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Abstract

Motivated by problems of coordination failure observed in weak-link games, we experimentally investigate behavioral spillovers for minimum- and median-effort coordination games. Subjects play these coordination games simultaneously and sequentially. The results show that successful coordination on the Pareto optimal equilibrium in the median game influences behavior in the minimum game when the games are played sequentially. Moreover, this positive, Pareto-improving spillover is present even when group composition changes across games, although the effect is not as strong. We also find that the precedent for uncooperative behavior in the minimum game does not influence play in the median game. These findings suggest guidelines for increasing cooperative behavior within organizations.

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1. Introduction

Coordination failure is often the reason for the inefficient performance of many groups, ranging from small firms to entire economies (e.g., Brandts and Cooper, 2006). When agents' actions have strategic interdependence, even when they succeed in coordinating they may be "trapped" in an equilibrium that is objectively inferior to other equilibria (Van Huyck et al., 1990). Coordination failure and inefficient coordination has been an important theme across a variety of fields in economics, ranging from development and macroeconomics to mechanism design for overcoming moral hazard in teams (e.g., Heller, 1986; Cooper and Ross., 1985; Bryant, 1983). This paper reports an experiment in which human subjects play the minimum- and median-effort coordination games simultaneously and sequentially. We also compare behavior when group composition changes across sequential play of the two games. The results show that successful coordination on the Pareto optimal equilibrium in the median game influences behavior in the minimum game when the games are played sequentially. Moreover, this positive, Pareto-improving spillover is present even when group composition changes across games, although the effect is not as strong.

Most research in game theory considers specific games in isolation. In practice, however, individuals interact strategically in many different settings. Sometimes they interact with same individuals across settings and sometimes with other individuals. Moreover, the order of play in the field is often a choice variable. Laboratory experiments have documented that prior experience of cooperation in one game can "spill over," resulting in cooperation in a related game where cooperation is usually not observed (Van Huyck et al., 1991; Schotter, 1998; Knez and Camerer, 2000; Ahn et al., 2001). We define a "behavioral spillover" as having occurred whenever observed (individual or group) behavior differs when a game is played together with other games, compared to the same game played in isolation. Behavioral spillover can be positive, such as when it induces Pareto-improving behavior in a game through an increase in cooperation or coordination, or it can be negative when it reduces efficiency, coordination or cooperation.

Understanding how playing different games in combination affects behavior can have significant practical relevance. In organizations, for example, workers may engage in a variety of different group tasks with their colleagues. Organizational experts contend that the context in which the group functions is important for explaining performance (Gersick, 1988). However, little evidence exists to help explain how the act of participating in multiple projects that overlap in time, space and organization composition can influence worker behavior. A central theme for organizational design is how to assign tasks of varying complexity and interdependence to groups in order to maximize performance (Postrel, 2001; Kozlowski and Bell, 2003).

In practice, individuals may work on many group projects, and individual effort impacts group performance in different ways depending on the interdependencies of group tasks and the degree of specialization required of group members to achieve high performance. In conjunctive tasks, the group's performance depends on the quality of work by the weakest member, such as a software development project where one bad coding bug can make the entire product unstable (Steiner, 1966). This is an example of a "weakest link" game, also known as a minimum-effort game. In additive and compensatory tasks, the group's overall performance depends on typical or average member work quality, such as in a geographically-dispersed sales team. Coordination incentives for this type of situation, if the returns to one's effort are shared with the group, are captured by the median-effort game. Experiments indicate that with relatively large groups, the median game often produces Pareto optimal outcomes, while the minimum game often produces coordination failure or convergence to low-payoff equilibria. Because of the complexity of work environments in practice, it is important to determine whether behavior may spill over from one situation to the other. One of the main contributions of this study is to evaluate the existence of behavioral spillover in two different environments, and to provide some empirical evidence about the different behavioral effects that may lead to this spillover.

A deeper understanding of the effect of behavioral spillover in sequential and simultaneous settings could be important for understanding group performance and improving efficiency. Organizations have the ability to structure their work environment or training in such a way as to harness advantageous, Pareto-improving ("positive") behavioral spillover and avoid disadvantageous, efficiency reducing ("negative") spillover, and this can explain "team development" methods used in different types of organizations. For example, the large consequences of team failure in aviation flight crews has led to widespread Crew Resource Management training to change the teamwork attitudes of team members early in the training process when members are more malleable (Kozlowski and Bell, 2003). Subsequent flight performance has weakest link characteristics, but many training activities include evaluations to make tasks more compensatory. These include team self-correction, where crew members monitor each other and provide corrective feedback, and cross training to develop critical knowledge about the skills and information needs of teammates.

Our use of a laboratory experiment allows us to control for confounding factors and isolate the impact of behavioral spillover. We also investigate how changing group composition influences behavioral spillover. Our findings suggest that the extent of behavioral spillover across activities may depend on when the activities take place. For example, we observe significant positive spillover from the median to the minimum game when the two games are played sequentially. Furthermore, we find that behavioral spillover occurs even when group composition is different across games played sequentially, and any negative spillover is weak and not statistically significant. This suggests that it may be useful to assign work teams first to less demanding group tasks in which performance depends on average or median effort, prior to assigning them to more unforgiving tasks that depend on the effort of the weakest group member.

2. Related Literature

Coordination games are relevant for many settings, including models of team production (Bryant, 1983), network externalities (Katz and Shapiro, 1985), product warranties under moral hazard (Cooper and Ross, 1985), and imperfect competition (Heller, 1986; Kiyotaki, 1988; Diamond, 1982). A number of studies have investigated mechanisms that can help overcome the coordination failure or convergence to an inefficient equilibrium that frequently occurs in the minimum game, such as pre-play communication (Cooper et al., 1992; Blume and Ortmann, 2007; Brandts and Cooper, 2007; Cason et al., 2010), repetition and fixed-matching protocols (Clark and Sefton, 2001), the introduction of leaders (Weber et al., 2001), and the introduction of between-group competition (Myung, 2009; Sheremeta, 2011). Other studies have considered the effect of longer time horizons (Berninghaus and Ehrhart, 1998) and increased feedback (Berninghaus and Ehrhart, 2001) or various levels of monitoring (Deck and Nikiforakis, 2011). Our work contributes to this literature by introducing behavioral spillover as another possible coordination- and efficiency-enhancing mechanism.

History of play from previous interactions has been shown to have an effect on future play in other games. For example, Knez and Camerer (2000) find that shared experience of efficient coordination in a minimum-effort game increases cooperation in a subsequent prisoner's dilemma game. Other studies have shown that both the minimum- and median-effort games can be used to establish precedents of cooperation for profit sharing contracts (Schotter, 1998) and prisoner's dilemma games (Ahn et al., 2001). Behavioral spillovers due to previously established cooperative precedent have also been observed between cooperative giving to a charity and a prisoner's dilemma game (Albert et al., 2007), between high and low incentive coordination games (Brandts and Cooper, 2006), and between minimum games and critical mass games (Devetag, 2005). In all these cases, behavioral spillovers cause an increase in cooperation in the subsequent game.[1] In addition, extrapolation and learning across games has been observed in players who first play a guessing game and then a coordination game (Mengel and Sciubba, 2010).

Much of the work on history of play from previous interactions focuses on the same groups playing related games in sequence. For example, Knez and Camerer (2000), Schotter (1998), Devetag (2005) and Brandts and Cooper (2006) examine how precedents of cooperation can be established when the same subjects play two games sequentially. One frequently studied game used for comparing fixed versus randomly matched groups is the prisoner's dilemma game. Ahn et al. (2001) consider how random versus fixed matching of 2-player groups in the prisoner's dilemma game affects future play, and find that the effect of past play is stronger for fixed matching. Recent research suggests that when subjects are in a fixed matching environment, a cooperative norm emerges in the prisoner's dilemma game, which does not emerge when subjects are randomly matched every period (Duffy and Ochs, 2009). When new members are introduced to small groups who have achieved Pareto optimal coordination, the coordination persists in the larger group (Weber, 2006). Our work contributes to this literature by studying behavioral spillovers when subjects are matched with the same subjects for both games, as well as when

[1] Other types of sequential spillovers are possible. For example, Cherry et al. (2003) and Cherry and Shogren (2007) find that rationality exhibited in one setting affects behavior in a subsequent disparate setting. Huck et al. (2011) observe feedback spillover when subjects have access to different information about actions of their group members. Further types of spillovers involve cross-game transfer of learning in signaling games (Cooper and Kagel, 2008).

subjects are matched with different subjects for each game. These treatments help to identify whether spillovers arise from learning at the individual level or from common knowledge of a precedent of play among a fixed group of subjects.

Simultaneous game-play has been under-studied to date and findings about the effect of behavioral spillover in simultaneous settings have been mixed. Our laboratory experiment provides additional evidence of the effect of simultaneous game-play in minimum- and median- effort coordination games on individual behavior. Previous experimental research has demonstrated that behavior in simultaneous settings differs from games played in isolation, but for games that differ from those we study. Bednar et al. (2010) report a laboratory experiment with two-player bimatrix games that produce behavioral spillovers. When two distinct games are played simultaneously with different opponents, behavior differs from the isolated controls. The authors conclude that subjects apply similar heuristics across games and that the type of game played influences individual behavior in predictable ways. Playing ensembles of games is cognitively difficult and compels agents to apply similar strategies to distinct games in order to reduce their cognitive burdens (Bednar and Page, 2007; Samuelson, 2001). However, when two identical minimum-effort coordination games or two identical public goods games are played simultaneously with different opponents, behavior does not differ from isolated controls (Falk et al., 2011).

3. Experimental Environment, Design and Procedures

3.1. Minimum- and Median-Effort Games

The objective of this study is to document behavioral spillovers between related games, one that tends to result in Pareto optimal coordination and one that often results in coordination failure or convergence to inefficient equilibria. We are also interested in understanding the underlying causes of behavioral spillovers by investigating behavioral spillovers both in settings when games are played simultaneously and in settings when they are played sequentially. For these reasons, we consider the minimum- and median-effort games.

In the n-player minimum-effort game, each player i chooses an effort e_i between 0 and $\bar{e}$. The payoff of player i depends on e_i and the minimum effort within the group, $\text{Min}(e_i, e_{-i})$:

$$\pi_i(e_i, e_{-i}) = a\,\text{Min}(e_i, e_{-i}) - b[e_i - \text{Min}(e_i, e_{-i})] + c, \tag{1}$$

where $b[e_i - \text{Min}(e_i, e_{-i})]$ denotes the deviation cost and *a, b* and *c* are constants such that *a=0.5, b=0.5* and *c=3*. The Pareto-optimal equilibrium that provides the highest payoffs to all players occurs when each player chooses the highest effort $\bar{e}$. Nevertheless, this game has been shown to produce convergence to the low-payoff, low-effort equilibria under certain conditions, such as large group size and high effort cost (Van Huyck et al., 1990; Knez and Camerer, 1994).

In the n-player median-effort game, each player i chooses an effort e_i between 0 and $\bar{e}$. The payoff of player i depends on e_i and the median effort within the group, $\text{Med}(e_i, e_{-i})$:

$$\pi_i(e_i, e_{-i}) = a\,\text{Med}(e_i, e_{-i}) - b|e_i - \text{Med}(e_i, e_{-i})| + c. \tag{2}$$

The only difference from (1) is that instead of using the minimum order statistic $\text{Min}(e_i, e_{-i})$, the median game uses the median order statistic $\text{Med}(e_i, e_{-i})$. This game often results in Pareto efficient outcomes (Van Huyck et al., 1991; Blume and Ortmann, 2007).[2]

Tables 1 and 2 show the minimum and median games used in the experiment. Subjects could choose any integer between 1 and 7 as their effort choice, e_i. Clearly, both games have the same set of equilibria along the diagonal with any common effort level.

[2] Note that we use the same linear cost functions for penalizing deviations from the relevant order statistic in both the median and minimum games. Often in median games (e.g., Van Huyck et al., 1991), the deviation costs are nonlinear, and increasing in the degree of deviation. We chose the linear payoff function for several reasons. First, we wanted to use a game in which the efficient outcome was easier to obtain so that there would be greater potential for spillovers. Second, we sought to increase comparability and symmetry across games by making the median game payoff function as similar as possible to the minimum game, other than the important difference in the order statistic used to determine payoffs.

3.2. Experimental Design & Procedures

The experiment was conducted at the Vernon Smith Experimental Economics Laboratory (VSEEL). Volunteers were recruited by email from a subject pool of undergraduate students from Purdue University. A total of 225 subjects participated in 9 sessions, with 25 subjects participating in each session. All subjects participated in only one session of this study. Some had participated in other economics experiments that were unrelated to this research.

The computerized experimental sessions used z-Tree (Fischbacher, 2007) to record subject decisions. Each session proceeded either in two or in three parts, depending on treatment. Subjects were given the instructions, shown in Appendix I, at the beginning of each part and the experimenter read the instructions aloud. In the first part, subjects' risk attitudes were elicited using a multiple price list of 15 simple lotteries, similar to Holt and Laury (2002).[3] At the end of each experimental session, one out of the 15 lottery decisions was randomly selected for payment.

We conducted four treatments as summarized in Table 3: a treatment in which the minimum game was followed by the median game (SeqMin), two treatments in which the median game was followed by the minimum game (SeqMed and SeqMedDiff), and a treatment in which these two games were played simultaneously (Sim). In SeqMin, SeqMed, and SeqMedDiff, subjects played the first game ten times with a known end period, and after reading additional instructions, played the second game ten times. In Sim, subjects read instructions about both games and then played both games simultaneously for ten rounds. In SeqMin, SeqMed, and Sim, 25 subjects were randomly assigned to a group of n=5 players and stayed in the same groups

[3] Subjects were asked to state whether they preferred safe option A or risky option B. Option A yielded $1 payoff with certainty, while option B yielded a payoff of either $3 or $0. The probability of receiving $3 or $0 varied across all 15 lotteries. The first lottery offered a 0% chance of winning $3 and a 100% chance of winning $0, while the last lottery offered a 70% chance of winning $3 and a 30% chance of winning $0.

throughout their entire session, playing both supergames with the same four partners. In SeqMedDiff, 25 subjects were randomly assigned to a group of n=5 players for the first supergame, and then were reassigned to a new group of n=5 players for the second supergame, using a perfect strangers matching protocol such that no subjects played the second supergame with any of their group members from the first supergame. This treatment allows us to distinguish learning at the individual level from common knowledge of precedent of play at the group level as contributing factors to behavioral spillovers.

At the beginning of each period, all subjects entered their effort choices without knowing the other subjects' effort choices for that period. After all subjects made their decisions, the output screen displayed the minimum effort (minimum game) or median effort (median game) for the subject's own group, as well as the subject's earnings. Subjects recorded their results in a hardcopy record sheet, and then moved on to the next period.[4] Subjects participating in the simultaneous treatment completed their decisions for both the minimum and median game before learning the order statistics and their payoffs for either game.

During the simultaneous treatment, the minimum and median games were displayed side by side on the same screen. Subjects typed their choices into each input box, and clicked "submit" at the bottom of the screen. The results of each game were also displayed side by side on the same screen – the median choice and outcome were displayed for the median game, and the minimum choice and outcome were displayed for the minimum game. We used categorical (and not ordinal) nomenclature to label each game, employing the colors blue and green as labels (instead of, for

[4] Recording results in a hardcopy record sheet is a standard procedure used at the VSEEL laboratory to provide subjects with convenient access to their previous decisions and payoff history. During the Sim treatment, the record sheet required subjects to enter actions from both games as they proceeded through the experiment. During the SeqMin, SeqMed, and SeqMedDiff treatments, however, subjects recorded their actions during the first game, and then received an entirely *new* set of instructions with a *new* record sheet for the second game.

example, 1 and 2 or A and B).[5] To control for presentation effects, we ran an extra session of the Sim treatment, switching the left-right location of the games on the subjects' screens. In two of the three Sim sessions, the minimum game was displayed on the left, and in the additional Sim session, the minimum game was displayed on the right.

In the Sim sessions, subjects had to click on the input box for that game to enter their decision. A function was executed in z-Tree that kept track of which input box the subject clicked on first. When the minimum game was displayed on the left, subjects made a decision in the minimum game first 94% of the time. When the median game was displayed on the left, subjects made a decision in the median game first 98% of the time. This consistent left to right decision-making is not surprising, since over 90% of subjects self-reported in our post-experiment questionnaire that they read and write from left to right horizontally in their native language. However, we do not find any difference between behavior in the sessions where the minimum game is displayed on the left as compared to the session where the median game is displayed on the left; therefore, we pool the three sessions for the analysis.

At the end of the experiment, one period from each game (minimum and median) was selected for payment using a random draw from a bingo cage. Subjects earned about $13 on average, and sessions (including instruction time) lasted approximately 35-45 minutes. Subjects also completed a demographic questionnaire at the end of each session.

4. Hypothesis Development

Our goal is to document behavior when these two different games are played simultaneously and in sequence, relative to each game played separately. Formal theoretical

[5] Blue and green were specifically chosen to avoid any color-dependent emotional response (Adams and Osgood, 1973; Valdez and Mehrabian, 1994).

models do not provide precise predictions for potential behavioral spillovers, so we proceed by providing some conjectures based on the findings of previous work.

Although currently game theory does not pinpoint potential sources of behavioral differences that have been documented in related work, in recent years some progress has been made in understanding spillovers (Samuelson, 2001; Page, 2006; Bednar and Page, 2007; Steiner and Stewart, 2008). This empirical study is intended to contribute additional evidence to inform the discussion of what behavioral effects may impact individual decisions in two games played simultaneously and sequentially. Our experimental design includes treatments in which individuals play the two games with different groups, so only individual learning can lead to spillovers, as well as when individuals play the games with the same groups, which can measure the marginal impact of adding common knowledge of a precedent of play on spillovers.

Spillover emerges whenever observed behavior – either individually or collectively in a group – differs when a game is played in isolation compared to when it is played together with other games. Behavior can spill over from one game to another when the two games are played simultaneously (Bednar et al., 2010; Savikhin and Sheremeta, 2010), as well as sequentially (Schotter, 1998; Knez and Camerer, 2000; Ahn et al., 2001; Devetag, 2005; Brandts and Cooper, 2006; Albert et al., 2007). Behavioral spillovers have also been referred to as "feedback spillovers" when they occur due to incomplete information or strategic uncertainty about each game (Huck et al., 2011). Different types of learning can be sources of behavioral spillovers.[6] For example,

[6] The effect described is a spillover of behavior rather than a focal point. While focal points can be excellent coordination devices, they tend to arise because of the framing of the game or because of exogenous influences such as label-based cues (Binmore and Samuelson, 2006). On the other hand, spillovers occur because of particular behavior that arises while playing the game. The only change in framing that could be considered a focal point is the addition of another payoff table during the Sim treatment (i.e., the median game payoff table acts as a focal point in the minimum game and vice versa). We conjecture that most of the effect is due to behavioral spillover and not a focal point, but this could be investigated in future work that manipulates framing by varying the set of available focal points.

individuals can learn about the strategies of the game, or they can learn about the social preferences of their teammates.[7]

The minimum and median game are descriptively similar since they have common strategy spaces and player numbers (Knez and Camerer, 2000), but they have different payoff structures. This could lead to significant differences in strategic uncertainty across games, which could also have implications for spillover. Standard game theoretic models assume that agents are rational and can fully optimize in any problem. However, when a problem is complex and requires high cognitive load to process, agents may use heuristics to make individual decisions (Wright, 1980; Gigerenzer et al., 1996; Simon, 1982). Cognitive load is a construct in psychology representing the burden that performing a task imposes on the learner's cognitive system (Paas and van Merrienboer, 1994).[8] A relevant measure for assessing cognitive load is the structure of the game, since tasks that are more complex by design or involve the need to process greater amounts of information require greater cognitive load than simpler tasks. In addition, games with higher strategic uncertainty are more demanding on subjects' belief formation and therefore may produce greater cognitive load relative to games with lower strategic uncertainty.

Following Bednar et al. (2010), we conjecture that games with lower strategic uncertainty have a stronger behavioral spillover effect onto other games with greater uncertainty because learning a strategy or learning about others' strategies in a game with lower strategic uncertainty requires less effort or cognitive load. The concept of entropy can be applied to measure the degree of strategic uncertainty in the median and minimum game. The entropy of a random variable X

[7] Extrapolation occurs when players, faced with new strategic situations, form beliefs by extrapolation from similar past situations and act on these beliefs (Steiner and Stewart, 2008). Analogical transfer describes the transfer of knowledge from one situation to another through finding correspondences and similarities across situations (Gick and Holyoak, 1983).
[8] Psychologists propose various methods for measuring cognitive load; for an overview, see Paas et al. (2003).

with a probability density function, $p(x) = \Pr\{X = x\}$, is defined by [9]

$$H(X) = -\sum_x p(x) \log_2 p(x). \quad (3)$$

Higher entropy indicates greater strategic uncertainty. Variants of this approach can be used to characterize many different classes of games, and the strategic uncertainty of a particular game can be measured after results have been collected.

Conjecture 1: Behavioral spillovers influence behavior more in a higher strategic uncertainty game than a lower strategic uncertainty game due to a greater cognitive load.

Van Huyck et al. (1991) use path-dependence to explain how decisions in future periods are influenced by subjects' shared experience within the same coordination game. Path-dependence is the extent to which the outcomes of previous periods matter for the current period (Page, 2006). Many games are path-dependent, of course, in the sense that current choices depend to some extent on previous choices. But some games may be more path-dependent than others. In addition, games are often path-dependent because of their incentive structure, so path-dependence can generally be thought of as a structural, not behavioral, characteristic. It is well documented that the median game exhibits stronger path-dependence than the minimum game (Van Huyck et al., 1991).[10] One plausible reason for this is that the median order statistic is more robust than the minimum, as it only takes one player to change the minimum order statistic whenever it exceeds one, while it may take several players to change the medium order statistic. In addition to evaluating the structure of the game, evidence of path-dependent behavior can be obtained through comparing individual behavior in early periods with behavior in later periods. Games with higher

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[9] Conventionally it is assumed that 0 log 0 = 0, since $x \log x \to 0$ as $x \to 0$.

[10] All reported sessions in Van Huyck et al. (1991), which were based on another variant of the median game, had final median outcomes that were identical to first-period median outcomes. Subjects' behavior showed little variation over time other than a reduced dispersion around this unchanging median. Knez and Camerer (1994) documented within-game precedent for the minimum effort game when played in isolation, but for this game only 12 of 20 groups had final-period minimum choices that were identical to first-period minimum choices.

path-dependence should be less susceptible to influence from other games, because behavior in these games is less volatile and actions depend more on actions of others in previous rounds of the same game. In addition, games with higher path-dependence may allow for greater learning, which should make behavior in these games more likely to spill over onto other games.

Conjecture 2: Games that are less path-dependent are more likely to be susceptible to behavioral spillover than games that are more path-dependent.

When an individual plays two distinct games with different group members, the behavioral spillovers can be attributed to individual behavior and cognitive processes. For example, subjects may have experienced successful coordination on the Pareto optimal equilibrium in the previous game and may seek to reproduce this success in the new game, or they may have acquired a general understanding of the structure of the game and understand the benefits of everyone choosing the maximum effort. However, when an individual plays these two games with the same group members, the behavioral spillovers observed may also be due to social processes, including common knowledge among group members of a precedent of play. This precedent provides a coordination device, and hence an equilibrium selection rule that is unavailable when group composition changes across games. This suggests that behavioral spillover will be stronger in games played with the same, rather than different, group members.

Conjecture 3: The behavioral spillover in games played with same subjects is stronger than the behavioral spillover in games played with different subjects.

5. Experiment Results

Table 4 reports the frequency of Pareto optimal coordination of each supergame in period 10. Pareto optimal coordination is defined as coordinating on the equilibrium of 7. In the SeqMin treatment, where the minimum game was played first, only 1 of 10 groups learned to coordinate on the efficient equilibrium in the minimum game. This finding is consistent with previous research (Knez and Camerer, 1994, 2000; Bornstein et al., 2002; Weber et al., 2004; Dufwenberg and Gneezy, 2005). A common reason cited for the lack of coordination in the minimum game is the presence of strategic uncertainty (Van Huyck et al., 1990; Blume and Ortmann, 2007). Strategic uncertainty may cause risk averse subjects to choose lower effort. Based on the initial lottery choice task, we classify 69% of subjects as risk averse, which may contribute to the lack of coordination in the minimum game.[11]

In the Sim treatment, where the two games were played simultaneously, 4 of 15 groups learned to coordinate on the Pareto optimal equilibrium in the minimum game. In the SeqMed treatment, where the minimum game was played after the median game, 8 of 10 groups learned to coordinate on the Pareto optimal equilibrium in the minimum game. These differences in the rate of efficient coordination for the minimum game between the SeqMed and SeqMin treatments and between the SeqMed and Sim treatments are significant (in both cases Fisher's exact test p-value < 0.05). However, no significant difference exists in the minimum game efficient coordination rates between the SeqMin and Sim treatments (Fisher's exact test, p-value = 0.61).[12] Thus, greater coordination on the efficient equilibrium in the minimum game occurs through behavioral spillover from the median game when the games are played sequentially. To summarize:

Result 1. Behavioral spillover exists in the minimum game. When the median game is played before the minimum game, groups coordinate on the Pareto optimal equilibrium

[11] However, this classification of individuals into groups of risk-averse and risk-seeking does not appear to be related to their initial behavior in the minimum game. We conducted a regression with choice of effort in the minimum game in period one as the independent variable and the risk preference classification as the explanatory variable, and found that the risk-averse dummy variable is not significantly different from zero (p-value > 0.10).

[12] It is conceivable that efficiency could improve in the minimum game if the supergame was repeated for a second time in an additional control treatment for comparison with the second (minimum) supergame conducted in the SeqMed treatment. We believe this is highly unlikely, however, since average choices in this game tended to decline rather than increase across rounds.

significantly more often in the minimum game than when the minimum game is played first or when the two games are played simultaneously.

Spillovers also occur in the minimum game even when subjects are matched with completely different group members in each supergame. In the SeqMedDiff treatment, where the minimum game was played with new subjects after the median game, 6 of 10 groups coordinated on the Pareto optimal equilibrium in the minimum game. This efficient coordination rate is significantly higher than in the SeqMin treatment based on a probit regression that uses coordination on the Pareto optimal equilibrium in the last period as the dependent variable and the treatment condition as the explanatory variable (p-value=0.02).[13] This result suggests that a major part of behavioral spillover is caused by subjects' previous experience with efficient coordination, since significant efficiency improvements occur in the minimum game even when this cooperation experience occurs through interactions with a set of completely different individuals. Coordination on the Pareto optimal equilibrium in the minimum game in the SeqMedDiff treatment is not as high as in the SeqMed treatment; however, the difference is not statistically significant (probit model p-value=0.41). Therefore, we find only weak support for Conjecture 3.

Result 2. Behavioral spillover on subsequent play of the minimum game is present even when group composition changes across games, although the effect is not as strong.

Figure 1 provides additional support for Results 1 and 2. This figure displays the time series of choices in the minimum game, with the average of the choices in each group on the left and the average of the minimum of group choices on the right. Both a t-test and nonparametric Wilcoxon Mann-Whitney test fail to reject the hypothesis that the average (or minimum) effort

[13] Nonparametric tests are not feasible for the second supergame in the SeqMedDiff treatment because different groups are not statistically independent. Subjects interacted with each other in different groups in the first supergame of the session. To account for this influence that interacting subjects could have on each other, the probit models summarized here are estimated using robust standard errors based on session clustering.

level in the SeqMin treatment is equal to the average (or minimum) effort level in the Sim treatment (all p-values are above 0.50).[14] On the other hand, the data reject the null hypotheses that the average (or minimum) effort level in the SeqMed and SeqMedDiff treatments is the same as in the SeqMin treatment (all p-values are below 0.05).[15]

In contrast with the minimum game, almost all groups coordinate on the Pareto optimal equilibrium in the median game, with choices in the last period at the equilibrium for 7 of 10 groups in SeqMin, 19 of 20 groups in SeqMed and SeqMedDiff and 12 of 15 groups in Sim treatments. Our finding that coordination on the Pareto optimal equilibrium is more likely in the median game as compared to the minimum game is in line with related literature. However, coordination rates in the median game in our experiment are generally greater than the rates of coordination found previously (Van Huyck et al., 1991; Schotter, 1998; Blume and Ortmann, 2007).[16] Rates of coordination on the Pareto optimal equilibrium in median game are not statistically different across treatments.

Result 3. No significant behavioral spillover occurs in the median game. Groups coordinate on the Pareto optimal equilibrium equally well in the median game in all treatments.

This result cannot be attributed simply to a bias towards cooperation and coordination among experimental subjects. Previous research has shown negative spillover from a simple "self-interest" game that reduces cooperation and coordination on prisoner's dilemma and intertemporal

[14] These tests use the average (or minimum) effort in each group across all the periods for each observation, and groups in this partner design are statistically independent.

[15] The Mann-Whitney test rejects the null hypotheses that the average minimum effort level in SeqMed is the same as in the SeqMin treatment, or that minimum effort in SeqMed is the same as in the Sim treatment (both p-values < 0.01). Simple regression models (with robust standard errors clustered at the session level) reject the null hypotheses that the average minimum effort level in SeqMedDiff is the same as in the SeqMin treatment (p-value = 0.03), and that minimum effort in SeqMedDiff is the same as in the Sim treatment (p-value = 0.02).

[16] For example, Van Huyck et al. (1991), who used a non-linear payoff function and placed subjects into groups of 9, found that the Pareto optimal equilibrium of 7 was chosen by 14 out of 27 of subjects, and actions 4, 5 and 6 were chosen by the remaining subjects. Schotter (1998) found that 2 out of 9 groups coordinated on the Pareto optimal equilibrium by the last round, while 3 groups coordinated on 6 (out of 7) and 2 groups coordinated on 5. Blume and Ortmann (2007) found that the average effort selected is 5 (out of 7) in the first round and 6 in later rounds.

coordination games (Bednar et al., 2010). It is possible that our results regarding behavioral spillover are sensitive to the setup of each game, i.e. the payoff function and other factors such as group size and strategy space. For example, choosing a nonlinear payoff function in the median game may reduce behavioral spillovers because of a decrease in analogical-based learning (as the payoff structures for the minimum and medium games would be more different) and a decrease in convergence to the Pareto optimal equilibrium. The sensitivity of behavioral spillovers to changes in experimental environment is an interesting question, which we leave for the future research.

To further illustrate how different groups behave in both games, Figure 3 displays the average choices across all periods for the minimum and median games by groups. The SeqMedDiff is omitted since in the minimum game the group composition was changed. A positive and significant relation exists between average group choices in the minimum and median games for the SeqMed and Sim treatments, with Spearman's rank correlation coefficients of 0.69 and 0.54. This suggests that more cooperative groups tend to be more cooperative in both games. In the SeqMin treatment, however, the correlation between minimum and median choices is not significantly different from zero. This provides further evidence that behavior in the median game is not influenced by the minimum game. Moreover, these results suggest that the correlation in cooperativeness in two games played sequentially is mostly due to behavioral spillovers and not due to inherent inclinations of cooperation for individual subjects.

Figure 4 displays the degree of miscoordination (a measure of convergence on any equilibrium) in the minimum and median games. Miscoordination, calculated as $[e_i - \mathrm{Min}(e_i, e_{-i})]$ for the minimum game and $|e_i - \mathrm{Med}(e_i, e_{-i})|$ for the median game, is lower on average in the median game than in the minimum game. In the minimum game, miscoordination in the SeqMed treatment is significantly lower than in the SeqMin or Sim treatments (p-values are

0.01 and 0.04). Miscoordination is somewhat lower in the SeqMedDiff treatment than in the SeqMin and Sim treatments, but this is not statistically significant based on a regression that uses the average miscoordination over all periods as the dependent variable and the treatment condition as the explanatory variable (p-values are 0.16 and 0.26).[17] In the median game, there are no statistically significant differences between treatments.

Result 4. Significantly less miscoordination occurs in the minimum game when it is played after the median game than when it is played first or simultaneously with the median game. This result is stronger when both games are played with the same group members.

6. Behavioral Explanations and Discussion

The findings of this experiment suggest that behavior in isolated games differs from behavior in games played in combination, providing evidence of behavioral spillover. In this section, we provide additional empirical measures of behavior in both games, related to the concepts introduced in Section 4.

In order to measure the degree of strategic uncertainty in each game, consider each game when played in isolation and first in the sequence. We model individual stage game strategies as a discrete random variable, X. The entropy in both the median and minimum games is in the interval [0; 3.32] when calculated based on the ten periods that each game is played. The lower bound indicates certainty, i.e., all players choose the same strategy over all periods of the experiment, resulting in a stable equilibrium outcome. The upper bound corresponds to a uniform distribution

[17] We conducted three two-sample t-tests comparing average (across all periods) miscoordination in the minimum game of each group between SeqMin, SeqMed, and Sim treatments. These tests reject the null hypothesis that miscoordination is equal between SeqMed and SeqMin (p-value = 0.01), or between SeqMed and Sim (p-value = 0.04), but do not reject the null hypothesis that miscoordination is equal between SeqMin and Sim (p-value = 0.72). To compare miscoordination in the SeqMedDiff treatment, we used a regression with robust standard errors based on session clustering.

among all possible outcomes.[18] Therefore, higher entropy indicates greater strategic uncertainty.

In the median game (SeqMed and SeqMedDiff), 14 of 20 groups begin at the Pareto optimal effort level 7, and 19 of 20 groups converge to the Pareto optimal equilibrium by period 4. The average entropy among all groups is 1.41, indicating only moderate strategic uncertainty. In the minimum game (SeqMin), average choices begin around effort level 4 and then usually decline, with 4 of 10 groups coordinating at 1 and some groups coordinating at 4 or 5 by the end of the ten periods. The average entropy among all groups is 2.82, indicating a considerably higher level of strategic uncertainty. The difference between entropy in both games is statistically significant, indicating lower strategic uncertainty in the median game (Wilcoxon Mann-Whitney test, p-value < 0.05 for both SeqMedDiff and SeqMed comparison with SeqMin). Consistent with Conjecture 1, we find that greater strategic uncertainty (indentified by higher entropy) results in a stronger behavioral spillover influencing the minimum game.[19]

Next, to test Conjecture 2, we measure the extent of path-dependence in each game. Simple evidence of path-dependence comes from comparison of behavior in period 1 with behavior in period 10. When the minimum game is played first (SeqMin), for 2 out of 10 groups playing the minimum game the tenth period minimum choice equals the first period minimum choice. On the other hand, when the median game is played first (SeqMed and SeqMedDiff), for 16 out of 20 groups playing the median game the tenth period median choice equals the first period median choice. These differences in path-dependence are significant across games (Fisher's exact test p-

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[18] Entropy is a better measure of strategic uncertainty than variance because it takes into account each individual's variability in choices. Consider a set of observed choices {1, 2, 2, 2, 2} and a set of observed choices in the following period {2, 1, 2, 2, 2}. While the variance in this case is unchanged, the entropy measurement identifies these as different. In a generic normal-form game with 5 players and 7 strategies entropy is in the interval [0; 14]. However, our experiment employed exactly 10 periods for each game, so the random variable X could take only 10 possible outcomes. This constrains the upper bound to only 3.32.

[19] The average entropy of the minimum game when it follows the median game (in SeqMed and SeqMedDiff) is 1.00, which is also significantly lower than the entropy of 2.82 when the minimum game is played first. This indicates that the spillover from the median game not only improves efficient coordination, but it also reduces strategic uncertainty in the minimum game.

value < 0.05), suggesting that as a result of different path-dependence, the median game should be less susceptible to influence from the minimum game.

To further test this prediction, Table 5 reports regression results of subjects' individual choices, separately for the minimum and median game. A time trend, the median (minimum) choice, and lagged group minimum (median) choice are the independent variables. The previous period group choices significantly influence the current choice. In the Sim treatment, we also find that the median choice in the current period positively affects the minimum choice in the current period (column 4), while the minimum choice in the current period does not affect the median choice in the current period (column 7).[20] This finding is consistent with Results 1 and 2, indicating greater behavioral spillover in the minimum game than in the median game.

To summarize, the two major reasons for behavioral spillovers identified in this study are strategic uncertainty and path-dependence. Consistent with Conjecture 1, behavioral spillovers influence behavior more in the higher strategic uncertainty (and greater cognitive load) minimum game than in the median game. We also find that the median game is more path-dependent than the minimum game, an additional potential source of behavioral spillover. This observation is consistent with Conjecture 2. Finally, behavioral spillover is present in the minimum game even when group composition changes, although the effect is not as strong as suggested in Conjecture 3.

The behavioral effects that we have highlighted have clear practical applications. Managers should be aware of how the properties of organizations and work activities affect the mechanisms through which spillovers occur. Among other factors, the volatility of expended effort during the

[20] We estimated the equations in columns 4 and 7 as a simultaneous equation system since subjects made both game choices simultaneously. The estimation results are qualitatively unchanged when using session dummy variables to control for session effects. Also, the estimation results are very similar when using individual subject dummy variables to control for individual subject fixed effects in specifications (4) and (7). The only exception is that in specification (4) the *Median Choice* variable is no longer significant. The main reason is that the estimation of simultaneous equation system with subject fixed effects uses 156 degrees of freedom with only 675 observations.

work assignment and the existence of other assignments can all influence the direction and magnitude of spillovers.

7. Conclusion

This study investigates behavioral spillovers in the minimum- and median-effort coordination games, and provides initial evidence for how the timing of play in different types of coordination games affects behavior. We find that cooperative behavior in the median game influences behavior in the minimum game when the games are played sequentially. This spillover occurs (but is weaker) even when group composition changes. Behavior in the minimum game does not significantly affect play in the median game.

In practical applications, organizations should be aware of the context and timing in which group tasks are assigned. First, providing work teams with tasks that only require good average performance for success might improve later performance on more demanding tasks that require good performance by every team member. Moreover, the results suggest that experience gained in tasks that an individual performs with one group of co-workers may influence performance on subsequent disparate tasks performed with a different group of colleagues.

Future work in the area of behavioral spillovers is needed in order to understand how behavior may be affected by simultaneous and sequential game play. In particular, simultaneous game-play and related behavioral spillovers is an important area of research that has been relatively unexplored to date. In addition, the effect of behavioral spillover in other environments, such as public goods games or contests, could be explored. Moreover, this study points out the importance of further development of a comprehensive theoretical framework for understanding behavioral effects, as well as dynamic models of path dependence and how these can influence spillovers within and across environments. We hope our findings will be useful for future, descriptively-accurate theories of how agents play combinations of games, building on the work of Samuelson (2001) and Bednar and Page (2007).

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Tables and Figures

Table 1: Payoffs in Minimum-Effort Game (*a*=0.5, *b*=0.5, and *c*=3)

		Minimum Value of X Chosen						
		7	**6**	**5**	**4**	**3**	**2**	**1**
Your Choice	**7**	$6.50	$5.50	$4.50	$3.50	$2.50	$1.50	$0.50
	6		$6.00	$5.00	$4.00	$3.00	$2.00	$1.00
	5			$5.50	$4.50	$3.50	$2.50	$1.50
	4				$5.00	$4.00	$3.00	$2.00
	3					$4.50	$3.50	$2.50
	2						$4.00	$3.00
	1							$3.50

Table 2: Payoffs in Median-Effort Game (*a*=0.5, *b*=0.5, and *c*=3)

		Median Value of Y Chosen						
		7	**6**	**5**	**4**	**3**	**2**	**1**
Your Choice	**7**	$6.50	$5.50	$4.50	$3.50	$2.50	$1.50	$0.50
	6	$6.00	$6.00	$5.00	$4.00	$3.00	$2.00	$1.00
	5	$5.50	$5.50	$5.50	$4.50	$3.50	$2.50	$1.50
	4	$5.00	$5.00	$5.00	$5.00	$4.00	$3.00	$2.00
	3	$4.50	$4.50	$4.50	$4.50	$4.50	$3.50	$2.50
	2	$4.00	$4.00	$4.00	$4.00	$4.00	$4.00	$3.00
	1	$3.50	$3.50	$3.50	$3.50	$3.50	$3.50	$3.50

Table 3: Summary of Treatments

Treatment	First Game	Second Game	Same or Different Groups	Number of Sessions	Number of Subjects
SeqMin	Minimum	Median	Same	2	50
SeqMed	Median	Minimum	Same	2	50
SeqMedDiff	Median	Minimum	Different	2	50
Sim	Minimum and Median		Same	3	75

Table 4: Frequency of Pareto Optimal Coordination in Period 10 (Number of Groups)

Treatment	Minimum Game	Median Game
SeqMin	1/10 (10%)	8/10 (80%)
SeqMed	8/10 (80%)	9/10 (90%)
SeqMedDiff	6/10 (60%)	10/10 (100%)
Sim	4/15 (27%)	11/15(73%)

Table 5: Regression Models of Individual Subject Choices

Dependent Variable:	**Minimum Game**				**Median Game**		
Individual Subject Choices	**(1) SeqMin**	**(2) SeqMed**	**(3) SeqMedDiff**	**(4) Sim**	**(5) SeqMin**	**(6) SeqMed⁺**	**(7) Sim**
Median Choice				1.03**			
(current period)				(0.09)			
Minimum Choice							0.03
(current period)							(0.02)
Group Minimum Choice	0.84**	0.39**	0.43**	0.57**			
(previous period)	(0.03)	(0.05)	(0.04)	(0.03)			
Group Median Choice					0.63**	0.67**	0.83**
(previous period)					(0.09)	(0.05)	(0.04)
Inverse of period	4.25**	1.31**	1.80**	3.85**	-0.07	-0.06	-0.06
	(0.42)	(0.21)	(0.34)	(0.35)	(0.14)	(0.16)	(0.15)
Observations	450	450	450	675	450	900	675
# of subjects	50	50	50	75	50	100	75

** p<0.01, * p<0.05. Standard errors in parentheses.

Columns (1), (2), (3), (5) and (6) are estimated using random subject effects. Columns (4) and (7) are estimated using a simultaneous system of equations.

⁺ Column (6) aggregates SeqMed and SeqMedDiff data since the treatments are identical for these first 10 periods of the session.

Figure 1: Average Minimum Game Choices over 10 Periods

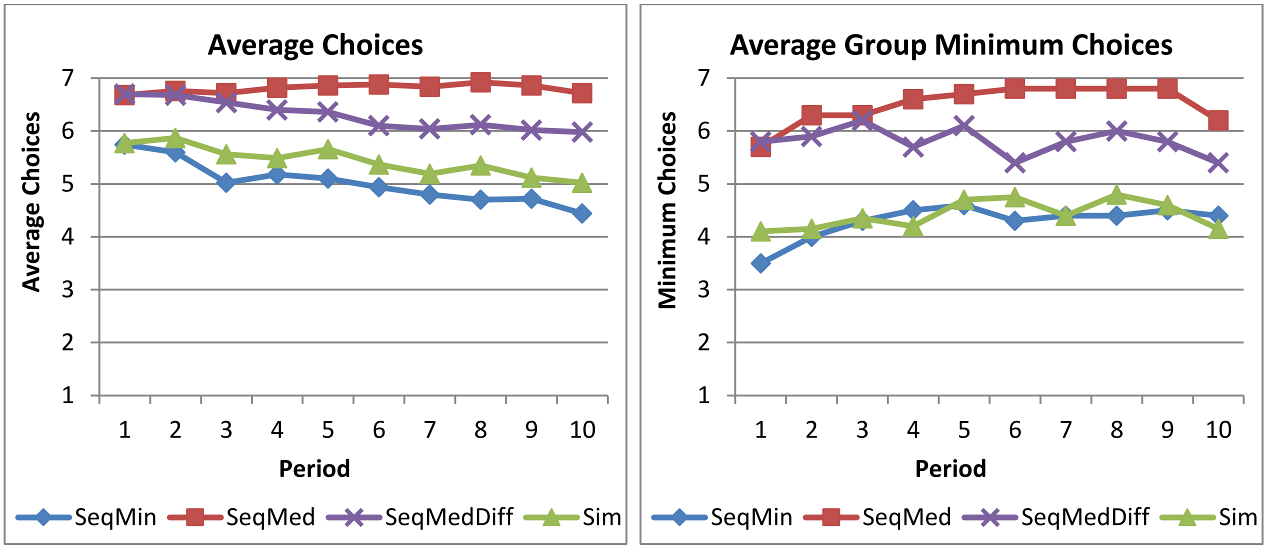


Figure 2: Average Median Game Choices over 10 Periods

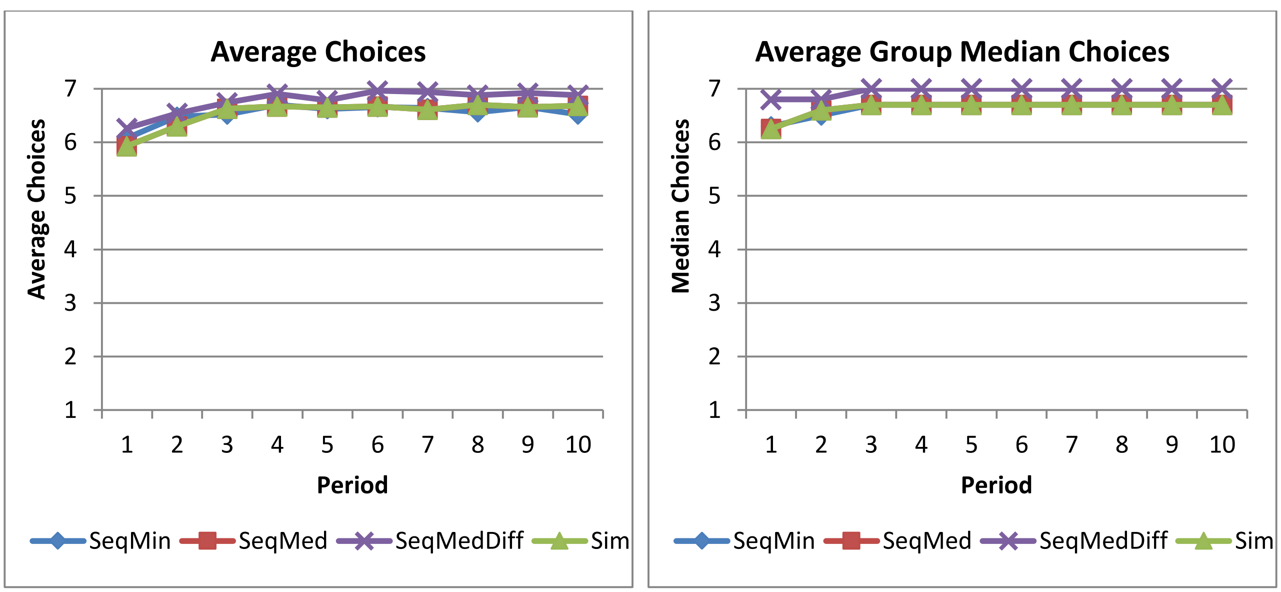


Figure 3: Correlation of Minimum and Median Game Choices

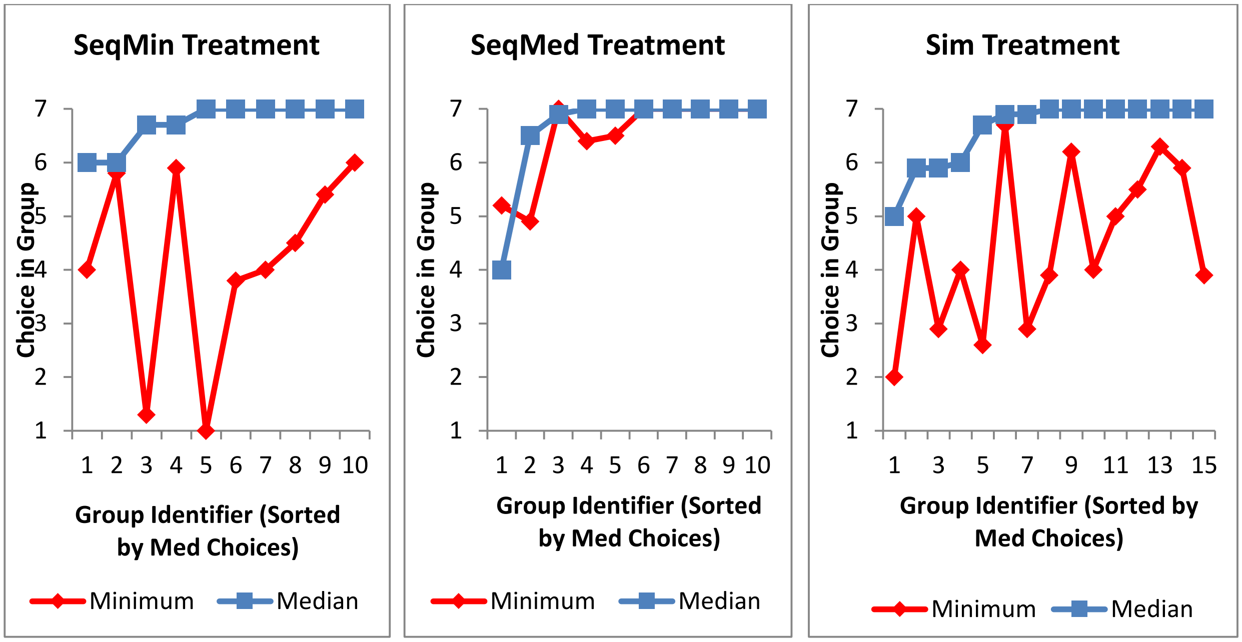
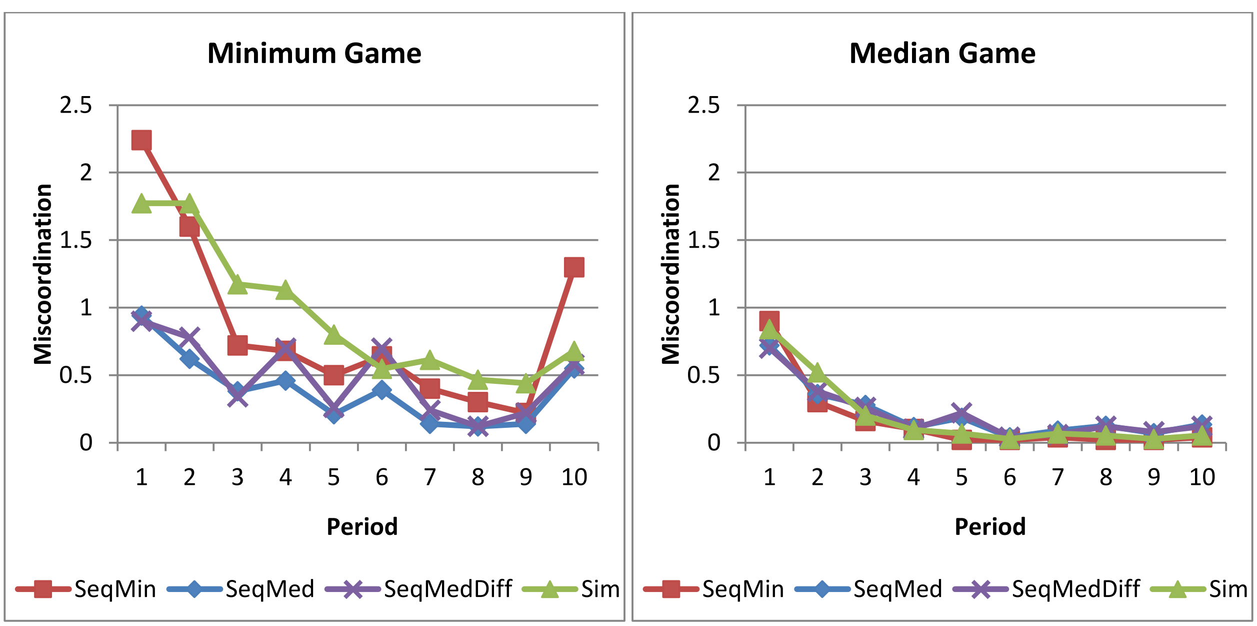


Figure 4: Miscoordination over 10 Periods



Appendix I. – Instructions for Simultaneous Treatment (Not Intended for Publication)

GENERAL INSTRUCTIONS

This is an experiment in the economics of decision making. Various research agencies have provided funds for this research. The instructions are simple. If you follow them closely and make appropriate decisions, you can earn an appreciable amount of money which will be paid to you at the end.

It is very important that you remain silent and do not look at other people's work. If you have any questions, or need assistance of any kind, please raise your hand and an experimenter will come to you. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid. We expect and appreciate your cooperation.

YOUR DECISION

In this part of the experiment you will be asked to make a series of choices in decision problems. How much you receive will depend partly on **chance** and partly on the **choices** you make. The decision problems are not designed to test you. What we want to know is what choices you would make in them. The only right answer is what you really would choose.

For each line in the table in the next page, please state whether you prefer option A or option B. Notice that there are a total of **15 lines** in the table but just **one line** will be randomly selected for payment. You do not know which line will be paid when you make your choices. Hence you should pay attention to the choice you make in every line. After you have completed all your choices a token will be randomly drawn out of a bingo cage containing tokens numbered from **1 to 15**. The token number determines which line is going to be paid.

Your earnings for the selected line depend on which option you chose: If you chose option A in that line, you will receive **$1**. If you chose option B in that line, you will receive either **$3** or **$0**. To determine your earnings in the case you chose option B there will be second random draw. A token will be randomly drawn out of the bingo cage now containing twenty tokens numbered from **1 to 20**. The token number is then compared with the numbers in the line selected (see the table). If the token number shows up in the left column you earn $3. If the token number shows up in the right column you earn $0.

Are there any questions?

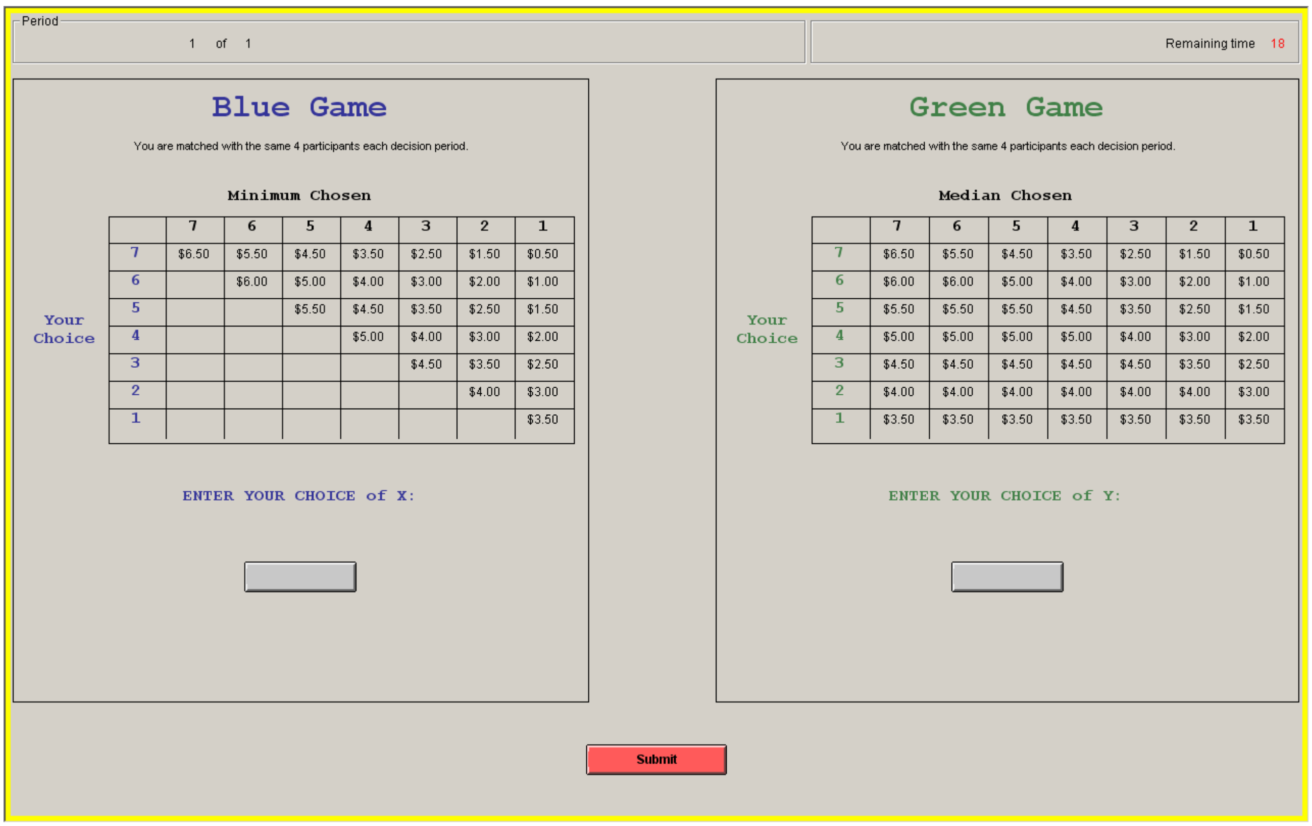
Decision no.	Option A	Option B		Please choose A or B
1	**$1**	**$3** never	**$0** if 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15, 16,17,18,19,20	
2	**$1**	**$3** if 1 comes out of the bingo cage	**$0** if 2,3,4,5,6,7,8,9,10,11,12,13,14,15, 16,17,18,19,20	
3	**$1**	**$3** if 1 or 2	**$0** if 3,4,5,6,7,8,9,10,11,12,13,14,15, 16,17,18,19,20	
4	**$1**	**$3** if 1,2 or 3	**$0** if 4,5,6,7,8,9,10,11,12,13,14,15, 16,17,18,19,20	
5	**$1**	**$3** if 1,2,3,4	**$0** if 5,6,7,8,9,10,11,12,13,14,15, 16,17,18,19,20	
6	**$1**	**$3** if 1,2,3,4,5	**$0** if 6,7,8,9,10,11,12,13,14,15, 16,17,18,19,20	
7	**$1**	**$3** if 1,2,3,4,5,6	**$0** if 7,8,9,10,11,12,13,14,15,16,17,18,19,20	
8	**$1**	**$3** if 1,2,3,4,5,6,7	**$0** if 8,9,10,11,12,13,14,15,16,17,18,19,20	
9	**$1**	**$3** if 1,2,3,4,5,6,7,8	**$0** if 9,10,11,12,13,14,15,16,17,18,19,20	
10	**$1**	**$3** if 1,2,3,4,5,6,7,8,9	**$0** if 10,11,12,13,14,15,16,17,18,19,20	
11	**$1**	**$3** if 1,2, 3,4,5,6,7,8,9,10	**$0** if 11,12,13,14,15,16,17,18,19,20	
12	**$1**	**$3** if 1,2, 3,4,5,6,7,8,9,10,11	**$0** if 12,13,14,15,16,17,18,19,20	
13	**$1**	**$3** if 1,2, 3,4,5,6,7,8,9,10,11,12	**$0** if 13,14,15,16,17,18,19,20	
14	**$1**	**$3** if 1,2, 3,4,5,6,7,8,9,10,11,12,13	**$0** if 14,15,16,17,18,19,20	
15	**$1**	**$3** if 1,2, 3,4,5,6,7,8,9,10,11,12,13,14	**$0** if 15,16,17,18,19,20	

INSTRUCTIONS

In this part of the experiment you will participate in a game with **four other** participants. You will not know the identity of the participants you are grouped with. The experiment will consist of **10 periods**. You will participate in both a **BLUE GAME** and a **GREEN GAME** at the same time and with the **same participants**. The **BLUE GAME** will appear on the left side of the screen and the **GREEN GAME** will appear on the right side of the screen at the same time in all 10 periods.

One period will be randomly selected for payment for each game at the end of the experiment. After you have completed all periods a token will be randomly drawn out of a bingo cage containing tokens numbered from **1 to 10**. The token number determines which period is going to be paid in the BLUE game. That token will be returned to the bingo cage, and a token will be randomly drawn again out of the bingo cage containing tokens numbered from **1 to 10**. The token number determines which period is going to be paid in the GREEN game.

In each period, you will select two numbers denoted by **X** and **Y**. The values of X and Y you may choose are 1, 2, 3, 4, 5, 6, or 7. When you are ready to make your decision, click on the “input boxes” below “Enter your choice of X” and “Enter your choice of Y” and the program will allow you to enter in your number choices. When you are finished making your choices, click “Submit”.



Blue Game — Minimum Chosen

	7	6	5	4	3	2	1
7	$6.50	$5.50	$4.50	$3.50	$2.50	$1.50	$0.50
6		$6.00	$5.00	$4.00	$3.00	$2.00	$1.00
5			$5.50	$4.50	$3.50	$2.50	$1.50
4				$5.00	$4.00	$3.00	$2.00
3					$4.50	$3.50	$2.50
2						$4.00	$3.00
1							$3.50

Green Game — Median Chosen

	7	6	5	4	3	2	1
7	$6.50	$5.50	$4.50	$3.50	$2.50	$1.50	$0.50
6	$6.00	$6.00	$5.00	$4.00	$3.00	$2.00	$1.00
5	$5.50	$5.50	$5.50	$4.50	$3.50	$2.50	$1.50
4	$5.00	$5.00	$5.00	$5.00	$4.00	$3.00	$2.00
3	$4.50	$4.50	$4.50	$4.50	$4.50	$3.50	$2.50
2	$4.00	$4.00	$4.00	$4.00	$4.00	$4.00	$3.00
1	$3.50	$3.50	$3.50	$3.50	$3.50	$3.50	$3.50

BLUE GAME

In the BLUE GAME, the value you pick for X and the **minimum value of X chosen by all members** in your group (including yourself) will determine your payoff in any one period.

Table 1 tells you how you earn money. Please look at the table now. The entries in the table give each participant’s U.S. Dollar earnings from selecting alternative values of X. The earnings in each period may be found by looking across from the value you choose on the left-hand side of the table, and down from the minimum value chosen from the top of the table. For example, if you chose a 4 and the minimum value chosen was a 3, you earn $4.00 that period. Alternatively, if you chose 4 and the minimum value of X chosen was 4, then you earn $5.00. Note that all five participants (including you) have the same payoff table.

Table 1 – Payoffs for BLUE GAME

		Minimum Value of X Chosen						
		7	**6**	**5**	**4**	**3**	**2**	**1**
Your Choice	**7**	\$6.50	\$5.50	\$4.50	\$3.50	\$2.50	\$1.50	\$0.50
	6		\$6.00	\$5.00	\$4.00	\$3.00	\$2.00	\$1.00
	5			\$5.50	\$4.50	\$3.50	\$2.50	\$1.50
	4				\$5.00	\$4.00	\$3.00	\$2.00
	3					\$4.50	\$3.50	\$2.50
	2						\$4.00	\$3.00
	1							\$3.50

The experiment will consist of 10 periods, where in each period you will be grouped with the same four participants. In each period the following will occur:

1. At the beginning of the period, you are asked to enter your choice of X for that period. Your choice of X is private and should not be discussed with anyone during the experiment. Note that you **do not** know the other participants' choices of X before making your selection.

2. After all participants make their decisions, the computer will determine the minimum value of X chosen in your group and display it on the output screen.

3. Then the computer will determine your earnings (you may confirm this using Table 1) for that period. Please record your results for the period on your **record sheet** under the appropriate heading.

GREEN GAME

In the GREEN GAME, the value you pick for Y and the **median value of Y chosen by all members** in your group (including yourself) will determine your payoff in any one period. The median is the middle number in the ordered Y numbers chosen by the five participants (including you) in the group. For example, if the five Y choices are 1, 3, 4, 4, 7 the middle, median value of Y is 4.

Table 2 tells you how you earn money. Please look at the table now. The entries in the table give each participant's U.S. Dollar earnings from selecting alternative values of Y. The earnings in each period may be found by looking across from the value you choose on the left-hand side of the table, and down from the median value chosen from the top of the table. For example, if you chose a 4 and the median value chosen was a 3, you earn \$4.00 that period. Alternatively, if you chose 4 and the median value of X chosen was 4, then you earn \$5.00. Note that all five participants (including you) have the same payoff table.

Table 2 – Payoffs for GREEN GAME

		Median Value of Y Chosen						
		7	**6**	**5**	**4**	**3**	**2**	**1**
Your Choice	**7**	\$6.50	\$5.50	\$4.50	\$3.50	\$2.50	\$1.50	\$0.50
	6	\$6.00	\$6.00	\$5.00	\$4.00	\$3.00	\$2.00	\$1.00
	5	\$5.50	\$5.50	\$5.50	\$4.50	\$3.50	\$2.50	\$1.50
	4	\$5.00	\$5.00	\$5.00	\$5.00	\$4.00	\$3.00	\$2.00
	3	\$4.50	\$4.50	\$4.50	\$4.50	\$4.50	\$3.50	\$2.50
	2	\$4.00	\$4.00	\$4.00	\$4.00	\$4.00	\$4.00	\$3.00
	1	\$3.50	\$3.50	\$3.50	\$3.50	\$3.50	\$3.50	\$3.50

The experiment will consist of 10 periods, where in each period you will be grouped with the same four participants. In each period the following will occur:

1. At the beginning of the period, you are asked to enter your choice of Y for that period. Your choice of Y is private and should not be discussed with anyone during the experiment. Note that you **do not** know the other participants' choices of Y before making your selection.

2. After all participants make their decisions, the computer will determine the median value of Y chosen in your group and display it on the output screen.

3. Then the computer will determine your earnings (you may confirm this using Table 2) for that period. Please record your results for the period on your **record sheet** under the appropriate heading.