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Stress induces contextual blindness in lotteries and coordination games *

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Abstract

In this paper, we study how stress affects risk taking in three tasks: individual lotteries, Stag Hunt (coordination) games and Hawk-Dove (anti-coordination) games. Both control and stressed subjects take more risks in all three tasks when the value of the safe option is decreased and in lotteries when the expected gain is increased. Also, subjects take longer to take decisions when stakes are high, when the safe option is less attractive and in the conceptually more difficult Hawk-Dove game. Stress (weakly) increases reaction times in those cases. Finally, our main result is that the behavior of stressed subjects in lotteries, Stag Hunt and Hawk-Dove are all highly predictive of each other (p-value < 0.001 for all three pairwise correlations). Such strong relationship is not present in our control group. Our results illustrate a "contextual blindness" caused by stress. The mathematical and behavioral tensions of Stag Hunt and Hawk-Dove games are axiomatically different, and we should expect different behavior across these games, and also with respect to the individual task. A possible explanation for the highly significant connection across tasks in the stress condition is that stressed subjects habitually rely on one mechanism to make a decision in all contexts whereas unstressed subjects utilize a more cognitively flexible approach.

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1 Introduction

How does stress influence human behavior? While a significant amount of the work in this direction connects chronic stress with poor health outcomes, stress has also been shown to influence decision-making. The pioneering theory suggests that any stress above an optimal level unambiguously decreases performance (Yerkes-Dodson Law, Yerkes and Dodson (1908)). In spite of this Law's intuitive appeal, subsequent research has unveiled a far more subtle relationship between stress and choice, even in purely objective tasks.[1] In particular, the recent literature has shown a complex relationship between stress and an individual's preference to take risks (reviews in Mather and Lighthall (2012) and Starcke and Brand (2012)). Studies using incentivized lotteries find that stressed males choose more risky lotteries while stressed females choose less risky lotteries (Preston et al., 2007; Van Den Bos et al., 2009; Lighthall et al., 2009).[2] In addition, compared to a one-time increase in stress, chronic stress experienced over the course of eight days has been shown to more significantly increase risk-aversion (Kandasamy et al., 2014). Finally, cortisol has been shown to play a role in the preference of subjects to avoid ambiguity - a concept closely related to risk (Danese et al., 2017).

There is also a small literature studying the relationship between individual lotteries and two-player coordination ("Stag Hunt") and anti-coordination ("Hawk-Dove") strategic situations (or "games"). Results in this area are inconclusive. While some papers suggest a correlation between risk taking in individual lotteries and risk taking in Stag Hunt games (Heinemann et al., 2009; Chierchia and Coricelli, 2015), others do not find any significant relationship (Neumann and Vogt, 2009; Al-Ubaydli et al., 2013; Büyükboyacı, 2014). Imaging studies have found correlations in neural activity between choices in lotteries and Stag Hunt games but no correlation between choices in lotteries and Hawk-Dove games or between choices in the two games (Nagel et al., 2014). The authors conclude that Stag Hunt games engage brain networks associated to risk while Hawk-Dove games engage brain networks associated to strategic thinking.

Our paper lies at the intersection of these two literatures by studying the effect of stress on risk-taking in lotteries and multi-player games of strategy - Stag Hunt and Hawk-Dove.[3] Our laboratory experiment relies on a novel way to represent these three

[1]For example, subjects under stress are less accurate at identifying visual cues located on the periphery of their vision, but these same subjects are actually *more accurate* than their non-stressed counterparts at identifying cues directly in front of them (Hockey, 1970).

[2]A differential effect across gender is not surprising since, in general, stress is theorized to affect men and women differently (Taylor et al., 2000).

[3]There is also a literature relating stress to behavior in multi-person games. However, it is only tangentially related to our work as it focuses mainly on the effect of stress on prosocial or anti-social behavior (see Buchanan and Preston (2014) and Van Den Bos and Flik (2015) for summaries).

tasks in an identical context that differs in the minimal amount to uniquely distinguish each task (Figure 1). Using this method, differences in behavior across tasks can best be explained by cognitive flexibility in response to fundamental differences across tasks rather than spurious differences in presentations.

Our first result is to show that subjects in both the control and stress condition behave in line with our theoretical predictions. In particular, our participants take more risks in all three tasks as the value of the safe option is decreased. They also take more risks in the individual lottery choice as the probability of the high payoff is increased (Result 1). Our second and main result is that stress impairs cognitive flexibility. More precisely, the choices made by stressed subjects in lotteries, Stag Hunt and Hawk-Dove are all highly and positively correlated with each other. In contrast, control subjects show a (weak) correlation between lotteries and Stag Hunt and no significant correlation between the other pairs of tasks. A cluster analysis reveals that about one-half of the subjects under stress allocate a similar and significant fraction of their endowment to the safe option in all tasks. These subjects are responsible for strengthening the behavioral relationship between tasks (Result 2). Finally, we show that subjects take more time to respond when stakes are high, when the safe option is less attractive and in Hawk-Dove (arguably, the conceptually more difficult game). Stress also tends to increase reaction times in all tasks (Result 3).

The findings suggest that some subjects under stress are oblivious to the fundamental differences that distinguish the three tasks (objective probabilities of lotteries, strategic complementarity of risk-taking in Stag Hunt, and strategic substitutability of risk-taking in Hawk-Dove). This *contextual blindness* fits in with recent findings which demonstrate that stress promotes habits in humans at the expense of goal-directed performance (Schwabe and Wolf, 2009). It has been shown that people under stress have an increased reliance on automatic over controlled cognitive processes (Schwabe et al., 2012) and are less likely to adjust their initial strategies (Kassam et al., 2009). Taken together, the results provide a framework for stress inducing intuitive, rather than deliberative, decision-making (Yu, 2016). Interestingly, previous research on decision-making under risk and stress has made it clear that "such habitual responses do not map neatly onto risk-aversion or risk-seeking" (Buchanan and Preston, 2014). Our paper shows that, rather than a story connecting stress and risk preferences, there is a more complex relationship between stress and risk evaluation across contexts.

A main implication of contextual blindness is that subjects under stress are generally more predictable. Knowing a subject's behavior in any one task is highly predictive of his behavior in the other two tasks. In addition, stress may affect the way we view the agency of our opponent. In our experiment, the behavior of stressed subjects was similar whether they were facing an objective probability or a strategic opponent. When facing an opponent, they expected the same behavior in games that are opposite in nature. One implication from this is that stress causes people to treat others as if they have less sophistication or less agency, which may have other ramifications in social settings.

The paper is organized as follows. Section 2 describes our experimental design and predictions, with particular emphasis on the methodological contributions. Section 3 analyzes the aggregate data in each task and treatment. Section 4 studies the effect of stress on decision-making both across and within tasks, which provides our main result pertaining to contextual blindness. Section 5 investigates how stress and task complexity affect reaction times. Section 6 concludes.

2 Design and procedures

2.1 Experimental design

We first describe our experimental design. Further details regarding implementation, timing, and exclusion criteria are relegated to Appendix A1.

Stress inducement and hormonal analysis. To induce a stress response in our treatment group, we closely followed the protocol of the Socially Evaluated Cold Pressor Test (SECPT - Schwabe et al. (2008)). This task requires subjects to place their hand in ice water while their face is video recorded. All 72 subjects in the stress group successfully passed our requirements for completing the SECPT. To measure hormonal changes, we followed the "passive drool" protocol provided by the laboratory that ran our assay analysis (ZRT Labs). Each subject was required to submit 3 saliva samples in order to collect data on their baseline, peak, and end cortisol levels. All samples were viable and were used to measure the amount of circulating cortisol.

Timeline and saliva sample collection. Since stress responses widely vary across individuals, we followed most of the literature on stress (Preston et al., 2007; Van Den Bos et al., 2009; Lighthall et al., 2009) and implemented a between-subjects design, with *Control* and *Stress* subjects (such method also avoids learning and endowment effects). The timeline of the experiment was the following. First, we provided detailed instructions of the tasks and performed a comprehension quiz. Subjects submitted their "Baseline" saliva sample. Subjects in the control treatment started the tasks immediately after the Baseline sample, whereas subjects in the stress treatment performed the SECPT before starting the tasks. 25 minutes after the Baseline saliva sample, all subjects were instructed to stop making choices in the task, and we collected the "Peak" saliva sample. Subjects completed the remaining tasks along with a brief demographic survey. They were shown all their choices and outcomes and provided the “End” saliva sample. One outcome was then randomly chosen by the computer to be used for payment.

Participants and sessions. The study was reviewed by the University Park Institutional Review Board at the University of Southern California (UP-14-00663). Experiments were conducted at the Los Angeles Behavioral Economics Laboratory (LABEL) at the University of Southern California. To participate in the experiment, subjects could not eat, drink anything other than water, smoke, exercise, ingest caffeine, or chew gum within one hour upon arriving at the laboratory. Subjects were also excluded if they had been asleep within two hours prior to arriving at the lab or used any lip products at any time after 8AM on the day of the experiment.

All sessions started at 3PM and lasted no longer than 5:15PM. They had either 6 or 8 subjects with, at most, two more subjects of one gender in a session. We gathered data on a total of 144 subjects. One subject (stress group) was excluded due to a baseline cortisol 15 times the average of the sample, so our data is comprised of the choices of 143 subjects (71 stress, 66 female).

2.2 Tasks

Each subject made choices in three experimental tasks: individual lotteries (**LO**), Stag Hunt games (**SH**), and Hawk-Dove games (**HD**). All three tasks have a *Safe* option S and a two-state *Risky* option, R_H and R_L, so that $R_L < S < R_H$. The inherent nature of risk in each task differs. **LO** is an individual choice problem, where the (objective) probability of earning R_H, $p \equiv \Pr(R_H)$, is known before the choice is made. **SH** and **HD** are two-person, simultaneous, non-cooperative games, where the probability of earning R_H depends on the choice of another subject in the room. In **SH**, the probability of earning R_H is *increasing* in the level of risk chosen by the other subject (a coordination game where risk-taking is a strategic complement), whereas in **HD** it is *decreasing* in the level of risk chosen by the other subject (an anti-coordination game where risk-taking is a strategic substitute). The basic structure of the tasks is summarized in Table 1.[4]

To implement these three tasks, we construct the following novel design. In each round, subjects are given 100 tokens, that they must allocate between the *Safe* and *Risky* options (neutrally labelled “Option A” and “Option B” in the experiment). The computer then randomly selects a ball from an urn with 100 green and orange balls (see below). For any

[4]As it is well-know, **SH** is a coordination game with two pure-strategy equilibria (*Safe-Safe* and *Risky-Risky*) and one mixed-strategy equilibrium whereas **HD** is an anti-coordination game with two pure-strategy equilibria (*Safe-Risky* and *Risky-Safe*) and one mixed-strategy equilibrium.

Lotteries - **LO**	
Risky:	$\begin{cases} R_H \text{ w.p. } p \\ R_L \text{ w.p. } 1-p \end{cases}$
Safe:	S

Stag Hunt - **SH**

	Risky	*Safe*
Risky	R_H, R_H	R_L, S
Safe	S, R_L	S, S

Hawk-Dove - **HD**

	Risky	*Safe*
Risky	R_L, R_L	R_H, S
Safe	S, R_H	S, S

Table 1: Experimental tasks

token allocation x ($\in \{0, ..., 100\}$) to *Safe* and $100 - x$ to *Risky*, the payoff obtained by the subject is:

$$\frac{x}{100}S + \frac{100-x}{100}R_H \quad \text{if the computer draws a green ball}$$
$$\frac{x}{100}S + \frac{100-x}{100}R_L \quad \text{if the computer draws an orange ball}$$

In words, each token allocated to *Safe* yields $\frac{S}{100}$ whereas each token allocated to *Risky* yields either $\frac{R_H}{100}$ or $\frac{R_L}{100}$. As x decreases, the spread between the payoff if the computer draws a green and an orange ball increases. If the subject sets $x = 100$, she obtains S for sure. If the subjects sets $x = 0$, she obtains either R_H (green ball) or R_L (orange ball).

As described, for each token allocated to *Risky*, the probability of earning payoffs $\frac{R_H}{100}$ and $\frac{R_L}{100}$ are simply the proportion of green balls and orange balls in the computer's urn, respectively. The only difference between our three tasks –**LO**, **SH** and **HD**– is the way in which the number of green and orange balls is determined:

- In **LO**, the number of green and orange balls is fixed and known (given by p).
- In **SH**, the number of green and orange balls is equal to the number of tokens that the participant with whom the subject is matched allocates to *Risky* and *Safe*, respectively.
- In **HD**, the number of green and orange balls is equal to the number of tokens that the participant with whom the subject is matched allocates to *Safe* and *Risky*, respectively.

In addition, in **SH** and **HD** subjects are told that their choice affects the number of green and orange balls in the urn of the participant with whom they are matched in the exact same way. That is, in **SH** (**HD**) the more tokens a subject allocates to *Risky*, the *more* (*less*) likely it is that the other participant earns R_H.

Figure 1 provides screenshots of the **LO** (top), **HD** (bottom left) and **SH** (bottom right) tasks. At the top of the screen, the subject is told the current task (neutrally labelled as "Method 1", "Method 2" and "Method 3" respectively). She is also reminded how the number of green and orange balls in her urn is determined. At the center of the screen, the subject can observe the parameters of the current round. In these three tasks, $S = \$21$, $R_H = \$53$ and $R_L = \$13$. At the bottom of the screen, there is a slider that the subject can use to allocate her 100 tokens across *Safe* and *Risky*. As the subject moves the slider to test different token allocations, the earnings for each ball color are calculated and presented in real-time on the screen. In all three screenshots, the subject has set $x = 29$. After the subject is satisfied with the allocation of tokens, she has to click the "CONFIRM" button to submit her choice.

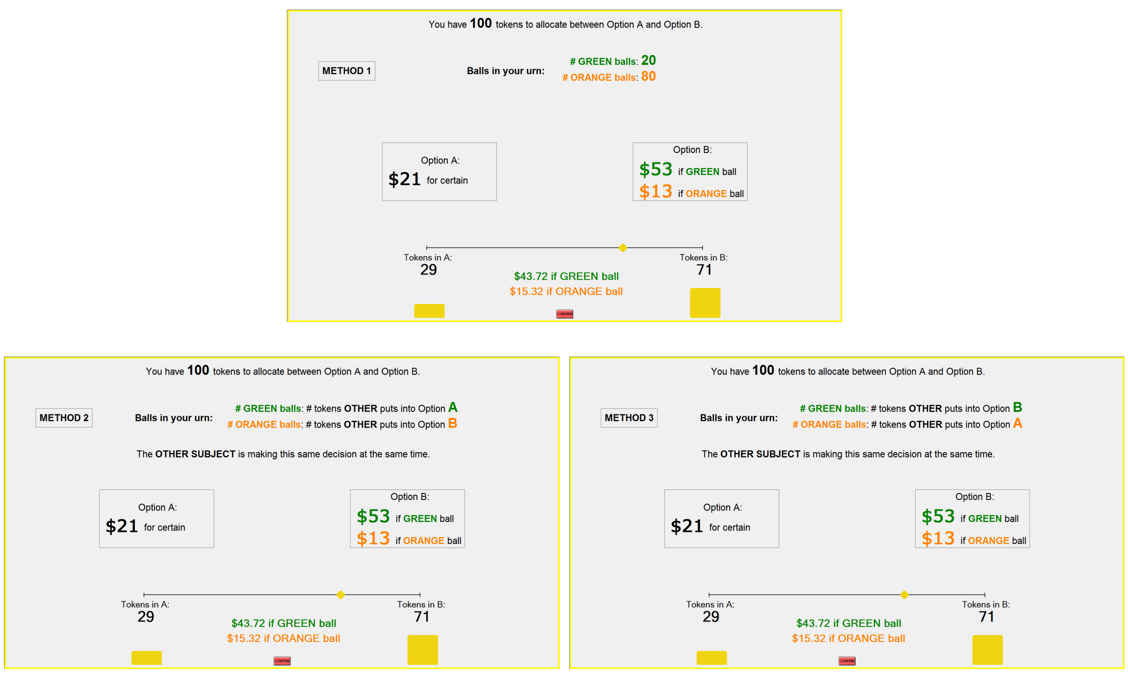


Figure 1: Screenshot of **LO** (Method 1), **HD** (Method 2) and **SH** (Method 3)

Our experiment has two methodological contributions that we would like to emphasize. First, the contextual presentation of the three tasks is almost identical. Only the information concerning the determination of green and orange balls is changed. Capturing the inherently different natures of risk in such a symmetric way serves an important purpose: different behavior is likely to be only in response to the meaningful differences between these tasks, rather than to superficial differences in presentation or comprehension. Second, endowing subjects with 100 tokens that can be allocated across *Safe* and *Risky* can be used to measure "interior" behavior. In lotteries, it is analogous to portfolio diversification. In games, it is analogous to allowing subjects to play mixed strategies. In both cases, it provides more information than the standard binary choice method.

2.3 Payoff-variants, stakes and equilibria

Subjects played a total of 48 rounds, 16 rounds of each task all with different payoffs. The experiment was broken up into blocks of 4 consecutive rounds of the same task, and all sessions started with a **LO** block, which was arguably simpler. Before each block, subjects were shown a screen reminding them that a new block was starting. This screen ensured that subjects would be aware of which task (**LO**, **SH**, or **HD**) they were playing next. For the games, subjects were randomly and anonymously rematched after each round. For the lotteries, they were playing an individual decision problem (the exact experimental instructions are in Appendix B). To avoid learning effects, subjects did not see the behavior of their partner nor the color of the ball drawn by the computer in each round. At the end of the 48 rounds, subjects observed all their choices and those of their partners. One round was randomly drawn by the computer and the outcome in that round was used for payment. Subjects earned an average of \$31, with a minimum of \$1 (twice) and a maximum of \$53 (three subjects). In addition to these earning, all subjects were paid a \$5 show-up fee.

We chose the payoffs in order to provide substantial variation in monetary stakes and equilibrium predictions. First, define:

$$\Delta \equiv R_H - R_L \tag{1}$$

as a measure of the monetary *stakes*. For all tasks, we set $\Delta \in \{10, 20, 30, 40\}$. In the analysis, we will refer to "low stakes" as $\Delta \in \{10, 20\}$ and "high stakes" as $\Delta \in \{30, 40\}$. Second, given a triplet (R_L, S, R_H), the mixed-strategy Nash equilibrium of the **SH** game is:

$$\alpha \equiv \frac{S - R_L}{R_H - R_L} \tag{2}$$

where α is the probability of choosing *Risky*. For each Δ, we choose (R_L, S, R_H) so that $\alpha \in \{0.2, 0.4, 0.6, 0.8\}$. This gives 16 combinations of stakes and mixed equilibrium predictions in **SH**. Finally, notice that once we fix Δ, then α is proportional to S the payoff of the *Safe* option.

Notice that for a given triplet (R_L, S, R_H), the mixed-strategy Nash equilibrium of **HD** is:

$$1 - \alpha \equiv \frac{R_H - S}{R_H - R_L} \tag{3}$$

where $1-\alpha$ is the probability of choosing *Risky*. Therefore, the same payoff-triplets as in **SH** provide also 16 combination of stakes ($\Delta \in \{10, 20, 30, 40\}$) and mixed-strategy equilibria ($1-\alpha \in \{0.8, 0.6, 0.4, 0.2\}$) in **HD**. Last, we use the technique developed by Jessie and Kendall (2015) to select the payoffs in a way that the differences between games are only in the component that the Nash Equilibrium uses to make predictions. Table 2 provides a sample of eight games used in the experiment and Appendix A2 provides the entire list.

SH ($\alpha = 0.2$, $\Delta = 40$)

	Risky	*Safe*
Risky	53, 53	13, 21
Safe	21, 13	21, 21

SH ($\alpha = 0.4$, $\Delta = 30$)

	Risky	*Safe*
Risky	43, 43	13, 25
Safe	25, 13	25, 25

SH ($\alpha = 0.6$, $\Delta = 20$)

	Risky	*Safe*
Risky	36, 36	16, 28
Safe	28, 16	28, 28

SH ($\alpha = 0.8$, $\Delta = 10$)

	Risky	*Safe*
Risky	30, 30	20, 28
Safe	28, 20	28, 28

HD ($1-\alpha = 0.8$, $\Delta = 40$)

	Risky	*Safe*
Risky	13, 13	53, 21
Safe	21, 53	21, 21

HD ($1-\alpha = 0.6$, $\Delta = 30$)

	Risky	*Safe*
Risky	13, 13	43, 25
Safe	25, 43	25, 25

HD ($1-\alpha = 0.4$, $\Delta = 20$)

	Risky	*Safe*
Risky	16, 16	36, 28
Safe	28, 36	28, 28

HD ($1-\alpha = 0.2$, $\Delta = 10$)

	Risky	*Safe*
Risky	20, 20	30, 28
Safe	28, 30	28, 28

Table 2: Examples of payoff-variants in **SH** and **HD** tasks

Finally, to create the **LO** tasks, we choose the payoffs (R_L, S, R_H) of the **SH** and **HD** games corresponding to the extreme mixed-strategy Nash equilibria of the games: $\alpha = 0.2$ and $\alpha = 0.8$. Using these payoffs, we set the lottery probability of the high payoff R_H to $p = 0.2$ and $p = 0.8$. Creating four lotteries in this way for $\Delta \in \{10, 20, 30, 40\}$ yields a total of 16 **LO** tasks. Table 3 provides some examples of lotteries.

LO ($\alpha = 0.2$; $\Delta = 40$; $p = 0.8$)		**LO** ($\alpha = 0.2$; $\Delta = 30$; $p = 0.2$)		**LO** ($\alpha = 0.8$; $\Delta = 20$; $p = 0.8$)		**LO** ($\alpha = 0.8$; $\Delta = 10$; $p = 0.2$)	
Safe:	21 w.p. 1	*Safe*:	22 w.p. 1	*Safe*:	30 w.p. 1	*Safe*:	28 w.p. 1
Risky:	53 w.p. 0.8	*Risky*:	46 w.p. 0.2	*Risky*:	34 w.p. 0.8	*Risky*:	30 w.p. 0.2
	13 w.p. 0.2		16 w.p. 0.8		14 w.p. 0.2		20 w.p. 0.8

Table 3: Examples of payoff-variants in **LO** tasks

2.4 Predictions

Our model has three parameters (Δ, α, p) in the **LO** tasks and two parameters (Δ, α) in the **SH** and **HD** tasks.

Predictions in **LO** are standard. Fixing the other two parameters, *Risky* becomes more attractive as p increases (first-order stochastic increase in the risky option) and α decreases (S closer to R_L). The effect of Δ is less clear. For example, increasing Δ makes *Risky* more desirable when $p = 0.8$ and $\alpha = 0.2$ and less desirable when $p = 0.2$ and $\alpha = 0.8$.

Predictions in **SH** and **HD** are more subtle. By construction, in all 32 rounds there are two pure-strategy and one mixed-strategy equilibria. Subjects may move from one equilibrium to another, so behavior depends crucially on beliefs about the other player's action and comparative statics should be taken with a grain of salt. However, fixing the belief about the other player's constant, it seems intuitive that *Risky* is more attractive in both **SH** and **HD** as the sure payoff S becomes closer to R_L, that is, as α decreases. Again, the effect of changes in the spread of payoffs Δ is more nuanced and depends on the position of S.

Finally, there are also interesting differences between **SH** and **HD**. **SH** is a coordination game, where risk-taking behavior is a strategic complement. This means that, holding constant the belief about the opponent, a decrease in α offers the subject more incentives to take risks. Furthermore, the subject realizes that the opponent also has more incentives to take risks, reinforcing the value of playing *Risky*. By contrast, **HD** is an anti-coordination game where risk-taking behavior is a strategic substitute. As α decreases, the subject has more incentives to choose *Risky* but realizes that the opponent has the same incentives, which decreases the value of risk-taking. Overall, strategic considerations make comparative statics significantly easier to evaluate when incentives of players are aligned (**SH**) than when they are not (**HD**).

3 Aggregate results

3.1 Stress

Figure 2 shows the evolution of cortisol levels throughout the experimental sessions in both treatments. Each dot represents the average level of salivary cortisol samples (ng/mL) taken at baseline, peak, and end of the experiment. The control and stress groups start with statistically indifferent levels of average cortisol (2.42 vs. 2.75; two-sided Welch t-test, p-value $= 0.133$). The stress group experiences a large and statistically significant increase in average cortisol (2.75 vs. 5.16; p-value < 0.001). In comparison, the control group experiences a slight and statistically significant decrease in average cortisol (2.42 vs. 2.03; p-value $= 0.022$). Higher cortisol levels are also observed in the stress group in the end sample (1.81 vs. 3.14; p-value < 0.001).

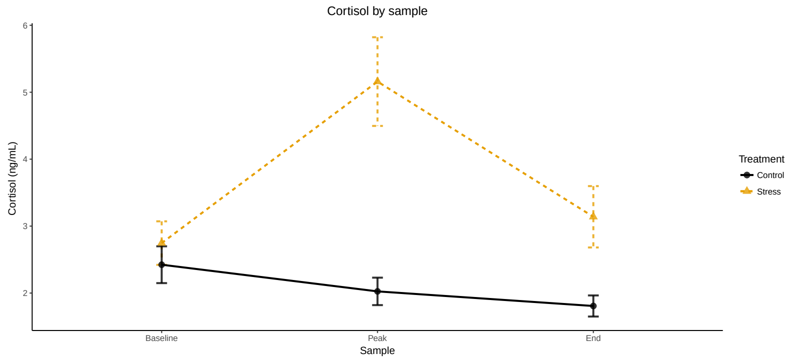


Figure 2: Cortisol levels over time

3.2 Allocation between options

The average proportion of wealth invested in *Safe* is 0.63 in **LO**, 0.53 in **SH** and 0.65 in **HD**. Results between lotteries and games are not directly comparable. By contrast, results between the two games are comparable since the 16 rounds of **SH** involve the same payoff triplets (R_L, S, R_H) as the 16 rounds of **HD**. We notice a significantly lower allocation to *Safe* in **SH** than in **HD** (t-test, p-value < 0.001).

3.3 Testing the theory

Behavior in lotteries. Choices in **LO** conformed to the theoretical predictions. Holding Δ constant, the proportion allocated to *Safe* increased as α increased and as p decreased for all stakes and in both treatments. Overall, subjects were (weakly) risk averse. They invested, on average, 97% of the endowment in *Safe* when the expected value of *Risky* was below the *Safe* option, against 70% when it was equal and 17% when it was above the *Safe* option.[5] Finally, the proportion in *Safe* was significantly lower in the low stakes rounds ($\Delta \in \{10, 20\}$) compared to the high stakes rounds ($\Delta \in \{30, 40\}$) under stress (p-value $= 0.035$) but only marginally in the control group (p-value $= 0.051$).

Behavior in games. The proportion of wealth allocated to *Safe* varied with α as predicted in section 2.4. In **SH** and keeping beliefs constant, increasing α makes *Safe* more attractive for a subject and, as the same logic applies for the partner, higher allocation rates in *Safe* are expected. Table 4 (left) shows that this is exactly how subjects behave

[5]Since virtually no subject exhibited risk-loving preferences, the four **LO** rounds where *Risky* has lower expected value than the *Safe* option contain no extra information. As a robustness check, we conducted the entire analysis of the paper without these four rounds. All the results were statistically identical.

for all stake levels. The average fraction allocated to *Safe* was significantly different between all pairs of α for all Δ (p-values < 0.05). In **HD** and keeping beliefs constant, increasing α (that is, decreasing $1-\alpha$) makes again *Safe* more attractive and should push more subjects to invest in *Safe*. However, they should expect their partner to also invest more in *Safe*, which should ultimately reduce the incentives to invest in that option. This implies that the response to an increase in α in **HD** should be less pronounced than in **SH**. Empirically, Table 4 (right) shows that increasing α made subjects invest significantly more in *Safe* for all pairs of α and all Δ (p-values < 0.05).[6] Finally, we also computed for each individual the average increase in the fraction allocated to *Safe* between $\alpha = 0.2$ and $\alpha = 0.8$ in both **SH** and **HD**. We found a statistically higher increase in **SH** than in **HD** (0.56 vs. 0.43, p-value < 0.001), suggesting that subjects understood the difference between the strategic complementarity and the strategic substitutability of risk-taking in these two tasks. Last and as noted before, there is no particular reason to observe an aggregate effect of stakes in behavior. Empirically, we found none.

SH	Stakes (Δ)			
	40	30	20	10
$\alpha = 0.2$	.31	.27	.19	.23
$\alpha = 0.4$	.49	.46	.41	.41
$\alpha = 0.6$	.66	.61	.62	.69
$\alpha = 0.8$	.75	.83	.80	.82

HD	Stakes (Δ)			
	40	30	20	10
$\alpha = 0.2$	.49	.49	.36	.41
$\alpha = 0.4$	.59	.58	.55	.52
$\alpha = 0.6$	.73	.72	.72	.78
$\alpha = 0.8$	.83	.83	.89	.89

Table 4: Allocation to *Safe* as a function of α and Δ by game (pooled treatments)

Result 1 *On aggregate, subjects behave in accordance with our predictions: the allocation to the safe option is increasing in α in all three tasks and decreasing in p in lotteries. Changes in stakes have no systematic effect on behavior.*

4 Stress

4.1 Stress and tasks

We noted a slight increase in the average proportion allocated to *Safe* in the stress treatment in all tasks compared to the control treatment (0.64 vs. 0.63 in **LO**, 0.55 vs. 0.52 in **SH**, and 0.65 vs. 0.65 in **HD**). However, the differences were not statistically significant. As presented in Figure 3, the cumulative distribution functions of the average amounts

[6] Recall that in **SH**, α is the probability of playing *Risky* in the mixed strategy equilibrium. In **HD**, $1-\alpha$ is the probability of playing *Risky* in the mixed strategy equilibrium.

allocated to *Safe* were also similar across treatments in all three tasks, with no statistically significant effect according the Kolmogorov-Smirnoff test (p-value = 0.31 in **LO**, p-value = 0.31 in **SH**, and p-value = 0.97 in **HD**). Overall, we found no evidence that stress affected behavior within each task.

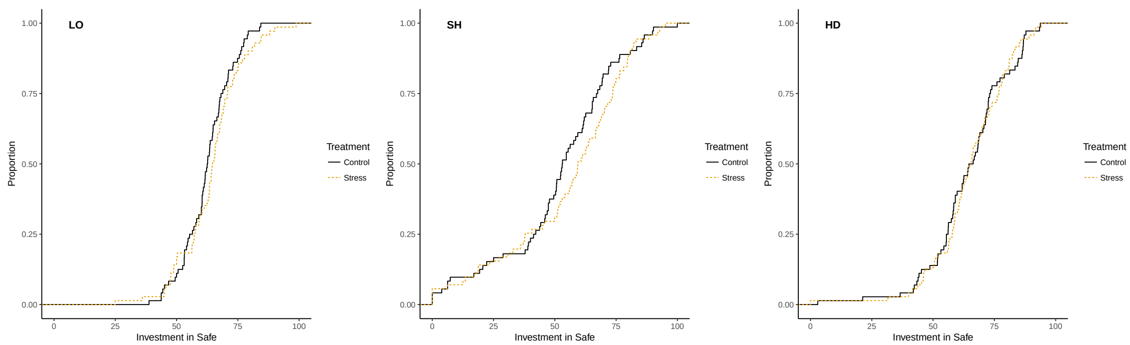


Figure 3: Distribution of average amounts in *Safe* by task and treatment

The existing literature is ambiguous on this issue. Some studies have found that stress affects behavior in lotteries (Preston et al., 2007; Van Den Bos et al., 2009; Lighthall et al., 2009) whereas others found no effect of stress (von Dawans et al., 2012; Gathmann et al., 2014). Differences in responses to stress may be attributed to differences across studies in risk elicitation methods (BART, IGT, objective lotteries) and experimental procedures (presence/absence of incentives, hypothetical/real choices, different stressors). For instance, it may be that the emotional component contained in the BART experiment (anticipation of the balloon explosion and visual representation of such explosion) is responsible for shifts in behavior. Moreover, in BART and IGT subjects are typically *not* informed of the objective probabilities of the events. This ambiguity component may also trigger different thought processes that are differentially affected by stress (Buckert et al., 2014; Danese et al., 2017).

4.2 Stress and gender

In Table 5 we present the differences in allocation across gender. In the control condition, females allocate significantly more to *Safe* than males in **LO** and **SH** but not in **HD**. In the stress condition we find no significant gender differences in any task.

Our data contribute to gender research in three ways. First, the fact that women take less risk in **LO** in the control group aligns with earlier literature (Charness and Gneezy, 2012). Second, finding males in the control group to be more cooperative in **SH**

	Control			*Stress*		
	Female	Male	difference. [p-value]	Female	Male	difference [p-value]
LO	.65	.60	0.045	.66	.62	0.194
	(.018)	(.014)		(.023)	(.020)	
SH	.59	.46	0.015	.60	.51	0.143
	(.039)	(.037)		(.042)	(.040)	
HD	.66	.63	0.554	.68	.63	0.112
	(.033)	(.022)		(.024)	(.027)	
	(standard errors in parenthesis)			(standard errors in parenthesis)		

Table 5: Average allocation to *Safe* by gender, treatment and task

contributes to our understanding of gender differences in coordination games. However, we are hesitant to extrapolate about general inclinations to cooperate since, as suggested by Croson and Gneezy (2009), gender differences seem to be highly sensitive to context. Finally, since the only significant gender differences are found in the control group, we conclude that stress has the capability to diminish differences between genders.

4.3 The effect of stress on the relationship between tasks

Our next question is whether the willingness of individuals to choose *Risky* is correlated across tasks. On the one hand, it seems natural that subjects who are less risk-averse, that is, those who invest more in *Risky* in **LO** (individual lotteries with objective probabilities) are also expected to take more risks in games. On the other hand, this may not be necessarily true since our games have multiple equilibria, so risk-taking in **SH** and **HD** depends crucially on beliefs about the other player's behavior. Furthermore, the two games are fundamentally opposite in the optimal reaction to the other player's choice (coordination vs. anti-coordination). Table 6 presents the Pearson correlation coefficient (ρ) of the proportion allocated to *Safe* by individuals across tasks, both in the control (left panel) and stress (right panel) conditions.

In the control condition, the amount allocated to *Safe* in **LO** is significantly correlated with the amount allocated to *Safe* in **SH**, suggesting that risk attitude is a reasonably good predictor of behavior in the coordination game. This finding aligns with previous studies showing a correlation between **LO** and **SH** choices (Heinemann et al., 2009; Chierchia and Coricelli, 2015). By contrast, the control condition shows no significant correlation between **LO** and **HD** or between **SH** and **HD**. This may not be surprising given the

	Control			*Stress*	
	LO	**SH**		**LO**	**SH**
SH	0.347**	—	**SH**	0.416***	—
HD	0.147	0.117	**HD**	0.461***	0.497***

$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 6: Correlation of individual risk taking behavior across tasks by treatment.

previous research showing that these tasks activate different areas of the brain (Ekins et al., 2013; Nagel et al., 2014).

By contrast, in the stress condition, the amounts allocated to *Safe* are significantly correlated across all tasks. Correlations are also stronger, suggesting that risk-taking under stress is very similar across tasks, irrespective of the situation. This important result indicates that, even though stress did not have an effect on the overall distribution of risk taking in the population across tasks, it did affect intra-personal decisions. The result was confirmed by a set of robust regressions (available upon request) which showed that the relationship between the amount allocated to *Safe* in **LO**, **SH** and **HD** were stronger and more significant under stress than in the control treatment.

A possible explanation for this result is that subjects under stress (and only those subjects) exhibit contextual blindness, that is, they ignore the context that distinguishes these three tasks. Indeed, **LO** measures an individual's propensity to take risks which has no social context. **SH** captures a tension between risk and cooperation whereas **HD** captures a tension between risk and aggression. The experiment was designed so that these contexts were the only difference between tasks. Table 6 reveals that the behavior of stressed subject when faced with an objective probability over earnings was strongly and positively correlated with their behavior when faced with a strategic opponent, even if games were opposite in nature. For control subjects there was only a relationship between **LO** and **SH**. In other words, control subjects responded more to the differing contexts than stressed subjects. One implication is that the choices of subjects under stress are generally more predictable: knowing the average amount a subject invests into *Safe* in any one task provides significant information about behavior in the other two.

We also ran OLS regressions of the trial-by-trial amounts allocated to *Safe* for each game and in each condition. We used as regressors the individual average amount allocated to *Safe* in **LO** (which captures the risk attitude of each individual), and dummies for stakes (1 = High stakes), for the position of S relative to R_L and R_H (α), and for gender (1 = Male). The results are compiled in Table 7.

	Control		*Stress*	
	SH	**HD**	**SH**	**HD**
Lottery	0.70*	0.23	0.78***	0.55***
	(0.27)	(0.20)	(0.22)	(0.13)
Male	-10.07	-1.27	-5.52	-3.64
	(5.29)	(3.97)	(5.46)	(3.35)
High Stakes	0.28	0.05	4.87**	3.42*
	(1.68)	(1.54)	(1.60)	(1.46)
$\alpha = 0.8$	55.3***	39.3***	54.9***	44.6***
	(2.37)	(2.18)	(2.27)	(2.07)
$\alpha = 0.6$	40.4***	30.6***	38.9***	29.6***
	(2.37)	(2.18)	(2.27)	(2.07)
$\alpha = 0.4$	17.5***	13.1***	20.9***	11.3***
	(2.37)	(2.18)	(2.27)	(2.07)
Constant	-15.4	30.23*	-23.2	8.9
	(18.0)	(13.5)	(15.1)	(9.3)
Observations	1,152	1,152	1,136	1,136
FE groups	72	72	71	71
df	9	9	9	9
Log-likelihood	-5559	-5447	-5429	-5300
BIC	11182	10957	10922	10663

Note: (standard errors in parenthesis) $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

Table 7: OLS of investment in *Safe* in **SH** and **HD** including fixed effects

In the *Control* condition, the average allocation to *Safe* in **SH** is predicted by the behavior in **LO**, but the average allocation in **HD** is not. In the *Stress* condition, the average amounts allocated to *Safe* in both **SH** and **HD** are highly predicted by behavior in **LO**. These regressions further confirm the contextual blindness result.[7] We also notice that gender has no explanatory power and that the allocation to the safe choice is increased for high stakes, but only in the *Stress* condition.

[7]We also ran the same OLS regressions with the behavior in the other game as an extra regressor. Results and significance were very similar. Furthermore, and confirming the results in Table 6, the new variable had a positive and significant coefficient in the *Stress* regressions and a positive but not significant coefficient in the *Control* regressions. Notice that a two-censored non-linear Tobit model would allow for censoring at 0 and 100 but requires analysis at the subject-average level since it cannot account for subject-level fixed effects. The average data was rarely censored at either 0 or 100 which makes such a model inappropriate.

	Control			*Stress*			
	C1	C2	C3	S1	S2	S3	S4
Male / Female	29 / 21	9 / 4	0 / 9	12 / 5	10 / 6	15 / 20	2 / 1
% *Safe* in **LO**	60.9	58.7	77.7	65.1	52.6	69.1	66.3
	(1.11)	(2.87)	(1.62)	(1.30)	(2.25)	(1.74)	(21.7)
% *Safe* in **SH**	56.0	12.1	86.0	50.9	27.9	73.4	10.3
	(1.49)	(2.88)	(2.42)	(3.13)	(5.02)	(1.71)	(10.3)
% *Safe* in **HD**	64.2	60.5	72.5	61.4	54.5	74.7	32.0
	(1.87)	(6.23)	(6.86)	(2.46)	(2.89)	(1.64)	(16.2)

Table 8: Endogenous clusters in each condition (standard errors in parenthesis)

4.4 Cluster analysis

The fact that stress does not have any visible effect on aggregate behavior (section 4.1) but reduces gender differences (section 4.2) and impacts the relationship between tasks (section 4.3) is puzzling. We therefore decided to study in more detail the behavior of individuals across the three tasks.

We conducted a cluster analysis in each condition to group subjects according to their average allocation to *Safe* in each task. We retained a model-based clustering method to identify the clusters present in our population. A wide array of heuristic clustering methods are commonly used but they typically require the number of clusters and the clustering criterion to be set ex-ante rather than endogenously optimized. Mixture models, on the other hand, treat each cluster as a component probability distribution. Thus, the choice between numbers of clusters and models can be made using Bayesian statistical methods (Fraley and Raftery, 2002). We implemented our model-based clustering analysis with the Mclust package in R (Fraley and Raftery, 2006). We considered ten different models with a maximum of nine clusters each, and retained the cluster combination that yielded the minimum Bayesian Information Criterion (BIC). In the *Control* condition, the best model consisted of three clusters (C1, C2 and C3). In the *Stress* condition, four different clusters best summarized behavior (S1, S2, S3 and S4). Table 8 summarizes the descriptive statistics in each cluster.

In the *Control* condition, the majority of the subjects (C1) exhibited the typical behavior: they invested similar proportions in the *Safe* asset in **LO** and **HD** and less in **SH**, suggesting large homogeneity across subjects in this treatment. A few individuals (C2) were an extreme version of this typical play, with overly risky behavior in **SH**. Finally, a minority of all female subjects (C3) allocated significantly more to *Safe* in **LO** and **HD**, but especially in **SH**. This group was responsible for the gender effect detected in **LO** and **SH** in the control condition.

In the *Stress* condition, there were three main clusters (S4 consists of 3 outliers), similar to the clusters obtained in the control condition. Cluster S1 was the analog of C1, while S2 was similar to C2, except for a safer proportion of choices in **SH**. However, half of the subjects were now grouped in S3, a cluster similar to C3. These subjects allocated a large fraction of their endowment to *Safe* in all tasks. S3 had also the particularity that allocations were extremely similar across tasks (69.1% to 74.7% with low standard errors). These subjects were responsible for strengthening the relationship between tasks. Moreover, there was no gender supremacy in that cluster, causing the gender effect observed in the control condition to disappear under stress.

Result 2 *Aggregate behavior is similar across treatments whereas individual choices are affected by stress. A significant fraction of participants in the stress condition are subject to contextual blindness, choosing a similar allocation independently of the task.*

5 Reaction times

Task difficulty. In Table 9 we report the average reaction time (RT) in seconds separated by task and treatment.

	LO	**SH**	**HD**	**All**
Control	25.6	24.2	28.2	26.0
	(0.71)	(0.61)	(0.62)	(0.37)
Stress	27.3	25.7	31.1	28.0
	(0.71)	(0.65)	(0.73)	(0.40)
Difference [p-value]	0.087	0.097	0.002	< 0.001

(standard errors in parenthesis)

Table 9: Reaction time by task and treatment

Making choices took more time under stress across all tasks, although the effect was mostly due to **HD**. We also found that RT were longer in **HD** compared to **SH** irrespective of the treatment ($p < 0.001$), consistent with the idea that the anti-coordination game is more complex to evaluate than the coordination game.

Attention in lotteries. As reflected in Table 10, risky options with expected value below the safe alternative (EV $<S$) were quickly discarded. Subjects took significantly more time to choose when the expected value of the risky option was equal (EV $=S$) or greater (EV $>S$) than the safe option (t-test, p-value <0.01 for all paired comparisons in *Control* and *Stress* treatments). For the more complex lotteries (EV $>S$), subjects took slightly more time under stress, although not significantly so.

	Control	*Stress*	Difference [p-value]
EV $<S$	19.8	19.6	0.937
	(1.51)	(1.59)	
EV $=S$	28.6	30.3	0.420
	(1.59)	(1.51)	
EV $>S$	25.6	28.7	0.173
	(1.51)	(1.70)	

Table 10: Reaction time in lotteries by treatment and expected value of lottery (EV)

Attention in games. Table 11 presents the reaction times in **SH** and **HD** as a function of the parameters of the games, α and Δ.

	α				Δ	
	0.2	0.4	0.6	0.8	high	low
SH						
Control	24.1	28.2	22.7	21.6	27.7	20.6
	(1.74)	(1.76)	(1.53)	(1.49)	(1.64)	(1.21)
Stress	26.6	30.5	23.8	21.6	28.5	22.9
	(1.72)	(1.93)	(1.62)	(1.68)	(1.64)	(1.47)
HD						
Control	29.7	33.5	28.4	21.8	31.4	25.0
	(1.54)	(1.86)	(1.75)	(1.31)	(1.54)	(1.23)
Stress	35.1	34.8	31.6	24.2	35.0	27.2
	(1.94)	(1.93)	(2.24)	(1.74)	(1.82)	(1.36)

Table 11: Reaction time in games as a function of α and Δ

In **SH**, we found that RT were shorter for higher α: shortest at $\alpha = 0.8$ and longest at $\alpha = 0.4$ in both conditions (t-tests of difference, $p < 0.01$ in both conditions). We also found that RT were longer in high stakes than in low stakes rounds (t-test of difference, $p < 0.001$ in *Control* and $p = 0.012$ in *Stress*). The trend was identical in **HD**, with shortest RT at $\alpha = 0.8$ and longest at $\alpha = 0.4$ in the control group and $\alpha = 0.2$ in the stress group (t-tests of difference, $p < 0.001$ in both conditions). RT were also longest in high stakes trials (t-test of difference, $p < 0.001$ in both groups). It is unclear why α significantly affects reaction times in the games. In both **SH** and **HD**, increasing α makes the safe option relatively more valuable. It is plausible that *Safe* becomes easier to evaluate as it becomes more attractive, resulting in a quicker response. As for stakes, we conjecture that subjects find the decision to be more important (hence, more worthy of attention) when, other things being equal, the set of payoffs is more spread out. In any case, the consistency of the reaction time comparative statics across games and conditions is remarkable and deserves further investigation. Finally, in **SH** there was no effect of stress. In **HD**, there was an increase in RT under stress only when $\alpha = 0.2$ ($p = 0.030$) and when stakes were high ($p = 0.015$), suggesting an interaction between game complexity and difficulty to evaluate alternatives. It is also consistent with studies showing that stress affects working memory and executive decision-making. High levels of cortisol have been associated with more errors in card sorting tasks meant to measure executive functioning (McCormick et al., 2007) as well as O-span and backwards digit-span tasks meant to measure working memory (Schoofs et al., 2009). While our finding reflects the intuition behind results showing stressed subjects performing worse on more complicated tasks (Schoofs et al., 2009), our contribution shows that more complicated decisions also take longer (in our setting, there are no right or wrong decisions). This finding illustrates an important difference between how stressed subjects reach decisions in strategic games versus in working memory or executive functioning tasks.

We then conducted a mixed effect OLS regression to better analyze the contribution of each effect to reaction times in both games. For both **SH** and **HD**, we regressed reaction times on a Treatment dummy (1 = *Stress*), a Gender dummy (1 = Male), a Stakes dummy (1 = High stakes), and dummies identifying the level of α in each round. The results are reported in Table 12. They confirm the effect of high stakes and α levels reported above. Stress and gender did not have significant effects.

Result 3 *Reaction times are higher in the conceptually more difficult game **HD**, in the more complex rounds of **LO**, when stakes are high and when the safe option is intrinsically less attractive in **SH** and **HD**. Stress (weakly) increases reaction times in those cases.*

	SH	**HD**
Stress	1.64	2.94
	(2.00)	(2.00)
Male	-2.24	0.141
	(2.00)	(2.00)
High Stakes	6.38^{***}	7.02^{***}
	(0.74)	(0.80)
$\alpha = 0.8$	-3.69^{***}	-9.08^{***}
	(1.04)	(1.13)
$\alpha = 0.6$	-2.02	-2.49^{*}
	(1.05)	(1.14)
$\alpha = 0.4$	4.04^{***}	2.18
	(1.04)	(1.14)
Constant	22.52^{***}	27.02^{***}
	(1.91)	(1.93)
Observations	2,260	2,227
FE groups	143	143
df	9	9
Log-likelihood	-9810	-9831
BIC	19689	19731

Note: (standard errors in parenthesis) $^{*}\, p < 0.05$; $^{**}\, p < 0.01$; $^{***}\, p \leq 0.001$

Table 12: OLS of decision time in **SH** and **HD** including fixed effects

6 Discussion

In this paper, we examined the effect of stress on decision-making in three tasks: lotteries, Stag Hunt games, and Hawk-Dove games. Previous experiments and neuro-imaging studies suggest that people are responsive to differences in incentives across these tasks, which aligns with our control group. However, a significant portion of subjects under stress do not respond to these different incentives, which we interpret as contextual blindness.

The results contribute to our understanding of the complex relationship between stress and decision-making. In this regard, we found both conflicting and confirming evidence. Unlike some of the recent literature on lottery choice, in our study we did not find that stress had a systematic effect on any of the three tasks. However, our main finding of contextual blindness fits in well with previous work on stress inducing habituation with regard to cognitive inflexibility.

Stress-induced contextual blindness is demonstrated by a predictable pattern where subjects who choose to be relatively risk-seeking in one context also choose to be relatively risk-seeking in other, radically different ones. This predictability can be leveraged in order to reach desirable outcomes in coordination games either through directly modulating stress or by optimizing the pairing of players and games. For example, placing under stress two subjects who are risk-takers in lotteries may encourage them to be risk-seeking in Stag Hunt, therefore promoting the payoff-dominant equilibrium outcome. Alternatively, in settings where subjects need to be paired together to play coordination games, risk-preference can serve as a guide to create optimal subject-pairings in stressful circumstances. In Stag Hunt situations, optimal pairings would combine subjects with similar risk-seeking behavior in lotteries whereas in Hawk-Dove situations, optimal pairings would combine subjects with opposite risk preferences. Practical applications include team formation in military operations with limited communication.

Finally, it is surprising to observe similar attitudes when facing another individual and a lottery draw. The extent to which contextual blindness contributes to an attributed loss of opponents' agency is unclear. Subjects under stress have been shown to treat other players as less strategic decision-makers (Leder et al., 2013), but this is different from treating them as probabilistic outcomes. Further research may disentangle how stress modulates the level of autonomy attributed to other players. It may be that stress makes humans less likely to incorporate the *intention* of an action, which would have important implications in social contexts.

References

Al-Ubaydli, Omar, Garett Jones, and Jaap Weel, "Patience, cognitive skill, and coordination in the repeated stag hunt.," *Journal of Neuroscience, Psychology, and Economics*, 2013, *6* (2), 71.

Bos, Ruud Van Den and Gert Flik, "Decision-making under stress: the importance of cortico-limbic circuits," *Frontiers in behavioral neuroscience*, 2015, *9.*

_ , Marlies Harteveld, and Hein Stoop, "Stress and decision-making in humans: performance is related to cortisol reactivity, albeit differently in men and women," *Psychoneuroendocrinology*, 2009, *34* (10), 1449–1458.

Buchanan, Tony W and Stephanie D Preston, "Stress leads to prosocial action in immediate need situations," *Frontiers in behavioral neuroscience*, 2014, *8.*

Buckert, Magdalena, Christiane Schwieren, Brigitte M Kudielka, and Christian J Fiebach, "Acute stress affects risk taking but not ambiguity aversion," *Frontiers in neuroscience*, 2014, *8.*

Büyükboyacı, Mürüvvet, "Risk attitudes and the stag-hunt game," *Economics Letters*, 2014, *124* (3), 323–325.

Charness, Gary and Uri Gneezy, "Strong evidence for gender differences in risk taking," *Journal of Economic Behavior & Organization*, 2012, *83* (1), 50–58.

Chierchia, Gabriele and Giorgio Coricelli, "The impact of perceived similarity on tacit coordination: propensity for matching and aversion to decoupling choices," *Frontiers in behavioral neuroscience*, 2015, *9.*

Croson, Rachel and Uri Gneezy, "Gender Differences in Preferences," *Journal of Economic Literature*, 2009, *47* (2), 448–474.

Danese, Giuseppe, Eugénia Fernandes, Neil V Watson, and Samuele Zilioli, "Testosterone and Cortisol Jointly Predict the Ambiguity Premium in an Ellsberg-Urns Experiment," *Frontiers in behavioral neuroscience*, 2017, *11.*

Ekins, W Gavin, Ricardo Caceda, C Monica Capra, and Gregory S Berns, "You cannot gamble on others: Dissociable systems for strategic uncertainty and risk in the brain," *Journal of Economic Behavior & Organization*, 2013, *94*, 222–233.

Fraley, Chris and Adrian E Raftery, "Model-based clustering, discriminant analysis, and density estimation," *Journal of the American statistical Association*, 2002, *97* (458), 611–631.

_ **and** _ , "MCLUST version 3: an R package for normal mixture modeling and model-based clustering," Technical Report, University of Washington 2006.

Gathmann, Bettina, Frank P Schulte, Stefan Maderwald, Mirko Pawlikowski, Katrin Starcke, Lena C Schäfer, Tobias Schöler, Oliver T Wolf, and Matthias Brand, "Stress and decision making: neural correlates of the interaction between stress, executive functions, and decision making under risk," *Experimental brain research*, 2014, *232* (3), 957–973.

Heinemann, Frank, Rosemarie Nagel, and Peter Ockenfels, "Measuring strategic uncertainty in coordination games," *The Review of Economic Studies*, 2009, *76* (1), 181–221.

Hockey, G Robert J, "Effect of loud noise on attentional selectivity," *The Quarterly Journal of Experimental Psychology*, 1970, *22* (1), 28–36.

Jessie, Daniel and Ryan Kendall, "Decomposing Models of Bounded Rationality," Technical Report, IMBS technical reports MBS 15-06 2015.

Kandasamy, Narayanan, Ben Hardy, Lionel Page, Markus Schaffner, Johann Graggaber, Andrew S Powlson, Paul C Fletcher, Mark Gurnell, and John Coates, "Cortisol shifts financial risk preferences," *Proceedings of the National Academy of Sciences*, 2014, *111* (9), 3608–3613.

Kassam, Karim S, Katrina Koslov, and Wendy Berry Mendes, "Decisions under distress: Stress profiles influence anchoring and adjustment," *Psychological science*, 2009, *20* (11), 1394–1399.

Leder, Johannes, Jan Alexander Häusser, and Andreas Mojzisch, "Stress and strategic decision-making in the beauty contest game," *Psychoneuroendocrinology*, 2013, *38* (9), 1503–1511.

Lighthall, Nichole R, Mara Mather, and Marissa A Gorlick, "Acute stress increases sex differences in risk seeking in the balloon analogue risk task," *PLoS One*, 2009, *4* (7), e6002.

Mather, Mara and Nichole R Lighthall, "Risk and reward are processed differently in decisions made under stress," *Current directions in psychological science*, 2012, *21* (1), 36–41.

McCormick, CM, E Lewis, B Somley, and TA Kahan, "Individual differences in cortisol levels and performance on a test of executive function in men and women," *Physiology & Behavior*, 2007, *91* (1), 87–94.

Nagel, R, A Brovelli, F Heinemann, and G Coricelli, "Neural correlates of risk and strategic uncertainty," 2014. Working Paper.

Neumann, Thomas and Bodo Vogt, *Do Players' Beliefs Or Risk Attitudes Determine the Equilibrium Selections in 2x2 Coordination Games?*, Univ., FEMM, 2009.

Preston, SD, TW Buchanan, RB Stansfield, and A Bechara, "Effects of anticipatory stress on decision making in a gambling task.," *Behavioral neuroscience*, 2007, *121* (2), 257.

Schoofs, Daniela, Oliver T Wolf, and Tom Smeets, "Cold pressor stress impairs performance on working memory tasks requiring executive functions in healthy young men.," *Behavioral neuroscience*, 2009, *123* (5), 1066.

Schwabe, Lars and Oliver T Wolf, "Stress prompts habit behavior in humans," *Journal of Neuroscience*, 2009, *29* (22), 7191–7198.

_ , Leila Haddad, and Hartmut Schachinger, "HPA axis activation by a socially evaluated cold-pressor test," *Psychoneuroendocrinology*, 2008, *33* (6), 890–895.

_ , Marian Joëls, Benno Roozendaal, Oliver T Wolf, and Melly S Oitzl, "Stress effects on memory: an update and integration," *Neuroscience & Biobehavioral Reviews*, 2012, *36* (7), 1740–1749.

Starcke, Katrin and Matthias Brand, "Decision making under stress: a selective review," *Neuroscience and Biobehavioral Reviews*, 2012, *36* (4), 1228–1248.

Taylor, Shelley E, Laura Cousino Klein, Brian P Lewis, Tara L Gruenewald, Regan AR Gurung, and John A Updegraff, "Biobehavioral responses to stress in females: tend-and-befriend, not fight-or-flight.," *Psychological review*, 2000, *107* (3), 411.

von Dawans, Bernadette, Urs Fischbacher, Clemens Kirschbaum, Ernst Fehr, and Markus Heinrichs, "The social dimension of stress reactivity: acute stress increases prosocial behavior in humans," *Psychological science*, 2012, *23* (6), 651–660.

Yerkes, Robert M and John D Dodson, "The relation of strength of stimulus to rapidity of habit-formation," *Journal of comparative neurology*, 1908, *18* (5), 459–482.

Yu, Rongjun, "Stress potentiates decision biases: A stress induced deliberation-to-intuition (SIDI) model," *Neurobiology of stress*, 2016, *3*, 83–95.

Appendix A1: Details of experimental design

SECPT utilization and exclusion criteria

For this task, each subject had an elastic band placed on their left arm slightly above the protrusion where the ulna connects to the wrist. Subjects were required to spread their fingers and place their left hand in ice water at 4 to 6 degrees Celsius to a depth that reached the elastic band. In addition, subjects were required to look directly into a camera mounted on top of their computer screen which displayed their face while their hand was in the water. Subjects were told that their facial expressions would be recorded, which we did. One experimenter was assigned to watch a set of two experimental subjects to ensure they kept their fingers spread open, their hand at a depth reaching the elastic band, and their face looking directly into the camera. Subjects were told that there was a 'required minimum amount of time' that they needed to follow these instructions 'in order to continue with the experiment.' Otherwise, they would be paid the show up fee ($5) and excluded from the experiment. Each subject was told that they only had 'one opportunity to keep your hand in the water for a long enough time to pass the minimum threshold.' The minimum threshold was 30 seconds, which was not known to the subjects. Instead, subjects were told that if they kept their hand in the water for 3 minutes they would be 'guaranteed to pass this portion of the experiment and will be allowed to continue.' All 144 subjects who were subjected to this SECPT passed. 140 of which kept their hands in the water for the full 3 minutes (while the other 4 passed the 30 second threshold).

Saliva collection protocol

Each saliva sample was collected as passive drool samples where subjects spit directly into a test tube to a level of at least 2.5 mL per sample. Immediately after collection, samples were stored in a freezer below -20 degrees Celsius. Within seven days of collection, samples were shipped in frozen shipping containers to ZRT laboratories for testing.

Further experimental details

Participants were required to stay in the room for the entirety of the experiment. Two subjects (from different sessions) needed to leave during the experiment. In these sessions another subject was randomly chosen to be excluded in order to maintain an even number of subjects. Each session was gender-mixed so that the worst gender imbalance would be two more of one gender than the other. This was done to avoid concerns that people behave differently when they know what gender they are playing against. Participants were randomly determined to be a control or treatment subjects before the start of a session. Before entering the lab, subjects were instructed to sign an informed consent and to drink an 8 ounce bottle of water (to ensure clean saliva tests). Subjects were paid in private as they left the laboratory. Our data consists of 20 sessions.

Pre-experiment survey (to ensure conformity with recruiting instructions)

Please take this short survey before we begin the experiment:

At what time did you wake up most recently today? ________________

Have you eaten any food today? Yes / No
If Yes, when was the last time you ate anything? ________________

Have you drank anything other than water today? Yes / No
If Yes, when was the last time drank anything?________________

Have you exercised rigorously today? Yes / No
If Yes, when was the last time you exercised?________________

Have you smoked anything today? Yes / No
If Yes, when was the last time that you smoked?________________

Have you chewed gum today? Yes / No
If Yes, when was the last time that you chewed gum?________________

Have you ingested caffeine today? Yes / No
If Yes, when was the last time that you ingested caffeine?________________

Have you used any products on your lips today (such as chapstick, lip balm, lip stick, lip gloss, or sunscreen)? Yes / No
If Yes, when was the last time that you used any of these products?________________

I acknowledge that the answers that I have provided are accurate according to my memory.

Signature________________

Appendix A2: List of payoffs in all 48 rounds

Lottery tasks - **LO** (16 rounds)

$SH40.2$	Lottery
21	53, 13
80 G; 20 O	

$SH40.2$	Lottery
21	53, 13
20 G; 80 O	

$SH40.8$	Lottery
33	41, 1
80 G; 20 O	

$SH40.8$	Lottery
33	41, 1
20 G; 80 O	

$SH30.2$	Lottery
22	46, 16
80 G; 20 O	

$SH30.2$	Lottery
22	46, 16
20 G; 80 O	

$SH30.8$	Lottery
31	37, 7
80 G; 20 O	

$SH30.8$	Lottery
31	37, 7
20 G; 80 O	

$SH20.2$	Lottery
24	40, 20
80 G; 20 O	

$SH20.2$	Lottery
24	40, 20
20 G; 80 O	

$SH20.8$	Lottery
30	34, 14
80 G; 20 O	

$SH20.8$	Lottery
30	34, 14
20 G; 80 O	

$SH10.2$	Lottery
25	33, 23
80 G; 20 O	

$SH10.2$	Lottery
25	33, 23
20 G; 80 O	

$SH10.8$	Lottery
28	30, 20
80 G; 20 O	

$SH10.8$	Lottery
28	30, 20
20 G; 80 O	

Stag Hunt tasks - **SH** (16 rounds)

$SH40.2$	B	A
B	53, 53	13, 21
A	21, 13	21, 21

$SH40.4$	B	A
B	49, 49	9, 25
A	25, 9	25, 25

$SH40.6$	B	A
B	45, 45	5, 29
A	29, 5	29, 29

$SH40.8$	B	A
B	41, 41	1, 33
A	33, 1	33, 33

$SH30.2$	B	A
B	46, 46	16, 22
A	22, 16	22, 22

$SH30.4$	B	A
B	43, 43	13, 25
A	25, 13	25, 25

$SH30.6$	B	A
B	40, 40	10, 28
A	28, 10	28, 28

$SH30.8$	B	A
B	37, 37	7, 31
A	31, 7	31, 31

$SH20.2$	B	A
B	40, 40	20, 24
A	24, 20	24, 24

$SH20.4$	B	A
B	38, 38	18, 26
A	26, 18	26, 26

$SH20.6$	B	A
B	36, 36	16, 28
A	28, 16	28, 28

$SH20.8$	B	A
B	34, 34	14, 30
A	30, 14	30, 30

$SH10.2$	B	A
B	33, 33	23, 25
A	25, 23	25, 25

$SH10.4$	B	A
B	32, 32	22, 26
A	26, 22	26, 26

$SH10.6$	B	A
B	31, 31	21, 27
A	27, 21	27, 27

$SH10.8$	B	A
B	30, 30	20, 28
A	28, 20	28, 28

Hawk-Dove tasks - **HD** (16 rounds)

$HD40.8$	B	A
B	13, 13	53, 21
A	21, 53	21, 21

$HD40.6$	B	A
B	9, 9	49, 25
A	25, 49	25, 25

$HD40.4$	B	A
B	5, 5	45, 29
A	29, 45	29, 29

$HD40.2$	B	A
B	1, 1	41, 33
A	33, 41	33, 33

$HD30.8$	B	A
B	16, 16	46, 22
A	22, 46	22, 22

$HD30.6$	B	A
B	13, 13	43, 25
A	25, 43	25, 25

$HD30.4$	B	A
B	10, 10	40, 28
A	28, 40	28, 28

$HD30.2$	B	A
B	7, 7	37, 31
A	31, 37	31, 31

$HD20.8$	B	A
B	20, 20	40, 24
A	24, 40	24, 24

$HD20.6$	B	A
B	18, 18	38, 26
A	26, 38	26, 26

$HD20.4$	B	A
B	16, 16	36, 28
A	28, 36	28, 28

$HD20.2$	B	A
B	14, 14	34, 30
A	30, 34	30, 30

$HD10.8$	B	A
B	23, 23	33, 25
A	25, 33	25, 25

$HD10.6$	B	A
B	22, 22	32, 26
A	26, 32	26, 26

$HD10.4$	B	A
B	21, 21	31, 27
A	27, 31	27, 27

$HD10.2$	B	A
B	20, 20	30, 28
A	28, 30	28, 28

Appendix B: Experimental instructions

Welcome to this experiment at USC. Thank you for signing up.

You are about to participate in a study of decision-making, and you will be paid for your participation in cash. The amount you earn for participating in this experiment depends partly on your decisions, partly on the decisions by other subjects in the room, and partly on chance. There are several parts to this experiment, and your earnings will be totaled up and paid to you privately in the other room at the end of the experiment. This experiment is scheduled to last for 2 hours.

As a reminder, your participation in this experiment is voluntary, and you may leave the room at any time. If you choose to leave the room before the experiment is over, you will only be paid the $5 show-up fee and nothing that you have earned during the experiment.

Please turn off your cell phone. It is important that you do not communicate with any other participants in the room during the experiment.

If you have a question about what you are being instructed to do in this experiment, please raise your hand and an experimenter will come over to your station. We encourage questions that help clarify how the experiment works. However, we cannot answer questions about how you should make choices in the experiment.

As a reminder, this experiment does not contain any deception (lying). The way we describe the experiment and your earnings is the exact way that you will be paid.

First, we will go through some instructions detailing what is expected of you during the experiment. This will include some examples and practice questions. You will not be paid according to these practice questions and the exact practice questions will never be asked as part of the decision periods of the experiment. After the instructions, you will participate in the decision periods where you will be paid according to your choices. You will be reminded when the instructions and practice have concluded and the decision periods are about to begin.

When you are ready, please click "Continue" to go to the instructions.

Continue

In this experiment, you will need to allocate 100 "tokens" over two different "Options" (A and B). These Options determine the actual amount of money that you will be paid at the end of the experiment. Option A will always give you a certain payoff whereas Option B will give you either high or low payoff. In order to determine whether you receive the high or low payoff from Option B, the computer will randomly draw a ball from your urn that has 100 balls where each ball is either **GREEN** or **ORANGE**. If a **GREEN** ball is drawn you will receive the high payoff and if an **ORANGE** ball is drawn, you will receive the low payoff. In later instructions, we will describe how the number of **GREEN** and **ORANGE** balls in your urn is determined.

You will make a decision to allocate 100 tokens in many "periods" with different dollar-amount payoffs associated with each Option. Each period always has only two options: Options A and B. However, the payoffs associated with these two Options will be different between periods. This means that your earnings from a **GREEN** or **ORANGE** ball will be different between periods.

For example, consider the Options A and B below. Option A gives you $7 for certain. Option B gives you $13 if a **GREEN** ball is drawn or $5 if an **ORANGE** ball is drawn. During the experiment, this information will always be represented in two boxes in the same way that it is shown below.

Option A:	Option B:
$7 for certain	**$13** if **GREEN** ball **$5** if **ORANGE** ball

You will be given 100 tokens to distribute across these two Options. If you want, you can put all 100 tokens into Option A, which will give you $7 for certain. You can also put all 100 tokens into Option B, which will give you $13 if a **GREEN** ball is drawn or $5 if an **ORANGE** ball is drawn. The purpose of using the tokens is that, if you want, you can submit a "mixture" of the two Options as your decision.

To see how mixtures work, click "Continue".

Continue

Your earnings in each period are dependent on how many tokens you choose to allocate between the two Options. Consider Options A and B from the last screen:

Option A:	Option B:
$7 for certain	**$13** if **GREEN** ball **$5** if **ORANGE** ball

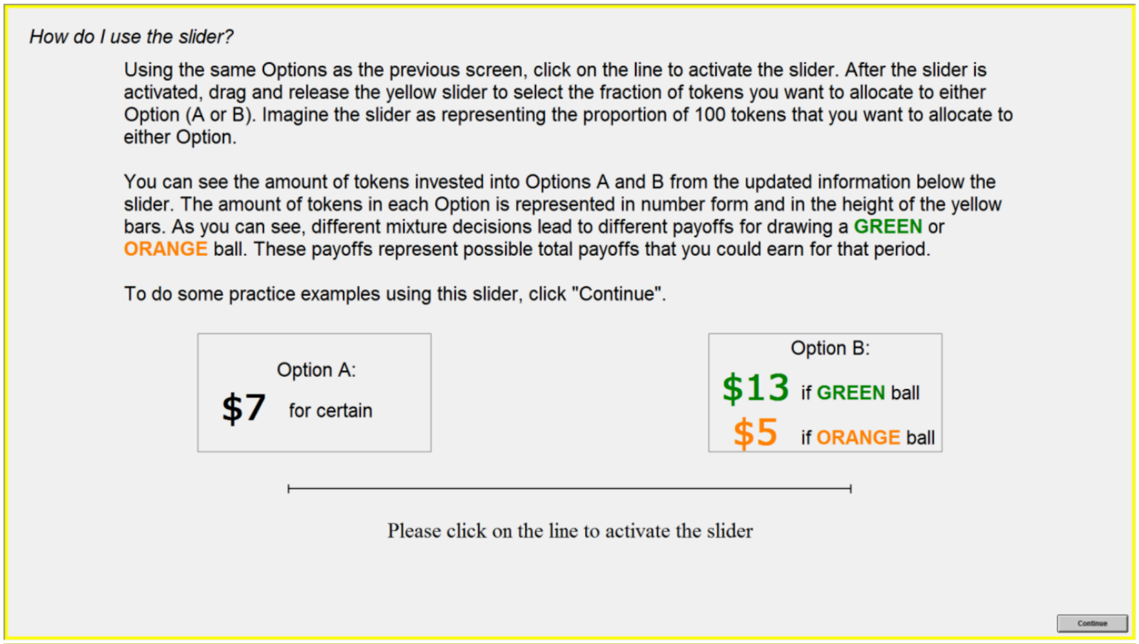
For example, suppose that you want to allocate 70 tokens into Option A and 30 tokens into Option B. These numbers are chosen purely as an example. With this allocation, you get (70/100)*$7 = $4.9 for certain because of the 70 tokens allocated to Option A. On top of that, you get an amount that depends on whether the ball is **GREEN** or **ORANGE**:

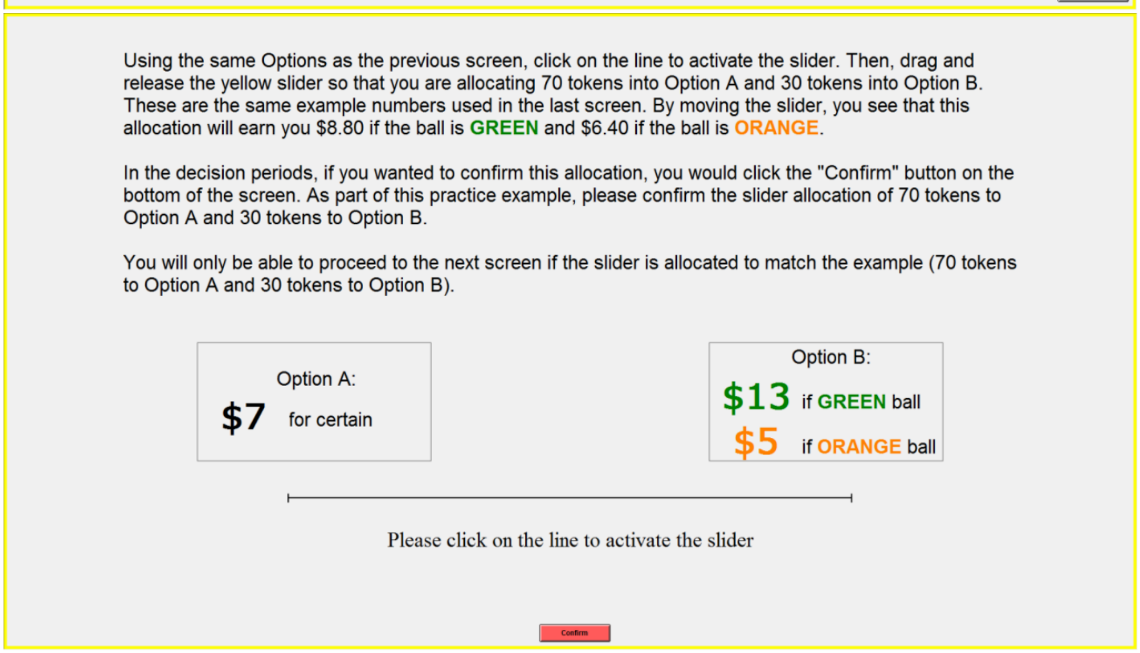
If the ball is **GREEN**, you also get (30/100)*$13 = $3.9, for a total earnings of $4.9 + $3.9 = $8.80
If the ball is **ORANGE**, you also get (30/100)*$5 = $1.5, for a total earnings of $4.9 + $1.5 = $6.40

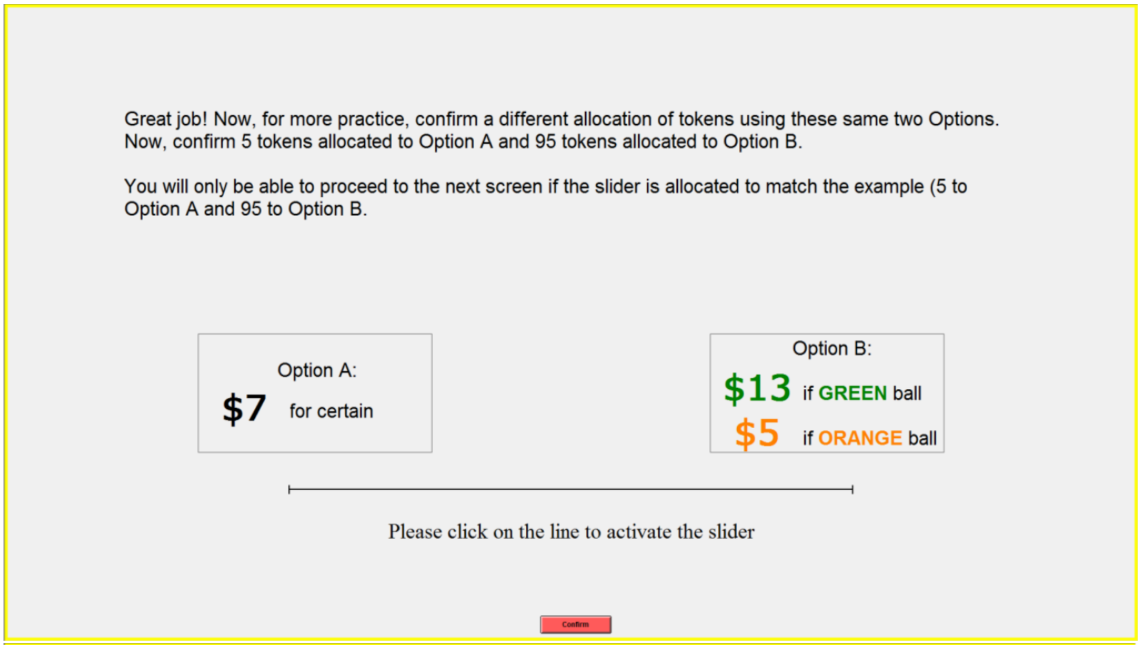
So, your total earnings from a **GREEN** or **ORANGE** ball depends on the number of tokens you allocate to each Option. Because this calculation is a bit complicated, each period will have a "slider" tool that you can use to calculate your possible earnings of each decision. The slider tool automatically calculates your earnings if a **GREEN** or **ORANGE** ball is drawn using that allocation.

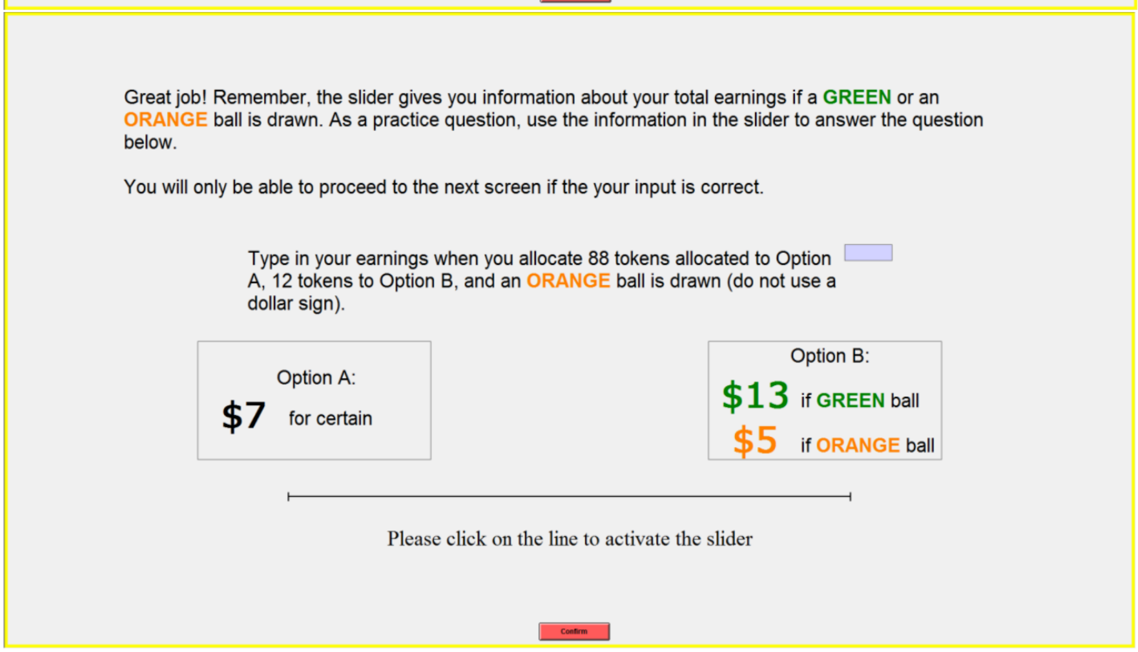
Click "Continue" to learn more about the slider.

Continue


How do I use the slider?
Using the same Options as the previous screen, click on the line to activate the slider. After the slider is activated, drag and release the yellow slider to select the fraction of tokens you want to allocate to either Option (A or B). Imagine the slider as representing the proportion of 100 tokens that you want to allocate to either Option.
You can see the amount of tokens invested into Options A and B from the updated information below the slider. The amount of tokens in each Option is represented in number form and in the height of the yellow bars. As you can see, different mixture decisions lead to different payoffs for drawing a GREEN or ORANGE ball. These payoffs represent possible total payoffs that you could earn for that period.
To do some practice examples using this slider, click "Continue".
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
Please click on the line to activate the slider
Continue


Using the same Options as the previous screen, click on the line to activate the slider. Then, drag and release the yellow slider so that you are allocating 70 tokens into Option A and 30 tokens into Option B. These are the same example numbers used in the last screen. By moving the slider, you see that this allocation will earn you $8.80 if the ball is GREEN and $6.40 if the ball is ORANGE.
In the decision periods, if you wanted to confirm this allocation, you would click the "Confirm" button on the bottom of the screen. As part of this practice example, please confirm the slider allocation of 70 tokens to Option A and 30 tokens to Option B.
You will only be able to proceed to the next screen if the slider is allocated to match the example (70 tokens to Option A and 30 tokens to Option B).
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
Please click on the line to activate the slider
Confirm


Great job! Now, for more practice, confirm a different allocation of tokens using these same two Options. Now, confirm 5 tokens allocated to Option A and 95 tokens allocated to Option B.
You will only be able to proceed to the next screen if the slider is allocated to match the example (5 to Option A and 95 to Option B.
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
Please click on the line to activate the slider


Great job! Remember, the slider gives you information about your total earnings if a GREEN or an ORANGE ball is drawn. As a practice question, use the information in the slider to answer the question below.
You will only be able to proceed to the next screen if the your input is correct.
Type in your earnings when you allocate 88 tokens allocated to Option A, 12 tokens to Option B, and an ORANGE ball is drawn (do not use a dollar sign).
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
Please click on the line to activate the slider

How many ***GREEN*** *and* ***ORANGE*** *balls are in my urn?*

In the previous screens you learned how to use the slider tool to make your decision. As you noticed, your earnings depend on whether a **GREEN** or **ORANGE** ball is drawn from your urn. This fact will be the same for every period in the experiment. However, depending on the period, the number of **GREEN** and **ORANGE** balls in your urn will be determined in one of the three possible methods that are explained over the next few screens.

Method 1.) In some periods, the number of **GREEN** and **ORANGE** balls in your urn will be displayed on the screen. In these periods, your payoff will not depend on the decision of any other participant in the room. This is an example of the text you will see at the top of the screen. In this example, there are 80 **GREEN** balls and 20 **ORANGE** balls in your urn.

METHOD 1 **Balls in your urn:** **# GREEN balls: 80** **# ORANGE balls: 20**

Please click "Continue" to move forward.

Continue

How many ***GREEN*** *and* ***ORANGE*** *balls are in my urn?*

In the previous screens you learned how to use the slider tool to make your decision. As you noticed, your earnings depends on whether a **GREEN** or **ORANGE** ball is drawn from your urn. This fact will be the same for every period in the experiment. However, depending on the period, the number of **GREEN** and **ORANGE** balls in your urn will be determined in one of the three possible methods that are explained over the next few screens.

Method 1.) In some periods, the number of **GREEN** and **ORANGE** balls in your urn will be displayed on the screen. In these periods, your payoff will not depend on the decision of any other participant in the room. This is an example of the text you will see at the top of the screen. In this example, there are 80 **GREEN** and 20 **ORANGE** balls in your urn.

METHOD 1 **Balls in your urn:** **# GREEN balls: 80** **# ORANGE balls: 20**

In other periods, the total number of **GREEN** and **ORANGE** balls in your urn will not be told to you when you make your decision. Instead, you will be anonymously paired with another subject in the room and the number of **GREEN** and **ORANGE** balls will be determined by that subject's choice to allocate their 100 tokens. This pairing does not depend in any way on the decisions of any subject in any past period. So, the subject you are paired with is randomly picked by the computer and you will receive a new pairing in every period. In a period where you are paired with another subject, the **OTHER SUBJECT** will be making the same choice that you will be making. This means that they will be allocating 100 tokens over the exact same Options A and B that you will see on your screen at the same time. The **OTHER SUBJECT's** choice will affect the number of **GREEN** and **ORANGE** balls in your urn in two other methods.

Please click "Continue" to see instructions about Methods 2 and 3.

Continue

Method 2.) The number of **GREEN** balls in **YOUR** urn equals the amount of tokens that the **OTHER SUBJECT** allocates to Option A. The number of **ORANGE** balls in **YOUR** urn equals the amount of tokens the **OTHER SUBJECT** allocates to Option B. In these periods, you will see the following text at the top of the screen:

METHOD 2

Balls in your urn:

 # GREEN balls: # tokens **OTHER** puts into Option **A**

 # ORANGE balls: # tokens **OTHER** puts into Option **B**

In these periods, your choice affects the **OTHER SUBJECT's** urn in the same way. So the number of **GREEN** balls in **THEIR** urn depends on the amount of tokens **YOU** allocate to Option A and the number of **ORANGE** balls in **THEIR** urn depends on the amount of tokens **YOU** allocate to Option B.

So, one way to think about it is the following: Every token that the **OTHER SUBJECT** allocates into Option A becomes a **GREEN** ball in your urn. Similarly, every token that you allocate into Option A becomes a **GREEN** ball in the **OTHER SUBJECT's** urn.

Please click "Continue" to learn about Method 3.

Continue

Method 2.) The number of **GREEN** balls in **YOUR** urn equals the amount of tokens that the **OTHER SUBJECT** allocates to Option A. The number of **ORANGE** balls in **YOUR** urn equals the amount of tokens the **OTHER SUBJECT** allocates to Option B. In these periods, you will see the following text at the top of the screen:

METHOD 2

Balls in your urn:

 # GREEN balls: # tokens **OTHER** puts into Option **A**

 # ORANGE balls: # tokens **OTHER** puts into Option **B**

In these periods, your choice affects the **OTHER SUBJECT's** urn in the same way. So the number of **GREEN** balls in **THEIR** urn depends on the amount of tokens **YOU** allocate to Option A and the number of **ORANGE** balls in **THEIR** urn depends on the amount of tokens **YOU** allocate to Option B.

So, one way to think about it is the following: Every token that the **OTHER SUBJECT** allocates into Option A becomes a **GREEN** ball in your urn. Similarly, every token that you allocate into Option A becomes a **GREEN** ball in the **OTHER SUBJECT's** urn.

Method 3.) The number of **GREEN** balls in **YOUR** urn equals the amount of tokens that the **OTHER SUBJECT** allocates to Option B. The number of **ORANGE** balls in **YOUR** urn equals the amount of tokens the **OTHER SUBJECT** allocates to Option A. In these periods, you will see the following text at the top of the screen:

METHOD 3

Balls in your urn:

 # GREEN balls: # tokens **OTHER** puts into Option **B**

 # ORANGE balls: # tokens **OTHER** puts into Option **A**

Once again, your choice affects the **OTHER SUBJECT's** urn in the same way. So the number of **GREEN** balls in **THEIR** urn depends on the amount of tokens **YOU** allocate to Option B and the number of **ORANGE** balls in **THEIR** urn depends on the amount of tokens **YOU** allocate to Option A.

So, one way to think about it is the following: Every token that the **OTHER SUBJECT** allocates into Option A becomes an **ORANGE** ball in your urn. Similarly, every token that you allocate into Option A becomes an **ORANGE** ball in the **OTHER SUBJECT's** urn.

Please click "Continue" to advance.

Continue

In summary, the number of **GREEN** balls in your urn is either displayed on the screen (Method 1), determined by the number of tokens the other allocates to Option A (Method 2), or determined by the number of tokens the other allocates to Option B (Method 3).

When you are paired with another subject in the room (Methods 2 and 3), your choice will affect the number of **GREEN** balls in their urn in the same way that their choice affects the number of **GREEN** balls in your urn. So, in other words, if you are in Method 2, then the other subject you are paired with is also in Method 2. Their screen will look identical to your screen.

You will always be informed about which Method is being used during a period. It is very important that in every period you pay attention to the Method being used to determine the amount of **GREEN** and **ORANGE** balls in your urn. In the decision periods, you will make a choice using the same Method 4 times in a row. Then the text "New Method" will flash on your screen and the Method will be changed. Then you will make a choice using this same new Method 4 times in a row. This process will continue many times until the experiment is over.

Please click "Continue" to advance to a practice quiz.

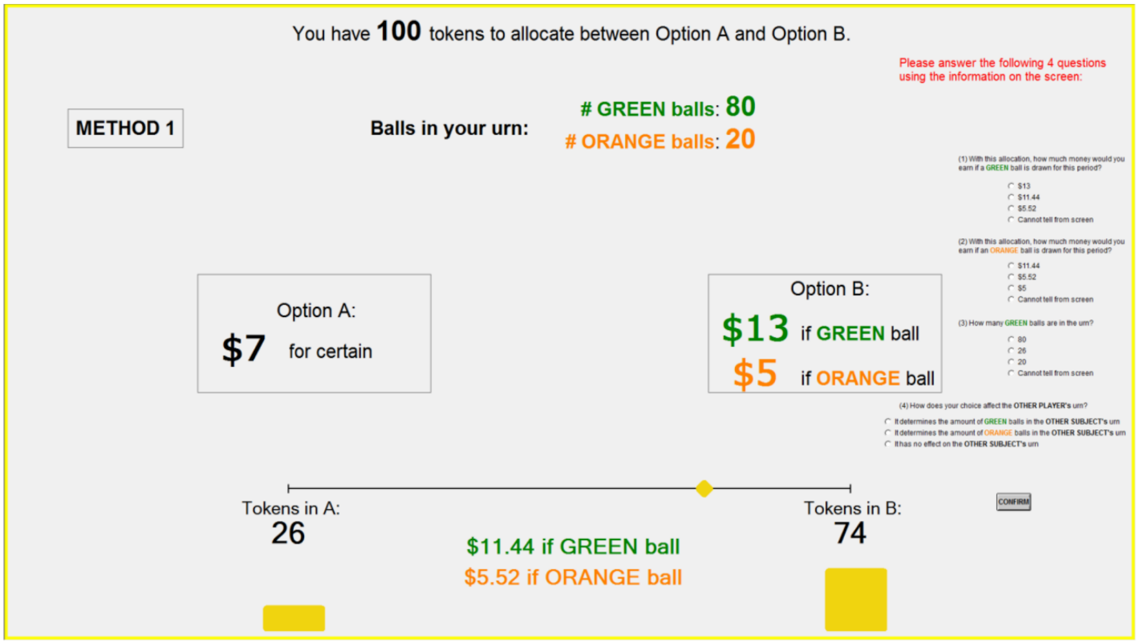
Continue

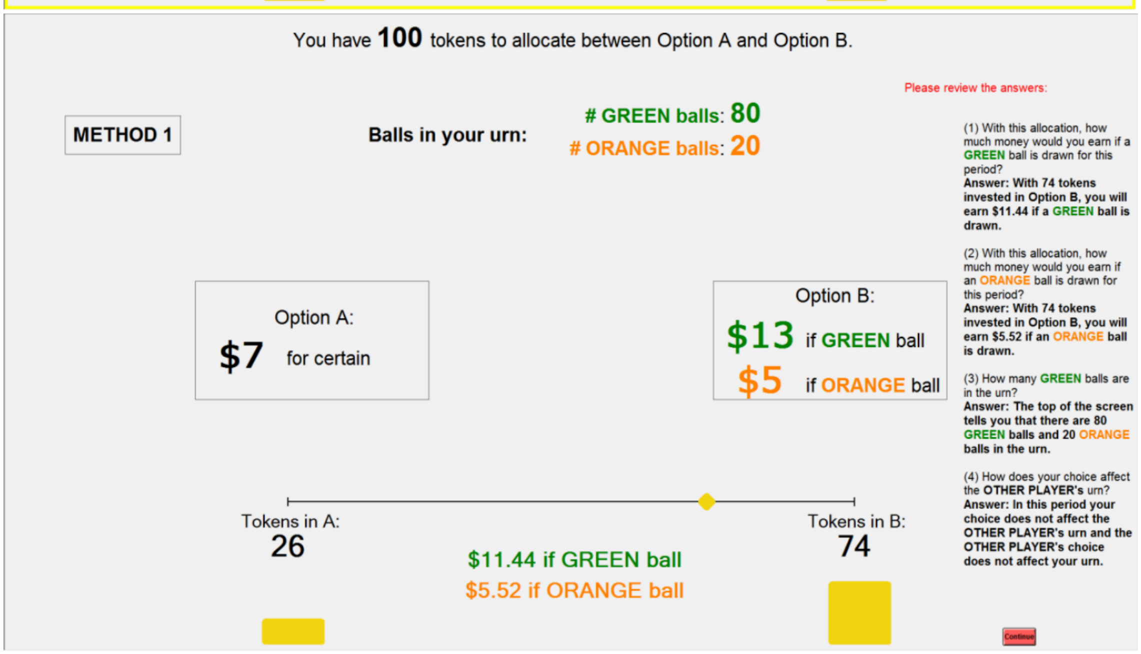
Practice Quiz

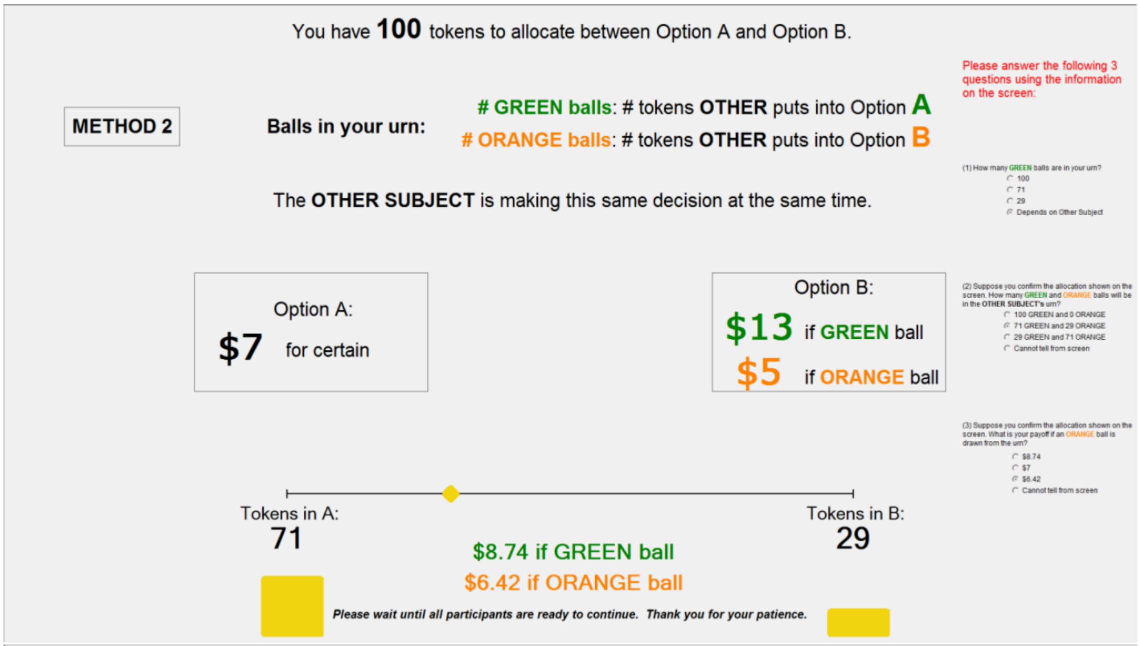
The next few slides will be a practice quiz. The computer will ask you to answer questions about the tasks that have been explained to you. The purpose of this practice quiz is for you to better understand how the experiment works. Your choices during the practice quiz do not affect your real-money payoff earned in the experiment. However, you will not be able to proceed in the practice quiz until you answer all of the questions on the screen correctly. If you have a question, please raise your hand, and an experimenter will come to assist you.

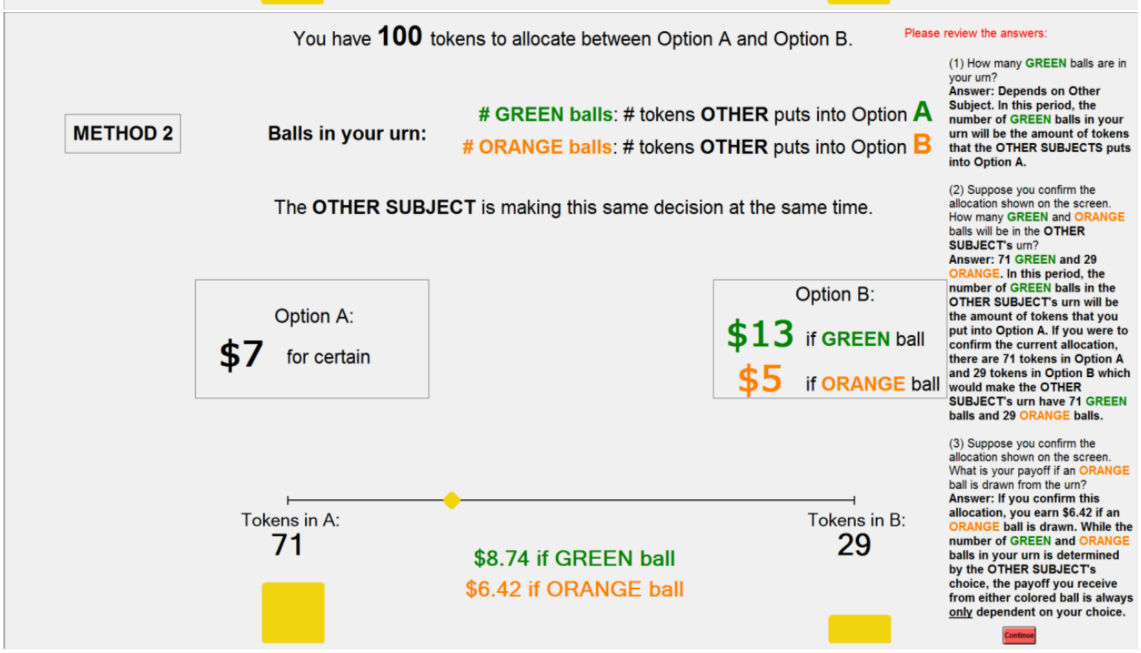
Please click "Continue" when you are ready to start the practice quiz.

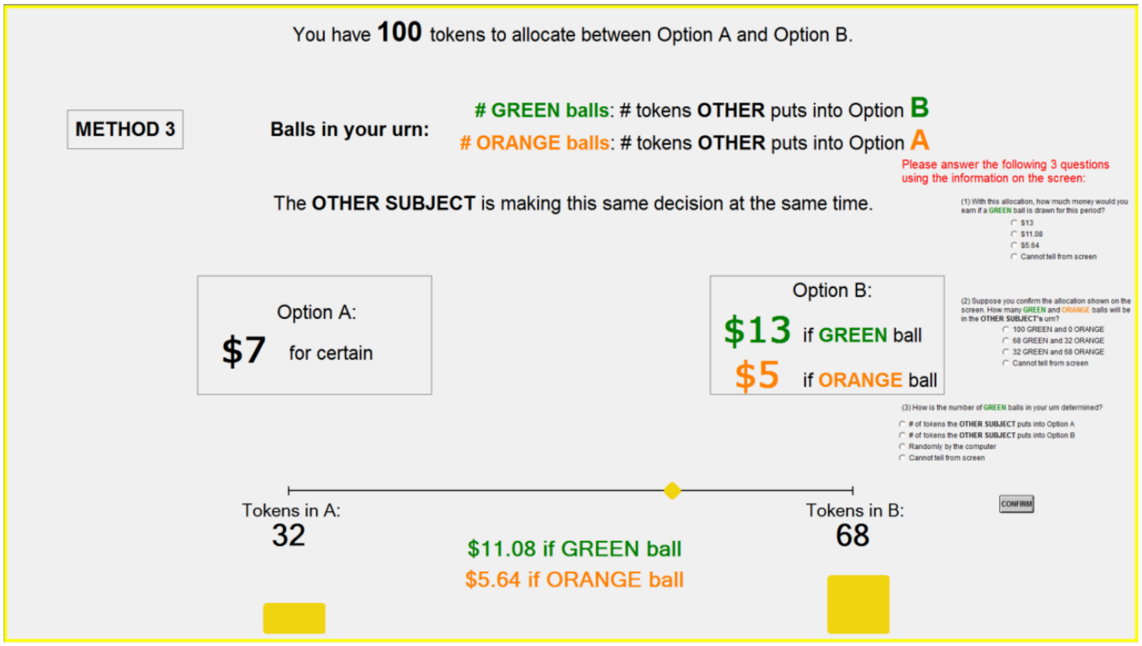
Continue


You have 100 tokens to allocate between Option A and Option B.
Please answer the following 4 questions using the information on the screen:
METHOD 1
Balls in your urn:
GREEN balls: 80
ORANGE balls: 20
(1) With this allocation, how much money would you earn if a GREEN ball is drawn for this period?
$13
$11.44
$5.52
Cannot tell from screen
(2) With this allocation, how much money would you earn if an ORANGE ball is drawn for this period?
$11.44
$5.52
$5
Cannot tell from screen
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
(3) How many GREEN balls are in the urn?
80
26
20
Cannot tell from screen
(4) How does your choice affect the OTHER PLAYER's urn?
It determines the amount of GREEN balls in the OTHER SUBJECT's urn
It determines the amount of ORANGE balls in the OTHER SUBJECT's urn
It has no effect on the OTHER SUBJECT's urn
Tokens in A:
26
Tokens in B:
74
CONFIRM
$11.44 if GREEN ball
$5.52 if ORANGE ball

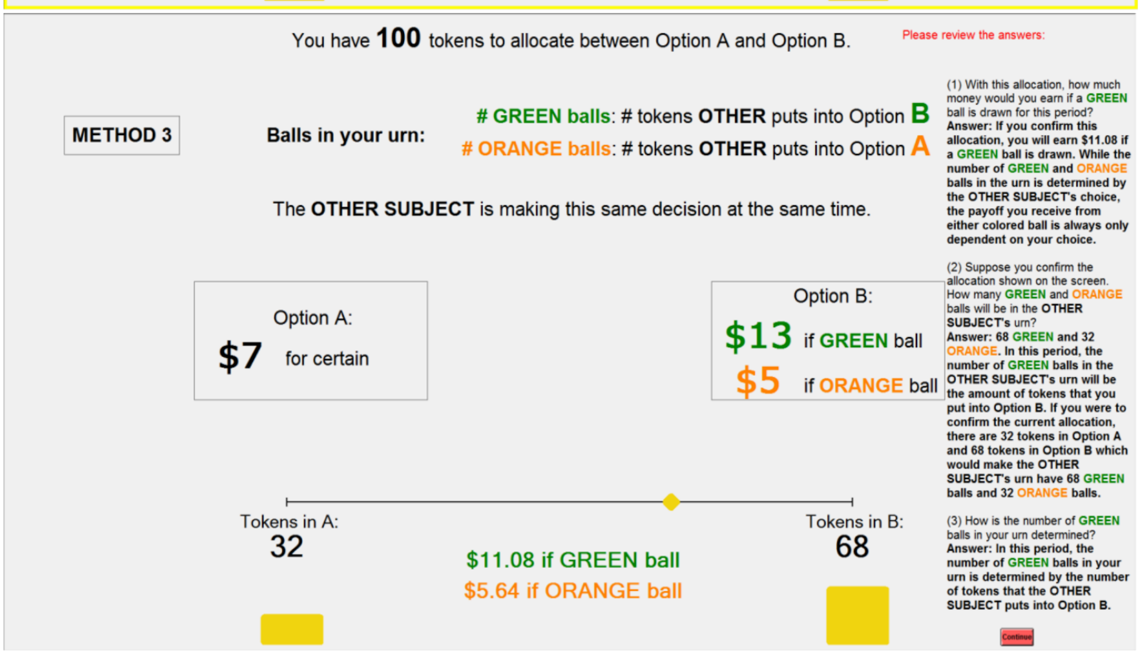

You have 100 tokens to allocate between Option A and Option B.
Please review the answers:
METHOD 1
Balls in your urn:
GREEN balls: 80
ORANGE balls: 20
(1) With this allocation, how much money would you earn if a GREEN ball is drawn for this period?
Answer: With 74 tokens invested in Option B, you will earn $11.44 if a GREEN ball is drawn.
(2) With this allocation, how much money would you earn if an ORANGE ball is drawn for this period?
Answer: With 74 tokens invested in Option B, you will earn $5.52 if an ORANGE ball is drawn.
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
(3) How many GREEN balls are in the urn?
Answer: The top of the screen tells you that there are 80 GREEN balls and 20 ORANGE balls in the urn.
(4) How does your choice affect the OTHER PLAYER's urn?
Answer: In this period your choice does not affect the OTHER PLAYER's urn and the OTHER PLAYER's choice does not affect your urn.
Tokens in A:
26
Tokens in B:
74
$11.44 if GREEN ball
$5.52 if ORANGE ball


You have 100 tokens to allocate between Option A and Option B.
Please answer the following 3 questions using the information on the screen:
METHOD 2
Balls in your urn:
GREEN balls: # tokens OTHER puts into Option A
ORANGE balls: # tokens OTHER puts into Option B
(1) How many GREEN balls are in your urn?
100
71
29
Depends on Other Subject
The OTHER SUBJECT is making this same decision at the same time.
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
(2) Suppose you confirm the allocation shown on the screen. How many GREEN and ORANGE balls will be in the OTHER SUBJECT's urn?
100 GREEN and 0 ORANGE
71 GREEN and 29 ORANGE
29 GREEN and 71 ORANGE
Cannot tell from screen
(3) Suppose you confirm the allocation shown on the screen. What is your payoff if an ORANGE ball is drawn from the urn?
$8.74
$7
$6.42
Cannot tell from screen
Tokens in A:
71
Tokens in B:
29
$8.74 if GREEN ball
$6.42 if ORANGE ball
Please wait until all participants are ready to continue. Thank you for your patience.

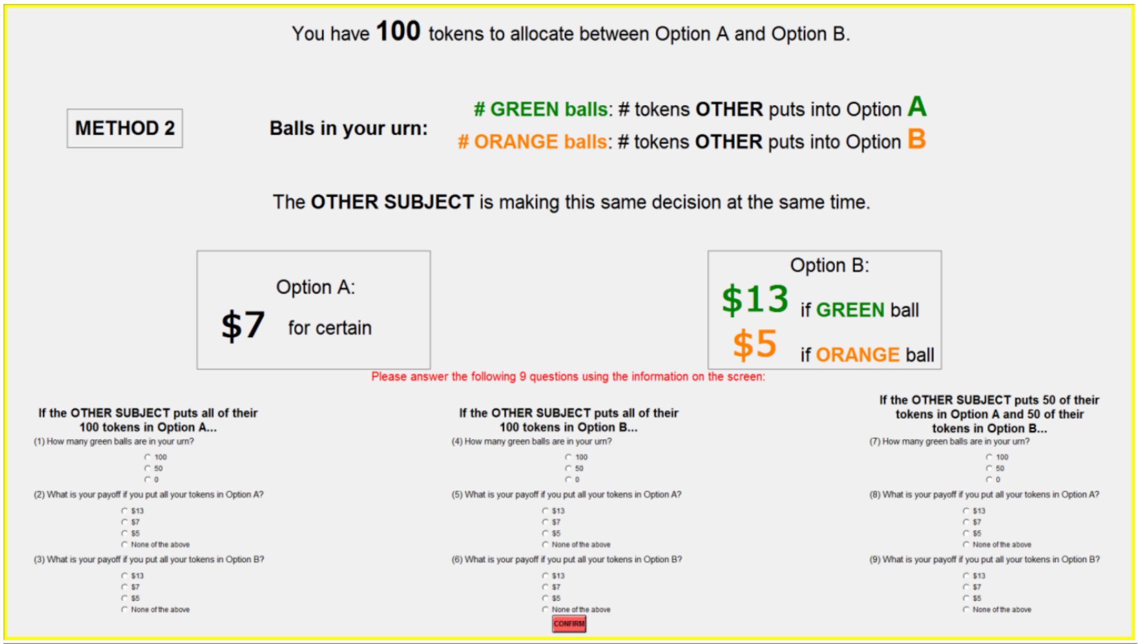

You have 100 tokens to allocate between Option A and Option B.
Please review the answers:
METHOD 2
Balls in your urn:
GREEN balls: # tokens OTHER puts into Option A
ORANGE balls: # tokens OTHER puts into Option B
The OTHER SUBJECT is making this same decision at the same time.
(1) How many GREEN balls are in your urn?
Answer: Depends on Other Subject. In this period, the number of GREEN balls in your urn will be the amount of tokens that the OTHER SUBJECTS puts into Option A.
(2) Suppose you confirm the allocation shown on the screen. How many GREEN and ORANGE balls will be in the OTHER SUBJECT's urn?
Answer: 71 GREEN and 29 ORANGE. In this period, the number of GREEN balls in the OTHER SUBJECT's urn will be the amount of tokens that you put into Option A. If you were to confirm the current allocation, there are 71 tokens in Option A and 29 tokens in Option B which would make the OTHER SUBJECT's urn have 71 GREEN balls and 29 ORANGE balls.
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
(3) Suppose you confirm the allocation shown on the screen. What is your payoff if an ORANGE ball is drawn from the urn?
Answer: If you confirm this allocation, you earn $6.42 if an ORANGE ball is drawn. While the number of GREEN and ORANGE balls in your urn is determined by the OTHER SUBJECT's choice, the payoff you receive from either colored ball is always only dependent on your choice.
Tokens in A:
71
Tokens in B:
29
$8.74 if GREEN ball
$6.42 if ORANGE ball
Continue



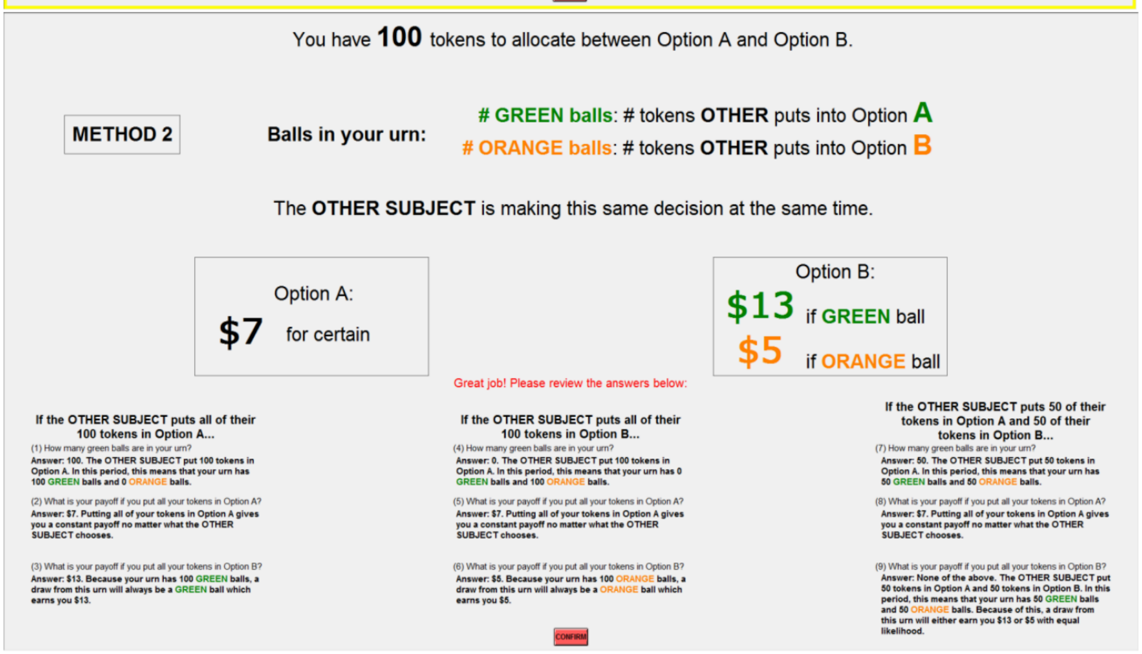
You have 100 tokens to allocate between Option A and Option B.
METHOD 3
Balls in your urn:
GREEN balls: # tokens OTHER puts into Option B
ORANGE balls: # tokens OTHER puts into Option A
Please answer the following 3 questions using the information on the screen:
The OTHER SUBJECT is making this same decision at the same time.
(1) With this allocation, how much money would you earn if a GREEN ball is drawn for this period?
$13
$11.08
$5.64
Cannot tell from screen
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
(2) Suppose you confirm the allocation shown on the screen. How many GREEN and ORANGE balls will be in the OTHER SUBJECT's urn?
100 GREEN and 0 ORANGE
68 GREEN and 32 ORANGE
32 GREEN and 68 ORANGE
Cannot tell from screen
(3) How is the number of GREEN balls in your urn determined?
# of tokens the OTHER SUBJECT puts into Option A
# of tokens the OTHER SUBJECT puts into Option B
Randomly by the computer
Cannot tell from screen
CONFIRM
Tokens in A:
32
Tokens in B:
68
$11.08 if GREEN ball
$5.64 if ORANGE ball



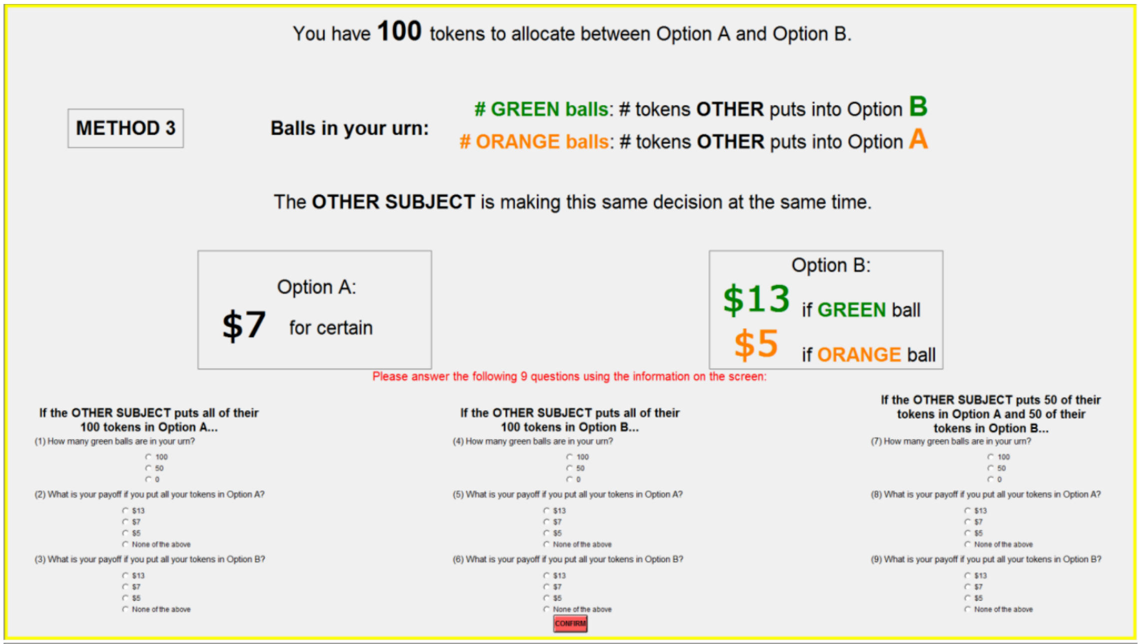
You have 100 tokens to allocate between Option A and Option B.
Please review the answers:
METHOD 3
Balls in your urn:
GREEN balls: # tokens OTHER puts into Option B
ORANGE balls: # tokens OTHER puts into Option A
The OTHER SUBJECT is making this same decision at the same time.
(1) With this allocation, how much money would you earn if a GREEN ball is drawn for this period?
Answer: If you confirm this allocation, you will earn $11.08 if a GREEN ball is drawn. While the number of GREEN and ORANGE balls in the urn is determined by the OTHER SUBJECT's choice, the payoff you receive from either colored ball is always only dependent on your choice.
(2) Suppose you confirm the allocation shown on the screen. How many GREEN and ORANGE balls will be in the OTHER SUBJECT's urn?
Answer: 68 GREEN and 32 ORANGE. In this period, the number of GREEN balls in the OTHER SUBJECT's urn will be the amount of tokens that you put into Option B. If you were to confirm the current allocation, there are 32 tokens in Option A and 68 tokens in Option B which would make the OTHER SUBJECT's urn have 68 GREEN balls and 32 ORANGE balls.
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
(3) How is the number of GREEN balls in your urn determined?
Answer: In this period, the number of GREEN balls in your urn is determined by the number of tokens that the OTHER SUBJECT puts into Option B.
Tokens in A:
32
Tokens in B:
68
$11.08 if GREEN ball
$5.64 if ORANGE ball
Continue



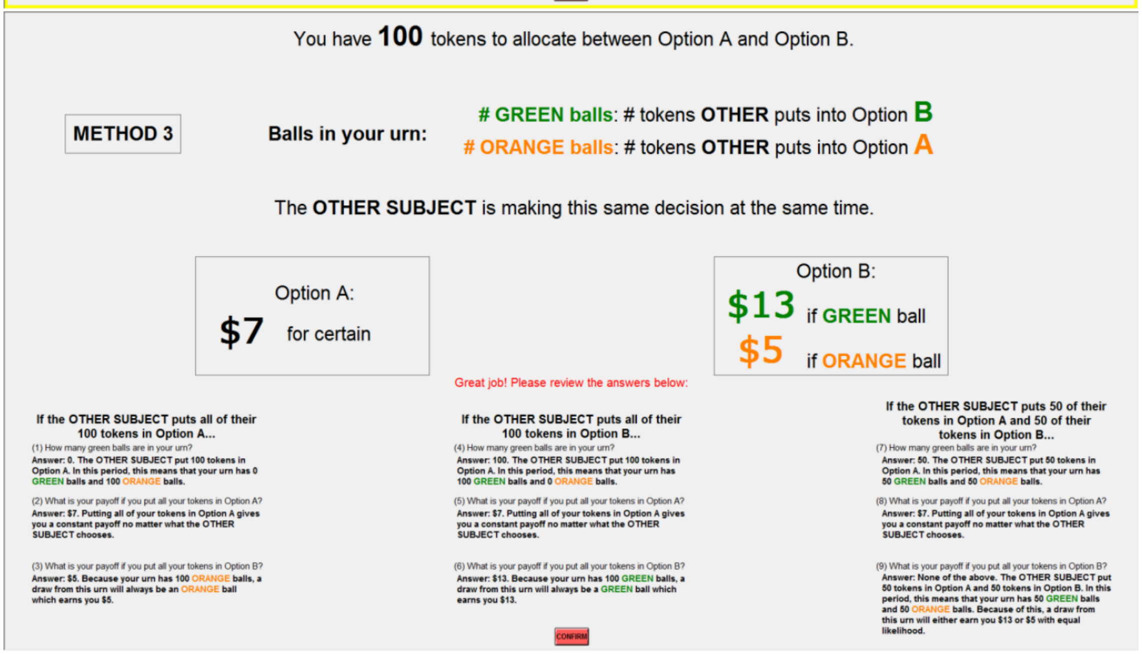
You have 100 tokens to allocate between Option A and Option B.
METHOD 2
Balls in your urn:
GREEN balls: # tokens OTHER puts into Option A
ORANGE balls: # tokens OTHER puts into Option B
The OTHER SUBJECT is making this same decision at the same time.
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
Please answer the following 9 questions using the information on the screen:
If the OTHER SUBJECT puts all of their 100 tokens in Option A...
(1) How many green balls are in your urn?
100
50
0
(2) What is your payoff if you put all your tokens in Option A?
$13
$7
$5
None of the above
(3) What is your payoff if you put all your tokens in Option B?
$13
$7
$5
None of the above
If the OTHER SUBJECT puts all of their 100 tokens in Option B...
(4) How many green balls are in your urn?
100
50
0
(5) What is your payoff if you put all your tokens in Option A?
$13
$7
$5
None of the above
(6) What is your payoff if you put all your tokens in Option B?
$13
$7
$5
None of the above
CONFIRM
If the OTHER SUBJECT puts 50 of their tokens in Option A and 50 of their tokens in Option B...
(7) How many green balls are in your urn?
100
50
0
(8) What is your payoff if you put all your tokens in Option A?
$13
$7
$5
None of the above
(9) What is your payoff if you put all your tokens in Option B?
$13
$7
$5
None of the above



You have 100 tokens to allocate between Option A and Option B.
METHOD 2
Balls in your urn:
GREEN balls: # tokens OTHER puts into Option A
ORANGE balls: # tokens OTHER puts into Option B
The OTHER SUBJECT is making this same decision at the same time.
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
Great job! Please review the answers below:
If the OTHER SUBJECT puts all of their 100 tokens in Option A...
(1) How many green balls are in your urn?
Answer: 100. The OTHER SUBJECT put 100 tokens in Option A. In this period, this means that your urn has 100 GREEN balls and 0 ORANGE balls.
(2) What is your payoff if you put all your tokens in Option A?
Answer: $7. Putting all of your tokens in Option A gives you a constant payoff no matter what the OTHER SUBJECT chooses.
(3) What is your payoff if you put all your tokens in Option B?
Answer: $13. Because your urn has 100 GREEN balls, a draw from this urn will always be a GREEN ball which earns you $13.
If the OTHER SUBJECT puts all of their 100 tokens in Option B...
(4) How many green balls are in your urn?
Answer: 0. The OTHER SUBJECT put 100 tokens in Option A. In this period, this means that your urn has 0 GREEN balls and 100 ORANGE balls.
(5) What is your payoff if you put all your tokens in Option A?
Answer: $7. Putting all of your tokens in Option A gives you a constant payoff no matter what the OTHER SUBJECT chooses.
(6) What is your payoff if you put all your tokens in Option B?
Answer: $5. Because your urn has 100 ORANGE balls, a draw from this urn will always be a ORANGE ball which earns you $5.
CONFIRM
If the OTHER SUBJECT puts 50 of their tokens in Option A and 50 of their tokens in Option B...
(7) How many green balls are in your urn?
Answer: 50. The OTHER SUBJECT put 50 tokens in Option A. In this period, this means that your urn has 50 GREEN balls and 50 ORANGE balls.
(8) What is your payoff if you put all your tokens in Option A?
Answer: $7. Putting all of your tokens in Option A gives you a constant payoff no matter what the OTHER SUBJECT chooses.
(9) What is your payoff if you put all your tokens in Option B?
Answer: None of the above. The OTHER SUBJECT put 50 tokens in Option A and 50 tokens in Option B. In this period, this means that your urn has 50 GREEN balls and 50 ORANGE balls. Because of this, a draw from this urn will either earn you $13 or $5 with equal likelihood.



You have 100 tokens to allocate between Option A and Option B.
METHOD 3
Balls in your urn:
GREEN balls: # tokens OTHER puts into Option B
ORANGE balls: # tokens OTHER puts into Option A
The OTHER SUBJECT is making this same decision at the same time.
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
Please answer the following 9 questions using the information on the screen:
If the OTHER SUBJECT puts all of their 100 tokens in Option A...
(1) How many green balls are in your urn?
100
50
0
(2) What is your payoff if you put all your tokens in Option A?
$13
$7
$5
None of the above
(3) What is your payoff if you put all your tokens in Option B?
$13
$7
$5
None of the above
If the OTHER SUBJECT puts all of their 100 tokens in Option B...
(4) How many green balls are in your urn?
100
50
0
(5) What is your payoff if you put all your tokens in Option A?
$13
$7
$5
None of the above
(6) What is your payoff if you put all your tokens in Option B?
$13
$7
$5
None of the above
CONFIRM
If the OTHER SUBJECT puts 50 of their tokens in Option A and 50 of their tokens in Option B...
(7) How many green balls are in your urn?
100
50
0
(8) What is your payoff if you put all your tokens in Option A?
$13
$7
$5
None of the above
(9) What is your payoff if you put all your tokens in Option B?
$13
$7
$5
None of the above



You have 100 tokens to allocate between Option A and Option B.
METHOD 3
Balls in your urn:
GREEN balls: # tokens OTHER puts into Option B
ORANGE balls: # tokens OTHER puts into Option A
The OTHER SUBJECT is making this same decision at the same time.
Option A:
$7 for certain
Option B:
$13 if GREEN ball
$5 if ORANGE ball
Great job! Please review the answers below:
If the OTHER SUBJECT puts all of their 100 tokens in Option A...
(1) How many green balls are in your urn?
Answer: 0. The OTHER SUBJECT put 100 tokens in Option A. In this period, this means that your urn has 0 GREEN balls and 100 ORANGE balls.
(2) What is your payoff if you put all your tokens in Option A?
Answer: $7. Putting all of your tokens in Option A gives you a constant payoff no matter what the OTHER SUBJECT chooses.
(3) What is your payoff if you put all your tokens in Option B?
Answer: $5. Because your urn has 100 ORANGE balls, a draw from this urn will always be an ORANGE ball which earns you $5.
If the OTHER SUBJECT puts all of their 100 tokens in Option B...
(4) How many green balls are in your urn?
Answer: 100. The OTHER SUBJECT put 100 tokens in Option A. In this period, this means that your urn has 100 GREEN balls and 0 ORANGE balls.
(5) What is your payoff if you put all your tokens in Option A?
Answer: $7. Putting all of your tokens in Option A gives you a constant payoff no matter what the OTHER SUBJECT chooses.
(6) What is your payoff if you put all your tokens in Option B?
Answer: $13. Because your urn has 100 GREEN balls, a draw from this urn will always be a GREEN ball which earns you $13.
CONFIRM
If the OTHER SUBJECT puts 50 of their tokens in Option A and 50 of their tokens in Option B...
(7) How many green balls are in your urn?
Answer: 50. The OTHER SUBJECT put 50 tokens in Option A. In this period, this means that your urn has 50 GREEN balls and 50 ORANGE balls.
(8) What is your payoff if you put all your tokens in Option A?
Answer: $7. Putting all of your tokens in Option A gives you a constant payoff no matter what the OTHER SUBJECT chooses.
(9) What is your payoff if you put all your tokens in Option B?
Answer: None of the above. The OTHER SUBJECT put 50 tokens in Option A and 50 tokens in Option B. In this period, this means that your urn has 50 GREEN balls and 50 ORANGE balls. Because of this, a draw from this urn will either earn you $13 or $5 with equal likelihood.

As a part of this experiment, you will be submitting 3 saliva samples. This is a very simple and non-invasive procedure where you basically spit a few times into a tube that is provided to you. This may seem a bit weird, but this procedure is very common and has been performed on thousands of subjects.

In order to submit a saliva sample, a lab assistant will give you an empty plastic tube in a plastic bag. Below are instructions for submitting a saliva sample using this tube. Please follow the instructions and submit your first saliva sample at this time.

(1) Unscrew the top of the tube and hold the open tube in your dominant hand.

(2) To help generate saliva, you can imagine that you are chewing food moving your jaw up and down as if you were actually eating.

(3) After you have generated some saliva, bring the open tube to touching your lips, and release saliva into the tube. Release as much saliva as you can without having to force it too much from your mouth.

(4) Repeat steps (2) and (3) until the tube is filled to the black line (not counting any bubbles). It may take around 5 minutes to fill the tube to the black line.

(5) Screw on the top of the tube. If needed, use the napkins provided to you to wipe the outside of the tube. Place the tube in the plastic baggie on the left side of your computer.

We will let you know when to give the next saliva sample (in approximately 25-30 minutes).

Click "Continue" when you have filled the tube up to the black line.

Continue

[Treatment subjects only]

For this part of the experiment, you will need to place your left hand in a bucket of ice water with your fingers spread open. It is very important that you leave your hand in the water as long as you possibly can. There is a required minimum amount of time that you need to keep your hand in the water in order to continue with the experiment. **If you do not keep your hand in the water for a long enough time to satisfy the minimum requirement, you will be asked to leave the experiment with only your $5 show-up fee.** You only have one opportunity to keep your hand in the water for a long enough time to pass the minimum threshold.

While you do not know the minimum required time, if you keep your hand in the water for 3 minutes you are guaranteed to pass this portion of the experiment and will be allowed to continue. I will announce when 3 minutes have passed. If, for some reason, you need to remove your hand before the 3 minutes are complete, please wait silently until the 3 minutes are up.

Also, we need to analyze and videotape your facial expressions during this task. It is important that you look directly into the camera for the entire time your hand is in the water.

Please remove all jewelry on your left hand and arm. The lab assistants are setting up a bucket of ice water for each of you and will be placing an elastic band on your left wrist above your wrist bone. Keeping your hand in the water means keeping the elastic band submerged underneath the water. Your time stops if your hand comes out of the water enough so that the elastic band is no longer under the water. The lab assistants will be watching the elastic band along with your video recording. Also, your fingers need to remain spread during the whole time your hand is in the water.

When everyone is ready to proceed, the experimenter will instruct everyone to begin. When the experimenter says "Begin", put your hand in the bucket of ice water and look directly into the camera. At this point, the timer will be started, and you will be told when 3 minutes have passed. Your time stops if you close your hand into a fist or if you remove your hand from the water such that the elastic band is no longer submerged.

If you feel it is necessary, please adjust your seat by using the lever on the right side of your chair.

Continue

Final Instructions

The cameras are turned off and you will not be videotaped at any other time during the experiment.

Now we are ready to begin the decision periods that will determine your dollar-amount earnings. After you have completed ALL of the periods, you will be shown a list displaying the choices that you made in every period. From this list, the computer will randomly select ONE PERIOD. Using the choices made in this period, the computer will then randomly draw ONE BALL from that period's urn. The earnings from this draw in this period will determine what you receive in the experiment (on top of the $5 show-up fee).

Because you will be paid based on the outcome of one of the upcoming periods, it is important to take your time in each period and make a choice that you are satisfied with.

Each period is unique. This means that you will never be shown the same choice twice.

If you have questions at any time during the experiment please raise your hand and an experimenter will come to assist you.
Please click "Continue" to start the decision periods.

Continue