experiment varied between experimental sessions. The main goal of this additional event was to raise subject earnings in the sequenced IGI experiments to the range of those in the Group 10X experiments.

Table 2: Lottery Expected Values (per subject) for the Ind 10x and Group 10X Experiment

	Lottery 1	Lottery 2	Lottery 3	Lottery 4	Lottery 5	Lottery 6	Lottery 7	Lottery 8	Lottery 9	Lottery 10
Choice A	$16.40	$16.80	$17.20	$17.60	$18.00	$18.40	$18.80	$19.20	$19.60	$20
Choice B	$4.75	$8.50	$12.25	$16	$19.75	$23.50	$27.25	$31.00	$34.75	$38.50

Table 3: Lottery Expected Values (per subject) for the Sequenced IGI Experiment

	Lottery 1	Lottery 2	Lottery 3	Lottery 4	Lottery 5	Lottery 6	Lottery 7	Lottery 8	Lottery 9	Lottery 10
Choice A	$1.64	$1.68	$1.72	$1.76	$1.80	$1.84	$1.88	$1.92	$1.96	$2.00
Choice B	$0.48	$0.85	$1.23	$1.60	$1.98	$2.35	$2.73	$3.10	$3.48	$3.85

Table 4: Poisson Count-Data Regression: Individual Data

Dependent variable: total number of safe choices

Dependent Variable	Incidence-Rate Ratio (IRR)	Standard Error	Z	p-value
ind10x	0.99227	0.116226	-0.07	0.947
white	1.097571	0.128932	0.79	0.428
male	0.985219	0.107088	-0.14	0.891
lowinc	1.02049	0.113529	0.18	0.855
undergrad	0.840803	0.097382	-1.5	0.134
mathmajor	0.972362	0.105147	-0.26	0.795

n = 75, McFadden's pseudo R^2 = 0.011, Ho: dependent variable is Poisson distributed: p = 0.989

Table 5: Number of safe Lottery Choices

	Individual 10X	Group 10X
Mean	5.67	5.73
Median	6	6
SD	2.12	1.28
Max	10	8
Min	0	3
n	30	15

Table 6: Poisson Count-Data Regression Comparing Group and Individual Data

Dependent variable: total number of safe choices

Independent Variable	Incidence-Rate Ratio (IRR)	Standard Error	Z	p-value
Ind10x	0.988372	0.130788	-0.09	0.93
phase2igi	1.023256	0.155156	0.15	0.879

n = 60, McFadden's pseudo R^2 = 0.0003, Ho: dependent variable is Poisson distributed: p = 0.964

Table 7: Clustered Logit Regression: Group 10X and Individual 10X Experiments

Dependent variable: safe=1, risky=0

Independent Variable	Coefficient	Robust Clustered Standard Error	Z	p-value
win percentage	-6.3819	1.2450	-5.13	0.000
group	5.3950	2.1711	2.48	0.013
interaction	-8.6443	3.1477	-2.75	0.006
constant	3.9727	0.9072	4.38	0.000

n = 450, McFadden's pseudo R^2 = 0.4585

Table 8: Number of Safe Lottery Choices: Sequenced IGI

	Phase 1	Phase 2	Phase 3
Mean	5.38	5.87	5.64
Median	5	6	6
SD	1.28	0.83	1.09
Max	8	7	9
Min	3	4	4
n	45	15	45

Table 9: Number of Safe Lottery Choices: Sequenced IGI

Group	Mem1 Ph1 safe	Mem2 Ph1 safe	Mem3 Ph1 safe	Ph1 mean	Phase 2 (group)	Mem1 Ph3 safe	Mem2 Ph3 safe	Mem3 Ph3 safe	Ph3 mean
1	5	7	5	5.67	6	5	6	4	5
2	7	6	4	5.67	6	7	6	5	6
3	4	3	3	3.33	4	5	4	4	4.33
4	8	4	6	6	6	6	4	5	5
5	4	6	7	5.67	6	4	5	7	5.33
6	6	4	5	5	5	6	4	5	5
7	5	5	8	6	5	5	5	6	5.33
8	4	5	6	5	6	6	5	6	5.67
9	6	5	6	5.67	5	5	5	6	5.33
10	7	4	6	5.67	7	8	4	7	6.33
11	7	5	5	5.67	7	7	6	6	6.33
12	6	6	5	5.67	7	6	6	7	6.33
13	7	5	4	5.33	6	6	6	6	6
14	6	5	7	6	6	6	6	6	6
15	4	6	3	4.33	6	5	6	9	6.67

Table 10: Clustered Logit Regression: Sequenced IGI

Dependent variable: safe=1, risky=0

Independent Variable	Coefficient	Clustered Robust Standard Error	Z	p-value
win percentage	-9.4698	1.6847	-5.62	0.000
phase 2	9.7449	3.5107	2.78	0.006
interaction	-14.5928	5.2184	-2.80	0.005
constant	5.5724	1.0357	5.38	0.000

n = 600, McFadden’s pseudo R^2 = 0.5856

Figure 1: Percent Choosing Safe Lottery: Group and Individual 10X

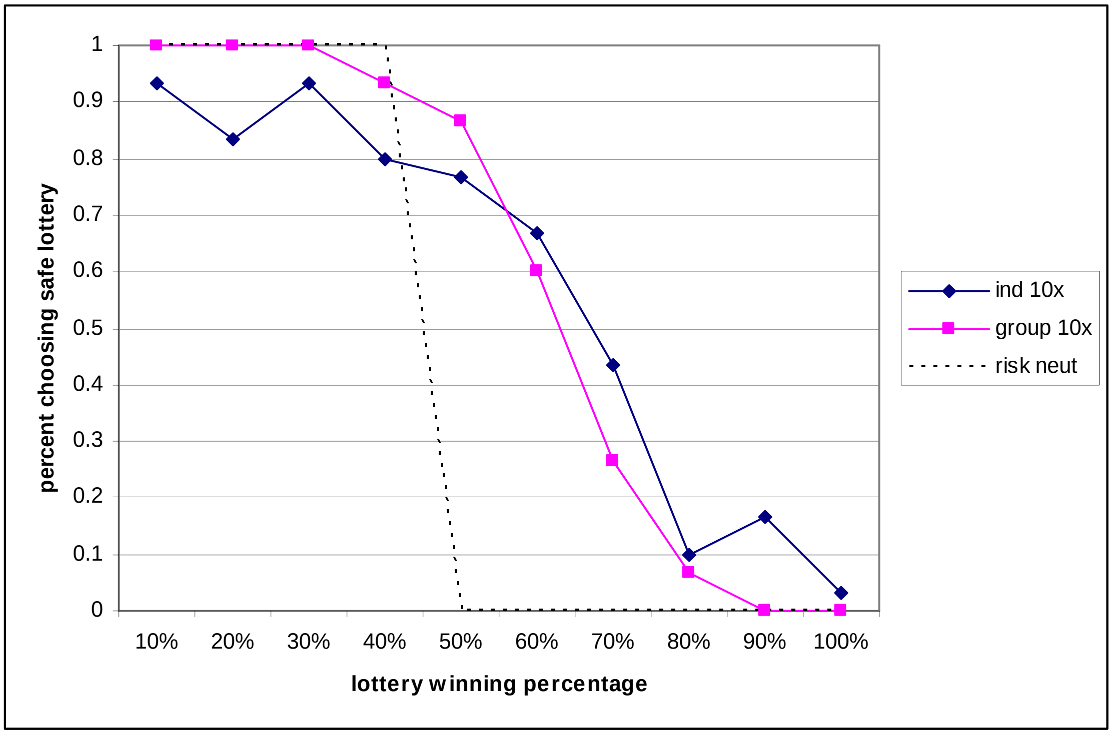


Figure 2: Logit Predicted Probabilities of Safe Lottery Choice: Group and Individual 10X

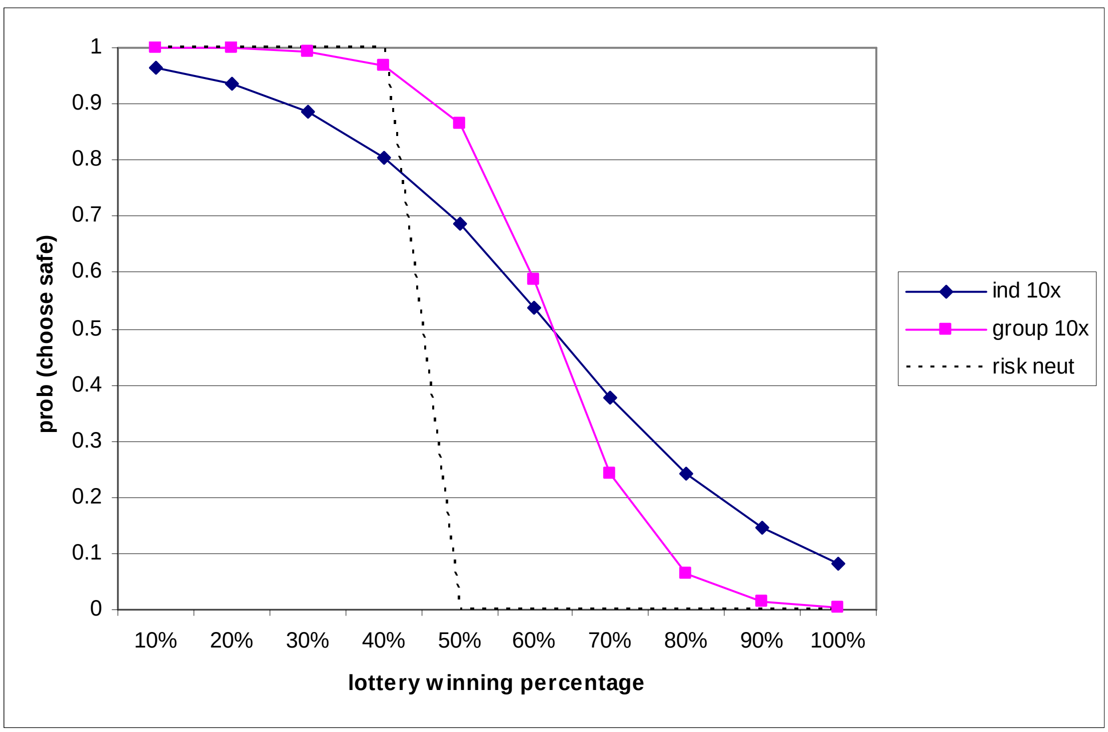


Figure 3: Percent Choosing Safe Lottery: Sequenced IGI

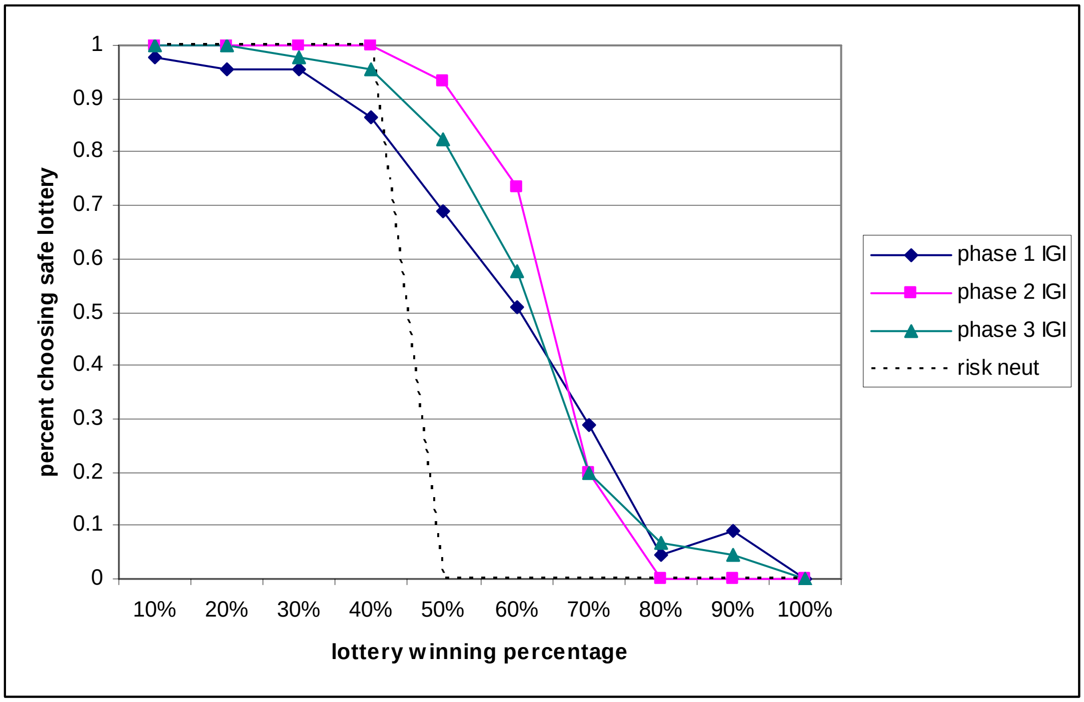
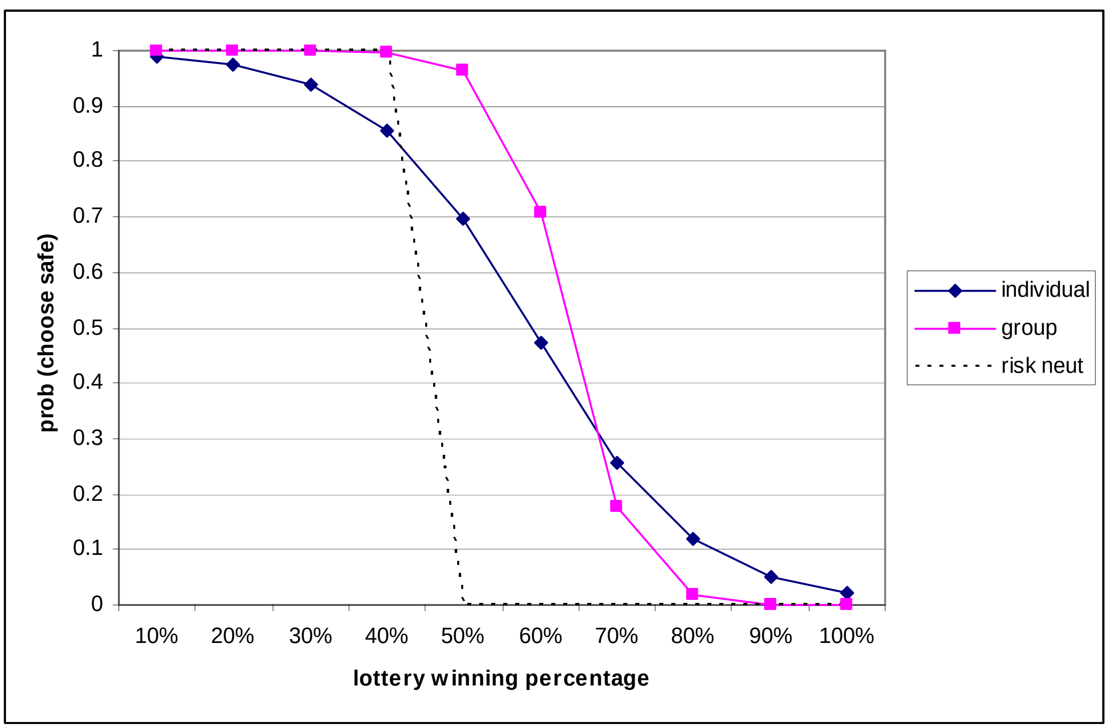


Figure 4: Logit Predicted Probabilities of Safe Lottery Choice: Sequenced Individual (Phase 1) and Group (Phase 2)



Appendix: Lottery-Choice Instructions and Decision Sheets

Group Decision Choice Experiment

The blue sheet of paper shows ten decisions. Each decision is a paired choice between "Option A" and "Option B." Your group will make ten choices by circling the option in the box to the right of the options, but only one of them will be used in the end to determine your group's earnings. Group earnings will be equally shared between all group members. Before your group starts making the ten choices, please let me explain how these choices will affect your group's earnings and the group decision-making process.

Here is a ten-sided die that will be used to determine payoffs; the faces are numbered from 1 to 10 (the "0" face of the die will serve as 10). After your group has made all of the choices, we will throw this die twice, once to select one of the ten decisions to be used, and a second time to determine what your group's payoff is for the option you choose, A or B, for the particular decision selected. Even though your group will make ten decisions, only one of these will end up affecting your earnings, but your group will not know in advance which decision will be used. Obviously, each decision has an equal chance of being used in the end.

Now, please look at Decision 1 at the top. Option A pays $60 if the throw of the die is 1, and it pays $48 if the throw is 2-10. Option B yields $115.50 if the throw of the die is 1, and it pays $3 if the throw is 2-10. The other decisions are similar, except that as you move down the table, the chances of the higher payoff for each Option increase. In fact, for Decision 10 in the bottom row, the die will not be needed since each Option pays the highest payoff for sure, so your group's choice here is between $60 and $115.50.

To summarize, your group will make ten choices: for each decision row your group will have to choose between Option A and Option B. Your group may choose A for some decision rows and B for other rows, and your group may change choices and make them in any order. Your group makes choices by circling "A" or "B" in the box next to the options for each decision. After your group has made all 10 choices, each member should sign on the second page of the Decision Sheet and please alert the experimenter to submit your group's decisions.

After your group has submitted its decisions, we will throw the ten-sided die once to select which one of the ten Decisions will be used. Then we will throw the die a second time to determine your group's money earnings for the Option your group chose for that decision. You will be paid all earnings in cash when we finish.

So now please look at the decisions on the blue sheet. Your group will have to choose A or B for each of these decisions, and then the die throw will determine which one is going to count. We will look at the decision that your group made for the choice that counts, and then the second die throw will determine your group's earnings for this part. The experimenter will then report your group's earnings to you.

Are there any questions? Now turn to the following page and let me describe the group decision-making process.

Group Decision-Making Process

Your group has 20 minutes to make choices for all ten decisions. Your group can reach a unanimous choice any way you choose. To ensure that the group unanimously agrees on the choices, each group member will sign their name on the Lottery-Decision Sheet stating they agree to the choices on the sheet before they submit the sheet to the experimenter. If your group cannot reach a unanimous choice for a particular decision, each group member will privately submit a choice, and the choice of the majority of group members will be the group choice for that decision.

Are there any questions? Now your group may begin making choices. Please do not talk with anyone outside of your group while we are doing this; raise your hand if you have a question.

Individual 10X Lottery-Choice Decision Sheet

ID:________ Group:________

	Option A	Option B	Your Choice A or B
Decision 1	\$20.00 if throw of die is 1 \$16.00 if throw of die is 2-10	\$38.50 if throw of die is 1 \$1.00 if throw of die is 2-10	
Decision 2	\$20.00 if throw of die is 1-2 \$16.00 if throw of die is 3-10	\$38.50 if throw of die is 1-2 \$1.00 if throw of die is 3-10	
Decision 3	\$20.00 if throw of die is 1-3 \$16.00 if throw of die is 4-10	\$38.50 if throw of die is 1-3 \$1.00 if throw of die is 4-10	
Decision 4	\$20.00 if throw of die is 1-4 \$16.00 if throw of die is 5-10	\$38.50 if throw of die is 1-4 \$1.00 if throw of die is 5-10	
Decision 5	\$20.00 if throw of die is 1-5 \$16.00 if throw of die is 6-10	\$38.50 if throw of die is 1-5 \$1.00 if throw of die is 6-10	
Decision 6	\$20.00 if throw of die is 1-6 \$16.00 if throw of die is 7-10	\$38.50 if throw of die is 1-6 \$1.00 if throw of die is 6-10	
Decision 7	\$20.00 if throw of die is 1-7 \$16.00 if throw of die is 8-10	\$38.50 if throw of die is 1-7 \$1.00 if throw of die is 8-10	
Decision 8	\$20.00 if throw of die is 1-8 \$16.00 if throw of die is 9-10	\$38.50 if throw of die is 1-8 \$1.00 if throw of die is 9-10	
Decision 9	\$20.00 if throw of die is 1-9 \$16.00 if throw of die is 10	\$38.50 if throw of die is 1-9 \$1.00 if throw of die is 10	
Decision 10	\$20.00 if throw of die is 1-10	\$38.50 if throw of die is 1-10	

Decision used:_______ Die Throw:_______ Your earnings:_______

Group 10X Lottery-Choice Decision Sheet

ID:________ Group:________

	Option A	Option B	Your Choice A or B
Decision 1	$60.00 if throw of die is 1 $48.00 if throw of die is 2-10	$115.50 if throw of die is 1 $3.00 if throw of die is 2-10	
Decision 2	$60.00 if throw of die is 1-2 $48.00 if throw of die is 3-10	$115.50 if throw of die is 1-2 $3.00 if throw of die is 3-10	
Decision 3	$60.00 if throw of die is 1-3 $48.00 if throw of die is 4-10	$115.50 if throw of die is 1-3 $3.00 if throw of die is 4-10	
Decision 4	$60.00 if throw of die is 1-4 $48.00 if throw of die is 5-10	$115.50 if throw of die is 1-4 $3.00 if throw of die is 5-10	
Decision 5	$60.00 if throw of die is 1-5 $48.00 if throw of die is 6-10	$115.50 if throw of die is 1-5 $3.00 if throw of die is 6-10	
Decision 6	$60.00 if throw of die is 1-6 $48.00 if throw of die is 7-10	$115.50 if throw of die is 1-6 $3.00 if throw of die is 6-10	
Decision 7	$60.00 if throw of die is 1-7 $48.00 if throw of die is 8-10	$115.50 if throw of die is 1-7 $3.00 if throw of die is 8-10	
Decision 8	$60.00 if throw of die is 1-8 $48.00 if throw of die is 9-10	$115.50 if throw of die is 1-8 $3.00 if throw of die is 9-10	
Decision 9	$60.00 if throw of die is 1-9 $48.00 if throw of die is 10	$115.50 if throw of die is 1-9 $3.00 if throw of die is 10	
Decision 10	$60.00 if throw of die is 1-10	$115.50 if throw of die is 1-10	

Decision used:_______ Die Throw:_______ Your earnings:_______

Sequenced IGI Individual Lottery-Choice Decision Sheet

ID:________ Group:________

	Option A	Option B	Your Choice A or B
Decision 1	\$2.00 if throw of die is 1 \$1.60 if throw of die is 2-10	\$3.85 if throw of die is 1 \$0.10 if throw of die is 2-10	
Decision 2	\$2.00 if throw of die is 1-2 \$1.60 if throw of die is 3-10	\$3.85 if throw of die is 1-2 \$0.10 if throw of die is 3-10	
Decision 3	\$2.00 if throw of die is 1-3 \$1.60 if throw of die is 4-10	\$3.85 if throw of die is 1-3 \$0.10 if throw of die is 4-10	
Decision 4	\$2.00 if throw of die is 1-4 \$1.60 if throw of die is 5-10	\$3.85 if throw of die is 1-4 \$0.10 if throw of die is 5-10	
Decision 5	\$2.00 if throw of die is 1-5 \$1.60 if throw of die is 6-10	\$3.85 if throw of die is 1-5 \$0.10 if throw of die is 6-10	
Decision 6	\$2.00 if throw of die is 1-6 \$1.60 if throw of die is 7-10	\$3.85 if throw of die is 1-6 \$0.10 if throw of die is 6-10	
Decision 7	\$2.00 if throw of die is 1-7 \$1.60 if throw of die is 8-10	\$3.85 if throw of die is 1-7 \$0.10 if throw of die is 8-10	
Decision 8	\$2.00 if throw of die is 1-8 \$1.60 if throw of die is 9-10	\$3.85 if throw of die is 1-8 \$0.10 if throw of die is 9-10	
Decision 9	\$2.00 if throw of die is 1-9 \$1.60 if throw of die is 10	\$3.85 if throw of die is 1-9 \$0.10 if throw of die is 10	
Decision 10	\$2.00 if throw of die is 1-10	\$3.85 if throw of die is 1-10	

Decision used:_______ Die Throw:_______ Your earnings:_______

Sequenced IGI Group Lottery-Choice Decision Sheet

ID:________ Group:________

	Option A	Option B	Your Choice A or B
Decision 1	\$6.00 if throw of die is 1 \$4.80 if throw of die is 2-10	\$11.55 if throw of die is 1 \$0.30 if throw of die is 2-10	
Decision 2	\$6.00 if throw of die is 1-2 \$4.80 if throw of die is 3-10	\$11.55 if throw of die is 1-2 \$0.30 if throw of die is 3-10	
Decision 3	\$6.00 if throw of die is 1-3 \$4.80 if throw of die is 4-10	\$11.55 if throw of die is 1-3 \$0.30 if throw of die is 4-10	
Decision 4	\$6.00 if throw of die is 1-4 \$4.80 if throw of die is 5-10	\$11.55 if throw of die is 1-4 \$0.30 if throw of die is 5-10	
Decision 5	\$6.00 if throw of die is 1-5 \$4.80 if throw of die is 6-10	\$11.55 if throw of die is 1-5 \$0.30 if throw of die is 6-10	
Decision 6	\$6.00 if throw of die is 1-6 \$4.80 if throw of die is 7-10	\$11.55 if throw of die is 1-6 \$0.30 if throw of die is 6-10	
Decision 7	\$6.00 if throw of die is 1-7 \$4.80 if throw of die is 8-10	\$11.55 if throw of die is 1-7 \$0.30 if throw of die is 8-10	
Decision 8	\$6.00 if throw of die is 1-8 \$4.80 if throw of die is 9-10	\$11.55 if throw of die is 1-8 \$0.30 if throw of die is 9-10	
Decision 9	\$6.00 if throw of die is 1-9 \$4.80 if throw of die is 10	\$11.55 if throw of die is 1-9 \$0.30 if throw of die is 10	
Decision 10	\$6.00 if throw of die is 1-10	\$11.55 if throw of die is 1-10	

Decision used:_______ Die Throw:_______ Your earnings:_______