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Turn-Taking in Finitely Repeated Symmetric Games: Experimental Evidence

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Turn-Taking in Finitely Repeated Symmetric Games: Experimental Evidence

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Abstract

In this paper we investigate the emergence of turn taking in three finitely repeated games: (i) an allocation game, (ii) a low conflict dominant strategy equilibrium (DSE) game and (iii) a high conflict DSE game in an experimental setting. The experiments are run with and without cheap talk communication between participants. In order to develop experimental conjectures and interpret results we develop a theoretical analysis which incorporates the presence of three types of participant: (i) cooperative, (ii) competitive and (iii) self seeking. Based on our theoretical analysis we hypothesize that turn taking may be exhibited experimentally in all three of the games we study when some participants have cooperative preferences. We find experimentally that turn taking emerges in all treatments, and its incidence is qualitatively similar in the allocation and DSE games. While cheap talk increased the rate of cooperative behavior and eliminated competitive behaviour, it had at most a small effect on self seeking behavior. The degree of conflict also had a small effect on the prevalence of turn taking. We observed, using a repeated matching experiment for the high conflict DSE games, that a large majority of participants' behavior can be attributed to one of the three types.

Key words: Laboratory experiment, turn-taking, repeated game.
JEL Classification: C91

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1 Introduction

Turn taking is a phenomenon observed in a great many daily activities. It arises spontaneously in many social contexts, and is a common method by which cooperation is expressed between individuals. For instance, friends may alternate in paying for meals or coffee drinks. Couples may take turns in domestic duties such as cooking a meal or cleaning. (Indeed, a failure to take turns is often a source of conflict.) In a commercial context, fishermen may take turns in utilising a preferred location. However, while it is known that turn taking can be an equilibrium to certain repeated games (specifically coordination games), the economics literature has paid relatively little attention to this issue.

In this paper we present the results of a series of economic experiments designed to investigate whether, and under what circumstances, turn taking emerges. In particular, we investigate the emergence of turn taking in three finitely repeated games: (i) an allocation game,[1] (ii) a low conflict dominant strategy equilibrium (DSE) game and (iii) a high conflict DSE game. (Conflict in the DSE games refers to differences in the payoffs when players adopt asymmetric strategies.) We explore the behaviour of participants in these games with and without the opportunity for them to engage in cheap talk.

These games are of particular interest when investigating the emergence of turn taking. Intuition suggests turn taking may be an aspect of play, though this intuition is not readily supported by standard game theory. In the allocation game it is well known that there are multiple equilibria, so it is unclear which of the many equilibria in the finitely repeated allocation game would be selected by experimental participants (though participants have been observed to play strategies that are close to that predicted by mixed strategy Nash equilibrium in coordination games, see Cooper et. al., 1993 and Straub, 1995). Nonetheless, as turn taking intuitively seems natural way to play the finitely repeated game, it may constitute a focal equilibria.

In DSE games there is a unique Nash equilibrium in payoffs which does not admit turn taking. However, it is now well established that experimentally observed behavior is often at variance with such standard predictions (i.e. Nash equilibrium in payoffs) in finitely repeated prisoners dilemma and public goods games. This inconsistency is commonly attributed to socially orientated preferences (Camerer, 2003). In particular, there are many examples where participants exhibit behavior consistent with cooperative preferences (Andreoni and Miller, 1992; Cooper et. al., 1996; Brosig, 2002[2]). We are motivated to look for turn taking in the DSE game because it represents a common form of cooperation which can achieve the efficient outcome. Indeed we show theoretically that participants who exhibit cooperative preferences would view a DSE game in payoffs as an allocation game in utilities

[1]Kuzmics et al. (2014) define an allocation game as involving two issues: a coordination issue and a competition issue.

[2]Brosig (2002) finds that cooperative behavior in the prisoner's dilemma is best thought of as a response to cooperative preferences than altruism.

(under appropriately controlled parametrizations). This suggests that if there are sufficient participants who exhibit cooperative preferences, we should observe turn taking occurring experimentally.

Not all participants would be expected to exhibit cooperative preferences. The literature suggests that some participants exhibit self seeking preferences, i.e. be payoff maximisers as predicted by standard theory. Furthermore, the economics and psychology literature has identified that some individuals may alternatively exhibit behavior associated with competitive preferences (Knigh and Dubro, 1984; Charness and Grosskopf, 2001; Charness and Rabin, 2002). Therefore we might expect some participants to view the both the allocation and DSE games as a competition: their goal being to 'beat' the other participant by adopting strategies designed to force an outcome more advantages to themselves than their opponent.

In light of previous findings we expect all three types of preference to coexist in our the participant population (Knigh and Dubro, 1984; Murphy, et. al., 2011). In order to develop experimental conjectures and interpret results we develop a theoretical analysis which incorporates the presence of these three types. In this analysis cooperative types would wish to turn take in all rounds of a DSE game, including the final round. Following the analysis by Kreps et. al. (1982) we show how it may be in the interest of self seeking participants' to mimic cooperators until the final round of a DSE game, then defect in order to maximise their pay-off. In this way we can experimentally distinguish between cooperative and self seeking behavior. We show that competitive players should resist turn taking in both DSE and allocation games. In the allocation game, we identify an equilibrium in which self seeking players mimic competitive types. Our theoretical analysis suggests that in the allocation game: (i) cooperators turn take while competitive types don't, and (ii) self seekers *may* randomise between turn taking and not. In this way there might be a qualitatively similarity in the incidence of turn taking across both games. However the equilibria are, of course, quantitatively different in both games, so the quantitative incidence of turn taking may differ across both games.

Motivated by our theoretical analysis, we hypothesize that turn taking will be exhibited by some participants in all three games. As noted above, this hypothesis is not predicted by standard game theory. We find that this is indeed the case, with turn taking emerging in all treatments. Its incidence is similar in allocation and DSE games. Furthermore, we find that cheap talk increases the rate of cooperative behavior and eliminates competitive behavior in the DSE game. Nevertheless, the presence of cheap talk has a small effect on self seeking behavior. By comparing the high and low conflict DSE games, we observe that increases in the degree of conflict leads to a small, statistically insignificant, reduction in the prevalence of turn taking. We also observe, using a repeated matching experiment for the high conflict DSE games, that a large majority of participants behavior can be attributed to one of the three types.

There is limited theoretical literature on the emergence of turn taking. Bhaskar (2000) considers the emergence of turn taking in finitely repeated symmetric coordination game with no communication between players. He shows that an efficient symmetric Nash equilibrium occurs when players to randomise their strategy until coordination occurs, then adopt turn taking until the game ends. He calls this set of strategies the 'Egalitarian convention'. Lau and Mui (2008) extend Bhaskar's results in the case of an infinitely repeated allocation game, and show the expected time taken to reach a turn taking equilibrium increases with the degree of conflict between the players (measured as the ratio of the payoffs in the PSNE). Lau and Mui (2011) show that a turn taking equilibrium may exist for certain classes of infinitely repeated dominant strategy games (such as a common pool resource games), and that the expected time taken to reach a turn taking equilibrium increases with the degree of conflict between the players.

Kuzmics et al. (2014) provide a theoretical analysis of rational play in allocation games. They show that a focal point equilibrium in these games will be both efficient and simple, and that equilibria involving turn taking behavior (or a rotation scheme as they describe it) satisfies their criteria. They find in their experiments that 93% of observations in a 2 person allocation game results in turn taking. Although this is a higher fraction than we find in our allocation game experiment without cheap talk, it is notable that turn taking is not universally played in either experiments.

There is limited amount of experimental literature on turn taking. Kaplan and Ruffle (2011) had participants play a repeated two-player, binary-choice game in which both players had private information as to their type. In their experimental framework turn taking was one of two ways for participants to cooperate. They found differences in the behaviour (i.e. whether to turn take or not) is related to private information. If participant's types were similar, turn taking was more likely. There are a number of differences between our study and that of Kaplan and Ruffle. A key difference is that Kaplan and Ruffle provided their subjects with private information, whereas we do not. Further, we specifically consider symmetric games. This allows us to isolate the differences in behavior of our participants and study in particular their endogenous characteristics, such as preferences.

Cason et al. (2013) found that turn taking emerges experimentally in an indefinitely repeated common pool resource game. They showed that learning can be important in determining the incidence of turn taking. In particular, they found that prior experience with turn taking increases the chance turn taking, and that experienced participants are more likely to teach inexperienced participants how to undertake turn taking. Fonseca and Normann (2012) conducted a series of experiments which investigated explicit tacit collusion between Bertrand oligopolists. In some of these experiments turn taking was detected, even though (in contrast to our experiment and those cited above) there was no incentive for turn taking in the game. This suggests (particularly in the light of our study) that some participants are gaining utility from the cooperation required for turn taking.

In section 2 we provide some theoretical analysis that allow us to develop our experimental conjectures and interpret our experimental results. The experiment is described in section 3. Conjectures about the behavior of participants in the experiment are presented in section

3.2. Section 4 presents the results of the experiment. Section 5 concludes the paper.

2 Theoretical Considerations

2.1 Overview

This paper is concerned with a finitely repeated game, where the duration is common knowledge. A general form of the stage game we consider is shown in Table 1.

Table 1: Game G_1

	T	S
T	Z, Z	$\alpha X, (1-\alpha)X$
S	$(1-\alpha)X, \alpha X$	$0, 0$

We assume that $X > 2Z \geq 0$ and $0.5 < \alpha < 1$. The parameter α measures the degree of conflict in the game. Notice that restricting $Z < (1-\alpha)X$ in game G_1 yields an allocation game with two pure strategy Nash Equilibrium and a single Mixed Strategy. Whenever $(1-\alpha)X < Z$, then game G_1 has a Dominant Strategy Equilibrium (DSE) corresponding to (T, T). We refer to this game as a Dominant Strategy Equilibrium game. [3]

Any combination of equilibrium strategies in each of the stage games of the allocation game represents an equilibrium in the finitely repeated game. In contrast, there is a unique DSE (and thus pure strategy NE) in pay-offs both in the stage and finitely repeated DSE game. Although turn taking is efficient, it is not supported by rational play in the finitely repeated game. However Lau and Mui (2011) show (using folk theorem arguments) that a turn taking equilibrium may exist for the infinitely repeated DSE game, and the expected time taken to reach a turn taking equilibrium increases with the degree of conflict between the players.

We aim to determine whether, and to what extent, turn taking could occur in the finitely repeated DSE game. We expect turn taking to occur because, we hypothesise, some participants have 'socially-oriented preferences'. Intuitively turn taking can be an equilibrium outcome in the finitely repeated DSE game because cooperative types view DSE game in pay-offs as an allocation game in utilities. To explore this further we propose participants are one of three types: (i) self seeking, (ii) cooperative and (iii) competitive. We now provide a formal definition of these types.

Self seeking players care only about their monetary payoffs. Hence their utility is taken to be simply $u^s = \pi_i$

[3] The games in which $Z < (1-\alpha)X$ are called the accommodating case by Lau and Mui (2012), while they call the games in which $Z > (1-\alpha)X$ the mutual-tough case.

Cooperative players gain utility from acting with others to achieve a common goal. In the finitely repeated version of game G_1 the co-operative goal in each round is to maximise joint pay-offs through turn taking. A cooperative player will receive additional utility $B > 0$ in each round by taking such a cooperative action. Cooperation must be expected to be mutual. A cooperative players receive zero utility from cooperation in rounds they expect their partner to act non-cooperatively. Thus the utility of a cooperative player, u^o, is given by:

$$u^o = \begin{cases} \pi_i + B & \text{if } i \text{ plays cooperatively} \\ \pi_i & \text{if } i \text{ plays non-cooperatively} \end{cases} \tag{1}$$

where π_i are player i's payoffs and $B > 0$ is the utility player i receives from cooperation.

By contrast, competitive players value the difference between their own pay-off and that of the other player in each round. We assume a player has a receives disuitlity in a round, $F > 0$, when their pay-off is lower in that round than that of their partner. For simplicity, we abstract from the possibility that a player may receive additional utility when their payoff is greater than that of their partner in a given round. Hence we assume the utility of competitive players is given by:

$$u^m = \begin{cases} \pi_i - F & \text{if } \pi_i < \pi_j \\ \pi_i & \text{if } \pi_i > \pi_j \end{cases} \tag{2}$$

It is additionally assumed that B and F are sufficiently large, to ensure that cooperative participants play cooperatively, and that competitive participants play competitively. Specifically:

Assumption 1. *$B > Z - (1-\alpha)X \equiv B^*$ and $F > X \equiv F^*$*

Assumption 1 ensures that the utility from cooperation, and the disutility from competition, dominate the pay-offs for the respective types in each round in both the allocation and DSE games.

2.2 The DSE game with turn taking

We begin our analysis of the DSE game by considering play in the final period

Proposition 1. *In the final round of the DSE game: (i) T is the dominant strategy for competitive, self seeking players and cooperative players whose turn it is to play T in the final round, and (ii) S is the dominant strategy for cooperative players whose turn it is to play S in the final round.*

Proof of proposition 1. Consider the final round. For either self seekers or competitive types T is the dominant strategy. For cooperative players who played S in the previous (penultimate) period, cooperative play means they play T in the final period. If cooperative players played T in the penultimate period, it will be their turn to play S in the final round. They will play S in the final period.

$$(1-\alpha)X + B > Z \tag{3}$$

or $B > B^*$. In other words, cooperative players continue turn taking into the final period provided the gain from cooperation outweighs the material pay-off. This is the case under assumption 1, and thus cooperative players will play S in the final round if it is their turn.

□

Proposition 1 identifies the play of each type. It is important to note that the strategy adopted by participants is independent of their beliefs of the type of other players.

In games with cheap talk, it is conceivable that linguistic clues in participants' communications to one another may signal their type. For this reason, and because it is useful in understanding the implications of having three participant types, we first consider the case in which type is public information.

Lemma 1. *Suppose participant type is public information and assumption 1 holds. An equilibrium strategy in the DSE game in rounds [1, ..., R-1] for each player type is as follows:*

1. *Competitive participants play T irrespective of their partner's type*
2. *Self seeking participants play:*
   (a) *T when facing a competitive or another self seeking partner*
   (b) *turn taking when facing a cooperative partner*
3. *Cooperative participants play:*
   (a) *T when facing a competitive partner*
   (b) *turn taking when facing a self seeking or cooperative partner*

Playing T in each round is a dominant strategy for competitive participant, so they play T irrespective of the type of their partner. When self seekers are matched together, the equilibrium requires both to play T as predicted by standard theory. Cooperative players gain utility simply by cooperating (i.e. turn taking) so will turn take up to the last period. Consequently self seekers will turn take up until the penultimate round when matched with cooperative players.

From proposition 1 and lemma 1 we have established:

Proposition 2. *Suppose participant type is public information and assumption 1 holds. It is an equilibrium strategy for each player to adopt the strategies identified in lemma 1 for rounds [1,...R-1] and the dominant strategy identified in proposition 1 in the final round.*

Note that the equilibrium described by proposition 2 is not unique. For instance, an equilibrium with no-cooperation (in which all cooperative types believe cooperation will not occur) is possible. Nonetheless, proposition 2 establishes that turn taking can be an equilibrium strategy for some participants in the finitely repeated DSE game when there are 3 types of participant.

Proposition 2 could be applied to experimental DSE games with cheap talk, if it is assumed that a participant's communication signalled their type. However in games without cheap talk, it is necessary to model an individual's type as private information. To this end, denote the probability that a player of type j believes their partner is a cooperator in round τ as λ_τ^j. Then:

Proposition 3. *Consider the DSE game in which participant type is private information and assumption 1 holds. Then the following are requirements for a perfect Bayesian equilibrium that involves turn taking to exist:*

1. *Competitive participants play (T, T) in all rounds*
2. *Cooperative participants continue turn taking in rounds $r > I$ when there is a sufficient history of turn taking from period I. In particular, a cooperative player will play S in the final round following a sufficient history of turn taking from period I.*
3. *Self seeking participants would only turn take in rounds $r \in [I, R-1]$ provided their partner exhibits an uninterrupted history of turn taking from period I and:*

$$\lambda_{R-1}^s > \frac{Z-(1-\alpha)X}{\alpha X - Z} = 1 - \frac{[\alpha X - Z] + [2Z - X]}{\alpha X - Z} \equiv \lambda_{R-1}^* \tag{4}$$

where period I is the round in which turn taking is initiated

Proposition 3 provides useful insight (in the form of the conditions necessary for turn taking to occur when there is a large but finite number of rounds) which are be used as the basis for our experimental conjectures. For instance, T in each round is a dominant strategy for competitive players, irrespective of the type of their partner. Thus, as in the case where type is public information, competitive players would be expected to play T in all rounds.

A self seeking participant's action depends on their belief of their partner's type. For example, if the self seeking player is certain their partner is either self seeking or competitive they will play T in each round. To engage, and then continue, with turn taking, a self interested play must have a sufficient belief they are matched with a cooperative player. The partner's type may be signalled by their history of play. To be cooperative, it is necessary that their partner exhibit uninterrupted turn taking, as this action maximises a cooperative player's utility. If their partner was to deviate from turn taking, this would signal that they are self seeking. In this case the logic of backward induction, as summarised by lemma 1, means turn taking is not an equilibrium.

Cooperative types will engage in turn taking whenever they view their actions as cooperative. Thus they will engage in turn taking with those types who are also willing to engage in turn taking, i.e. self seeking and other cooperative types.

Proposition 3 does not indicate how turn taking might be initiated, and thus does not identify equilibrium outcomes. When type is private information, a participant's strategy choice, in particular their initial strategy choice, sends a signal to their partner regarding their type. This may influence their partner's strategy choice in subsequent rounds. Thus a comprehensive analysis of the prefect Bayesian Equilibria of the game, when participant type is private information and R is large, is of such complexity as to be beyond the scope of this paper.[4] However, while a theoretical analysis of how turn taking is initiated in equilibrium seems intractable in the DSE game with a large number of rounds, it is possible to find and analyse a perfect Bayesian equilibrium involving turn taking when the number of rounds is sufficiently small. This case is shows turn taking is an equilibrium outcome in the DSE game, and proves sufficient to identify behavioural conjectures for our experimental study.

Appendix B analyses a 3-round DSE game. To further simplify the analysis of this game, we assume only cooperative and self seeking types are present in the population. We consider two ways in which turn taking is initiated. First, it is shown in appendix B.1 that a separating equilibrium can exist in which cooperative types play S and self seeking types play T in the first round. Turn taking occurs when self seeking types meet cooperative types, and they both coordinate in subsequent rounds. It is necessary that the cooperative types are a sufficiently large proportion of the population for this strategy to be an equilibrium. If cooperative types were too small a proportion of the population, a self seeking type could gain by playing S in round 1, effectively signalling they are cooperative when they are not. In this equilibrium the fraction of participants that engage in turn taking is:

$$1 - (1 - \lambda)^2 \tag{5}$$

where λ is the proportion of the population that are cooperative. That is, all participants undertake a turn taking type strategy except those self seekers who are matched with other self seekers.

It is shown in Appendix B.2 that another equilibrium involving turn taking can exist in a three round game, one in which cooperative types play S in round 1 and self interested types randomise in round 1. This 'semi-pooling' equilibrium results in turn taking when cooperative types are matched with each other and when a self seeking type is matched with a cooperative type. However, turn taking can also result when two self seeks are matched: specifically when a self seeker who plays T in round 1 is matched with a self seeker who plays S in round 1. In effect, the latter is initially mimicking the actions of a cooperative player. This behaviour parallels the equilibrium strategy identified by Kreps et al. (1982).

[4]See the comments of Kreps et. al. (1982) regrading the technical difficulties associated with the simpler case of cooperation in the finitely repeated prisoners' dilemma.

They show, in the context of the finitely repeated prisoners' dilemma, that self interested types may gain by acting as if they are a cooperative type, and cooperate to induce beneficial cooperation from their partner. However, from proposition 1, this participant will be revealed as being self interest in the final round if it is that player's turn to play S. A self interested participant would defect from turn taking and play T under these circumstances. A player who plays S in the final period must be an cooperator.

The semi pooling equilibrium requires that the proportion of cooperative types not be too small (otherwise a self seeker will not turn take in round 2). It also requires that the proportion of cooperative types in the population not be too large, otherwise a self seeker would adopt S as a pure strategy in round 1. In this equilibrium the fraction of participants who undertake turn taking is:

$$1 - p_1^2(1-\lambda)^2 \tag{6}$$

where p_1 is the probability that a self seeker plays T in round 1. That is, all participants undertake a turn taking type strategy except those self seekers who play T and are matched with other self seekers who plays T.

The faction of self seeking types which end up turn taking in the semi pooling equilibrium is higher than the fraction who turn take in the separating equilibrium. In neither case do all self seeking types undertake turn taking.

Finally, an increase in the degree of conflict, α, may affect p_1. It is shown in Appendix B.2 that an increase in the degree of conflict in the DSE game would increase the frequency with which self seeking participants initially play T in the semi pooling equilibrium. By (6), this would decrease the prevalence of turn taking.

2.3 The allocation game with turn taking

We now turn our attention to the allocation game. It is straightforward to show the following equilibrium proposition in the allocation game, with public information of types:

Proposition 4. *Suppose participant type is public information and assumption 1 holds. An equilibrium strategy in the allocation game is as follows:*

1. *Competitive participants play T irrespective of their partner's type*
2. *Self seeking participants play:*
   - (a) *S when facing a competitive partner*
   - (b) *turn taking when facing a cooperative partner or another self seeking partner*
3. *Cooperative participants play:*
   - (a) *S when facing a competitive partner*

(b) turn taking when facing a self seeking or cooperative partner

When both participants are either self seeking or cooperative, there a multiple Nash equilibrium. Proposition 4 indicates that one of these, arguably the focal equilibrium, involves turn taking. In contrast, when one participant is competitive, the Nash equilibrium is unique as, under assumption 1, playing T in each round yields a higher utility to the competitive player than turn taking. In addition, when the competitive player's partner is either self seeking or cooperative, the competitive player receives a monetary pay-off double that they would be receive if they adopted a turn taking strategy.

We now consider play when participant type is private. Intuitively, as with the DSE game, it will make no difference to the strategy of competitive types whether their type is public or private information. Similarly, cooperative players will also undertake turn taking when type is private information, provided their partner has acted cooperatively, because there is a sufficient history of turn taking.

However, in the allocation game with private information, self seeking players have the option of mimicking competitive players. This option to mimic a competitive type only remains available to self seekers if they have no history of playing S, otherwise their actions would have signalled that they are not competitive. To this extent playing S in the first round signals that a player is not competitive, and thus reduces the strategic options available to self seekers. These arguments suggest that self seeks may choose not turn take in the allocation game, even if facing a cooperative player.

To assess this possibility it is necessary to consider how, and if, turn taking is initiated in equilibrium play. However, as noted above, a theoretical analysis of this possibility seems intractable when there are a large number of rounds. However, in appendix C we find perfect Bayesian equilibrium in a two round allocation game, which will be sufficient to provide our behavioural conjectures for our experiment. To further simplify this analysis, only competitive and self seeking types are assumed present in the population.

Two equilibria are described in Appendix C. First, it is shown in Appendix C.1 that a 'mimicking' equilibrium can exist - in which self seeking types randomise in the first round. When two self seekers are matched in round 1, if one plays T and the other plays S, this play is repeated in round 2. In this equilibrium turn taking does not exist. Second, it is shown in Appendix C.2 that a turn taking equilibrium also exists, again in which self seeking types randomise in round 1. If these types coordinate in round one (i.e. one plays T and the other S) then they switch strategies (i.e. turn take) in the second round. In this equilibrium the fraction of participants that engage in turn taking is:

$$1 - \mu - p_1^2(1 - \mu) = (1 - p_1^2)(1 - \mu) \tag{7}$$

Note we are treating those matched self seeking players who play S in round 1 as turn takers, as if there were more rounds their strategy would result in turn taking (as both revealed they are self seeking rather than competitive).

3 The Experiment

3.1 Experimental design

Experiments were carried out at the University's experimental economics laboratory using specialized experimental software between May 2012 and October 2014. Participants were recruited from the University's student population through a web-based recruitment system. On arrival at the experiment, each participant was randomly assigned to a computer, provided with a set of instructions and asked to complete a quiz to ensure they understood the experiment. The instructions and quiz provided to each of the participants in one of the treatments is provided in Appendix **??**. Once participants answered all the questions correctly, they received a password enabling them to access the experiment.

3.1.1 Single matching experiment

The single matching experiments involved sixteen pairs of participants played 30 rounds of one of the three stage games shown in Table 2. In treatment 1 participants played the allocation game, in treatment 2 they played the low conflict DSE game, and in treatment 3 they played the high conflict DSE game. Matching of participants was done randomly. Each treatment was conducted with and without cheap talk.

Treatment 1 is conducted to identify the strategic behavior of players in a finitely repeated coordination game. As noted above the game has many Nash equilibria, consisting of the Nash equilibria in each stage game. The mixed strategy Nash equilibrium of the stage game used in treatment 1 requires player to play T with a probability of 2/3. The expected payoff to player adopting the mixed strategy Nash equilibrium is 200. If players coordinate immediately on turn taking in the first period their payoff is 450.

Table 2: Stage Games

Allocation game

	T	S
T	$0, 0$	$20, 10$
S	$10, 20$	$0, 0$

Low confict DSE game

	T	S
T	$11, 11$	$20, 10$
S	$10, 20$	$0, 0$

High Conflict DSE game

	T	S
T	$11, 11$	$29, 1$
S	$1, 29$	$0, 0$

3.1.2 Repeated matching experiment

Each repeated matching treatment consisted of four sessions with 8 participants. Within each session participants were sequentially randomly matched (without replacement) with each other 5 times. In each of the matchings the participants played 14 rounds of the high conflict DSE game shown in table 2. Two treatments, with and without cheap talk, were conducted. Each treatment had sixteen pairs of participants.

In designing the repeated matching experiment, we were constrained by the maximum time available for sessions of 2 hours. We restricted the rounds per match to 14, as we judged this the minimum number of rounds required for turn taking to become well established. Given 14 rounds per match, the number of matches were at 5 capped by time constraints. We decided to use the high conflict version of the DSE game to highlight, in participants minds, the strategic considerations they face.

3.2 Behavioral Conjectures

We develop a number of conjectures of the outcome of our experiment based on the theoretical discussion above. First, we have argued that social preferences transform the DSE game into an allocation game for competitive players and consequently, the DSE game may have equilibria involving turn taking. Hence:

Conjecture 1. *Turn taking is observed in all treatments.*

The presence of turn taking in the coordination game is to be expected in light of the arguments presented Bhaskar (2000) and Lau amd Mui (2008). However, the presence of turn taking in the DSE game suggests that player either have, or believe other players have, cooperative preferences.

Utilising the above theory, we can identify the presence of each of the participant types in each of the DSE game treatments in the following way:

- An observation contains a cooperative participants if one participant plays S in the final round.[5]
- An observation contains a self-seeker if after a period of turn taking the participant plays T when it it their turn to play S, and continues to do so until the game ends.
- An observation contains a competitive participant if the participant resists adopting turn taking.

If the population contains each of these three types, then the following conjecture will hold:

Conjecture 2. *Behaviour consistent with the presence of cooperative, self seeking and competitive types is observed in all treatments.*

[5]Both participants would be cooperative if they both played S in the final round, though this is never observed.

We ran each treatment with and without cheap talk. In the allocation game the introduction of cheap talk allowed for coordination between the players. Cheap talk, in the absence of social preferences, should not change the play in the DSE games. However, Meier's (2007) survey of experimental evidence suggests pro sociality is increased by the presence of cheap talk. Thus we would expect cheap to increase the proportion of cooperators (relative to no cheap talk) and thus observe more turn taking in both the DSE and allocation games. Thus we conjecture:

Conjecture 3. *The presence of cheap-talk increases the incidence turn taking in both the allocation and DSE games.*

As shown above, it is in the interests of self seeking players to mimic the play of cooperators up until the final round, and it is an equilibrium strategy for at least some to do so. Thus we expect the proportion of participants who turn take to be less than or equal to the sum of proportions of matches between participants who are both either competitors or self seekers (equivalently less than 1 minus matches involving self seekers). In the allocation game, however, it is in the interest of self seekers to mimic the play of competitors, and as such this may be an equilibrium strategy. Again we would expect the proportion of participants who turn take to be less than or equal to the matches between participants who are both either competitors or self seekers. Note that in the both the allocation and DSE games there exist equilibria which do not involve turn taking. In light of these results it is natural to ask whether we see qualitatively similar strategies adopted in the allocation and DSE games. We thus propose the following conjecture:

Conjecture 4. *The frequency of turn taking in the allocation game is equal to that in the DSE game*

We noted that changing the degree of conflict may affect the incidence of turn taking in the DSE game, because it reduces the frequency in which pairs of self seekers undertake turn taking in semi-pooling perfect Bayesian equilibrium. Thus we make the following conjecture:

Conjecture 5. *An increase in the degree of conflict in the DSE game reduces the incidence of turn-taking.*

In perfect Bayesian equilibria of the three round DSE and two round allocation games (analysed in Appendices B and C), self seeking types and competitive types are the only ones to play T in the initial round, and self seeking types play S in the initial round. We might expect therefore that those who defect from turn taking in the final round predominately play T in the initial round, while those who do not defect predominately play S. Thus we conjecture:

Conjecture 6. *Those participants who defect from turn taking in the final round play T in the first round. Those participants who do not defect from turn taking in the final round play S in the first round.*

We now consider the issue of learning. Cason, Lau and Mui (2013) show that some participants, being taught by other participants, can learn to turn take in an indefinitely repeated game. Thus, in the single matching game it might be argued that players adopt turn taking only because they do not understand or capable of undertaking the backward induction necessary to realise turn taking is not subgame perfect in pay-offs. We adopt the following:

Conjecture 7. *In the repeated matching game, the prevalence of turn taking increases and the prevalence of cooperative play diminishes as the number of matches increases.*

This conjecture is premised on the assumption that each participant is one of three types. If this is the case, we should observe individual participants playing as predicted for their type.

Conjecture 8. *In the repeated matching game, each participants plays each of their 5 matches in accordance with the behavior predicted by one of the three types.*

There is a potential conflict arising from conjectures 7 and 8. For instance, a self seeking player may only learn to defect from turn taking in the final round after observing this play in another player. Such a player may initially appear to be cooperative, but later revealed to be self seeking.

4 Results and Analysis

The strategies and payoffs of the players in each round of each treatment in shown in graphically in Appendix D. This data is summarised in Table 3 for the single matching treatments and in table 4 for the repeated matching treatments.

First consider the single matching treatments. We assume turn taking has been observed if there are 4 strategy switches in a row, as that has a probability of occurring of 1 per cent under the MSNE in the allocation game. Table 3 captures some of the important features of turning taking revealed in the single matching experiments. The first column in Table 3 shows the number of observations in each treatment which exhibit turn taking. The second column gives the number of observations in which, once turn taking has commenced, turn taking experiences an interruption prior to the end of the treatment. The fourth column gives the number of interruptions to turn taking occurring in the treatment. The fifth column indicates the number of interruptions to turn taking that advantages one player. The sixth column shows the number of observations in each treatment in which one player plays S and the other player plays T in the final round. The final column indicates the number of observations in which player who have been turn taking defect to (T, T) in the last or second to last round.

The data in Table 3 yields:

Table 3: Strategies in the single matching treatments

	Obs with TT	Obs without deviations	Obs with deviations	num. deviations	Adv. deviations	TT at end	Defection at end
T1N	$10^{\curlywedge}$	7	3	6	0^{nn12}	9^{n12}	-
T1C	$15^{\curlywedge}$	10	5	5	1^{c12}	14^{c13}	-
T2N	$11^{\curlywedge}$	7	4	6^{n23}	$6^{nn12,n23}$	$4^{\curlywedge n12}$	$7^{\curlywedge}$
T2C	$16^{\curlywedge}$	11	5	6	5^{c12}	$13^{\curlywedge}$	$3^{\curlywedge}$
T3N	$9^{\curlywedge\curlywedge}$	8	1	1^{n23}	0^{n23}	5	4
T3C	$16^{\curlywedge\curlywedge}$	12	4	6	4	10^{c13}	6

^{c} significantly different C between treatments at $\alpha = 0.05$

^{n} significantly different N between treatments at $\alpha = 0.05$

$^{\curlywedge}$ significantly different C.N within treatments at $\alpha = 0.05$

Significance levels determined using the two samples proportion t-test

^{cc} significantly C different between treatments at $\alpha = 0.01$

^{nn} significantly N different between treatments at $\alpha = 0.01$

$^{\curlywedge\curlywedge}$ significantly different C.N within treatments at $\alpha = 0.01$

Table 4: Repeated matching

	TRN					TRC				
Match	1	2	3	4	5	1	2	3	4	5
Turn taking	$9^{\curlywedge\curlywedge}$	$8^{\curlywedge\curlywedge}$	$8^{\curlywedge\curlywedge}$	$10^{\curlywedge\curlywedge}$	$10^{\curlywedge\curlywedge}$	16	16	16	16	16
TT final	$7^{\curlywedge\curlywedge}$	$5^{\curlywedge\curlywedge}$	$7^{\curlywedge\curlywedge}$	$5^{\curlywedge\curlywedge}$	$4^{\curlywedge\curlywedge}$	14	14	13	15	12
Defect final	2	4	2	5	6	2	2	3	1	4
Advantageous deviation	2	0	1	5	0	1	0	0	4	2
Disadvantageous deviation	0	0	0	0	0	0	0	1	1	2

$^{\curlywedge}$ significantly difference at $\alpha = 0.05$ $^{\curlywedge\curlywedge}$ significantly difference at $\alpha = 0.01$

Significance levels determined using the two samples proportion t-test

Observation 1. *(i) Turn taking is observed in all treatments. Once started, turn taking continues uninterrupted in 70 per cent of turn taking observations in T1N, in 64 per cent of turn taking observations in T2N, and 89 percent of turn taking observations in T3N. Turn taking is not observed in 38 per cent of observations in T1N, in 31 per cent of observations in T2N, and 44 percent of observations in T3N*

This observation is consistent with conjecture 1.

There are deviations from turn taking once it is established in both the allocation and DSE games. Deviating from turn taking in the DSE game advantages a player whose turn it is to play S, while disadvantages a play whose turn it is to play T. Deviating from turn taking disadvantages both players. The interruptions to turn taking might either be due to (i) participants making an error in whose turn it was (ii) participants trying to gain an edge over the turn taking strategy. In the allocation game, once turn taking is initiated, unilateral deviation would lead to loss, and thus would be expected to be an error. However in the DSE game, a unilateral deviation in which a participant plays T rather than S could increase the participant's payoff if turn taking resumes. On the other hand, it would be expected that when a player plays S rather than T, that the deviation from turn taking is an error.

The proportion of observed deviations does not vary significantly across or within treatments, in particular across T2N, T2C and T3C. In these treatments advantageous deviations dominate. We observed only one deviation in T3N, which is not advantageous (so presumably a mistake). The players in the chat treatments typically framed their deviations from turn taking as a mistake. Given that the total number of deviations in Treatment 1 is not significantly different to those in T2N, T2C and T3C, and virtually all deviations in Treatment 1 are disadvantageous, this explanation is plausible. On the other hand, frequency of advantageous deviations in T2N, T2C and T3C, suggests some of players are attempting to gain an edge over their partners.

Turn taking does not always come about through a process of coordination using randomisation. For example, in some instances (T2N: players 3 and 4, and players 7 and 8 in group 2) it appears one player initiates turn taking (by consecutively playing T and S) and waits for their partner to coordinate with them.

Of the no-cheap talk observations where turn taking did not occur, one or both players adopted T at least 75 percent of the time. Some participants (T2N: group 2 player 1, group 4 player 2 T3N: group 3 player 4, group 4 players 7 and 8) played T throughout the whole experimental session. Note that this result could not be due to a coordination failure when cheap talk is not available. By playing the Egalitarian convention, the probability that people repeatedly play the DSE and do not coordinate for 30 rounds is vanishingly small.

Turn taking is not exhibited in all observations. Let us say (by analogy to the definition of turn taking) that players coordinate on the DSE in the repeated game if the DSE is played in four consecutive stage games. With these definitions it is possible for players to exhibit both turn taking and coordinate on the DSE at different stages during the game. However this combination is not observed in our data. In fact once turn taking is established, apart from brief deviations, it continued until either the last or penultimate round. This makes the division between observations with or no turn taking stark, suggesting participants differ qualitatively in type.

From Table 3 we find that:

Observation 2. *(i) Turn taking continued to the last round in 36.4 per cent of observations in treatment T2N and 55.6 per cent of observations in treatment T3N. Turn taking continued to the final round in 81.25 per cent of observations in T2C and in 62.5 per cent of observations in T3C. (ii) Defections from turn taking in either the last or penultimate round occurred in 37.5 per cent of observations in treatments T2N and in 12.5 per cent of observations in T3N. Defections from turn taking in either the last or penultimate round occurred in 12.5 per cent of observations in T2C and in 25 per cent of observations in T3C.*

Observation 2(i) is behaviorally consistent with the presence of cooperative types in all treatments, while observation 2(ii) is behaviorally consistent with the presence of self seeking types. Observation 1, taken in conjunction with Observation 2(i), indicates behavior consistent with the presence of competitive types in treatments without cheap talk. Taken together these observations are consistent with conjecture 2, except that competitive behavior is not observed in the chat treatments of the DSE game (T2C and T3C). Furthermore:

Observation 3. *Cheap talk increases the prevalence of turn taking.*

Cheap talk significantly increased the occurrence of turn taking. As shown in Table 3, the proportion of observed turn taking with communication (T.C) is significantly higher than the proportion without communication (T.N) in all treatments. As noted earlier, in T2C and T3C turn taking occurred in all cases compared to 11/16 and 9/16 of the observations respectively without communication. The proportion of observed turn taking at the end is also significantly greater with cheap talk compared to no communication across all treatments ($p < 0.05$). This finding is consistent with conjecture 3.

Without cheap talk a minority of observations in the DSE games involved participants exhibiting cooperative behavior. However, cheap talk substantially increased the instances of cooperative behavior to the point where it is exhibited by a majority of the observations.

It could be that some pairs simply did not learn to take turns, and that apparent competitive behavior is due to ignorance (Cason et. al., 2013 show how participants can learn turn taking from one another). The fact that participants readily coordinated on turn taking in the cheap talk treatments might suggest this. However, in all but one of the no-cheap-talk observations that settled into the DSE, there was some early attempt by one participant to initiate turn taking by alternating their strategy. It appears therefore that the failure to initiate turn taking was because some participants resisted adopting turn taking in the DSE game treatments with no cheap talk.

In one observation in T1C, one player (player 2, group 6) made an undisguised attempt to force the pure strategy Nash equilibrium that advantages themselves, in effect indicating to their partner that they would play T no matter what. Such a player, in effect, cast themselves as a competitive player. It can be seen that the player carried out this threat for some time, though eventually relented. In both chat and no chat at least one player tried to force the PSNE that advantaged them.

There is a significant reduction in the proportion of turn takers who defected in the final round from T2N to T2C. However, the equivalent change in Treatment 3 is not significant. Indeed, although cheap talk decreases defectors as a proportion of the population in T2N, it increases defectors as a proportion of the population in T3N. Nonetheless, neither of these changes in defectors (as a proportion of the population) are significant (p=0.07 and p=0.23 respectively). Thus, the proportion of observations in each treatment in which self seeking behavior was exhibited does not vary significantly across treatments. This suggests that cheap talk has the effect of causing those who would be competitive in treatments without cheap talk to be cooperative when they can engage in cheap talk. This is consistent with cheap talk influencing only the behavior of those with social preferences, leaving self seeking behavior unchanged.

The fact that defection occurred overwhelmingly in the last period of the DSE game treatments suggests that self seekers were relatively confident they were playing a cooperator. The inequality (4) in proposition 3 provides the precise condition for self seekers to turn take in the penultimate period. From (4) the critical proportion of turn takers who are cooperators, λ_*^s, is $\lambda_*^s = 1/9$ in T2 and $\lambda_*^s = 5/9$ in T3. From table 3 the proportion of observations in which turn takers are cooperators can be estimated as $\lambda_{R-1}^s = 4/11$ in T2N and $\lambda_{R-1}^s = 10/18$ in T3N . The proportions are higher in the respective cheap talk treatments. Thus condition 4 would appear to be satisfied in all DSE game treatments, it is rational for self seekers to turn take in these treatments. The data in Table 3 also yields:

Observation 4. *The incidence of turn taking in the allocation game is not significantly different the incidence in the DSE game.*

This observation is consistent with conjecture 4. While we found no significant difference in the proportion turn taking across the different games ($N : \chi^2 = 0.533, p = 0.3829; C : \chi^2 = 0.2.04, p = 0.18$), in games with cheap talk, turn taking occurred in all observations in each of the DSE games while turn taking did not occur in 1/16 of the observations of the allocation game. Note the degree of conflict is the same in T1 as in T2 and TN, while it is higher in T3. The higher conflict in T3 may have the effect of reducing the incidence of turn taking in T3N.

Observation 5. *An increase in the degree of conflict is associated with only a small reduction in the incidence of turn taking when there is no cheap talk.*

We found no statistically significant difference in the incidence of turn taking across treatments (p $>$ 0.05) and so support for assumption 1 rather than conjecture 5. The degree of conflict did not influence the prevalence of turn taking when there is cheap talk, suggesting that more severe changes in the degree of conflict may be necessary to produce a behavioural change.

Note the increase in conflict is associated with an increase in turn taking in the final period. The proportion of groups turn taking at the end is found to be significantly greater with cheap talk in all treatments (p $<$ 0.05). However, there was no significant difference in the proportion defecting in the last round between or within treatments (p $>$ 0.05). Cheap talk, while improving the proportion turn taking at the end, did not improve the proportion of groups defecting in the last round.

Turn taking was less prevalent in the DSE game without cheap talk when the conflict was higher. This observation is consistent with conjecture 5. Note that this effect is not particularly strong, and the increased conflict did not affect the prevalence of turn taking in the treatments with cheap talk. Note also that turn taking was more likely to be maintained when conflict is higher. One explanation of this finding is that players were more careful to strictly maintain turn taking when the costs of deviating from it are higher.

Observation 6. *(i) Of the 17 observations of defection in the DSE treatments, 11 involved the participant playing T in the round turn taking was initiated. (ii) Of the 29 observations of non-defection in the final round of the DSE treatment, 25 involved the participant playing T in the round turn taking was initiated.*

Recall that the optimal turn taking strategy for a self seekers is to play T in round 1, and defect in round 30. This happened in 9 out of the 11 rounds in which defectors played T in the initial round. Of the 6 observations in which defectors in the final round did not play T in the round in which turn taking was initiated, 2 of them encouraged turn taking early in the game by alternating strategy. In this way they might be seen to mimic cooperators in accordance with observation 6(i) and consistent with conjecture 6.

Observation 6(ii) does not appear to consistent with conjecture 6 as only 4 out of the 29 observations conforming with it. Of the 25 inconsistent observations, 20 were in cheap talk treatments. Additionally, 18 of the 29 involved turn taking in every round. Of these 18, 15 are in the cheap talk treatments. One explanation of this finding is that, in a cheap talk game, a cooperative player who suspects their partner is self seeking might have played T in the initial round to ensure cooperation from their partner in all rounds, especially the final rounds. A similar argument might also be applied to remaining 5 observations in cheap talk treatments that were inconsistent with conjecture 6(ii) in which there is interruption to turn taking or delay in initiating turn taking.

There were 5 observations in treatments T2N and T3N which were not consistent with 6(ii). In these cases the cooperative participants may have been trying to enforce cooperation in the final round (as suggested for the cheap talk treatment) or they may have adopted a mixed strategy.

We now turn to consider the repeated matching treatments. The summary results presented in Table 4, suggest that the conclusions derived from the single matching treatments also apply to the repeated matching treatments. Furthermore the data in Table 4 yields:

Observation 7. *In TRN, there is a small increase in the prevalence of turn taking as the number of matches increases. There is also a small increase in the number of final period defectors, and a small decrease in turn taking persisting into the final period.*

This observations suggests that some learning on how to turn take, and how to defect in the final round, may have occurred. However, the changes observed over the rounds is not statistically significant. Some further insight is found by looking at individual's behavior in the repeated matching treatments:

Observation 8. *A large proportion of participants play to type.*

Observation 8 is established by reference to the repeated matching graphs in appendix D. Individuals are referred to by the identifier IJ, where $I \in \{1, ..., 8\}$ is the group they belong to and $J \in \{1, ..., 8\}$ is their player number in their group. First consider TRN ($I \in \{1, ..., 4\}$). Three participants (31,32, 48) in TRN defected in the last round of 3 or more of the matches. None of these participants played S in the final round of any of their matches. However, in all matches, two of the three played S either before their partners first played S or in the same round as their partner first played S. This could be viewed as encouraging their partners into turn taking, and is consistent with the behaviour of a self seeker mimicking a cooperator. One player (13) defected in the final round twice (match B and E). However this participant also played S in the final rounds twice (match A and C). The defection in these cases could be interpreted as 'evening the score' for the reluctance of participant 13's partners to initial reluctance to undertake turn taking. Seven participants (11, 21, 22, 33 42,43,47) defected in only one match in the final round. Four of these did not play S in the final round of any other matching. Three participant who defected once also played S one or more times. One of the three (33) seems to be 'reciprocating' an earlier advantageous defection by their partner, while another (22) seems to be responding to the initial resistance of the partner to coordinate on turn taking. One player (42) seemed to adopted the defection strategy in the final round. In total seven participants in TRN (11, 21,31,32,43,47,48) behaved in a manner consistent with them being self seekers.

Six participants in TRN (12, 17, 23, 27, 28, 36) did not engage with turn taking, thus behaved in a manner consistent with being competitive types.

Thirteen participants (14, 15, 18, 24, 25, 26, 34, 35, 37, 41. 44, 45, 46) played S in at least one final round of their 5 matches, and did not defect in the final round of any match. Indeed once participant (41) played S in the final round of all of their 5 matches. This behviour is consistent with them being cooperative type.

Of the remaining 7 participants in TRN, four exhibited both self seeking and cooperative behaviors (13,22,33,42). This could be due to learning self seeking behavior through experience, though two of these participants played S in the final round after defecting in the final round in a previous match (13, 33). Further the mixture of behaviours may be explained in terms of the specifics of the interaction between participants, such as that of player 13 discussed above.

Two players engaged in turn taking in at least one match but did not either play S in the final period or defect in the final period (16,38). It is not therefore possible to classify the behavior of these players.

Now consider TCN ($I \in \{5, ..., 8\}$). Two participants (67,75) in TRC defected in the last round of 4 or more of the matches. None of these participants played S in the final round of any of their matches. However, in all matches, both played S in a round before, or in the same round, as their partner first played S. Three participants (71, 76, 83) defected in only one match in the final round. One of these (76) did not play S in the final round of any other matching. The remaining two who defected once also played S in one or more earlier matches. In total three participants in TRC (67,75, 76) behaved in a manner consistent with being self seekers in all matches, while two (71,83) seem to have learned to behave as self seekers.

There were no participants in TRC who do not engage with turn taking. Thus there is no evidence of competitive play in the cheap talk treatment.

Nine participants in TRC (52, 53, 64, 66, 67, 74, 75, 76, 88) did not play S in the final round, and six of these (52, 53, 64, 66, 74, 88) did not defect in the final round either. It is thus not possible to classify these 6 players, though it is possible they are cooperative types who ensure cooperation in the final round by playing T in the initial round.

The remaining 21 played S at least once in the final round and did not defect. Their behaviour is consistent with that of a cooperative type. One participant (51) played S in the final round of all of their 5 matches.

Table 5 summaries the above identification of player types made for both the chat and no chat treatments of the repeated matching treatment, and the p values for their difference using a two samples proportion t-test. The introduction of chat significantly reduces the number of participants identified as competitive, while it increases the number of participants

Table 5: Number of types identified in repeated matching experiments

	No Chat	Chat	p value
Competitive	6	0	0.006*
Self seeking	7	5	0.26
Cooperative	13	21	0.02*
Not classified	6	6	0.5

*Significant at the 0.05 level.

identified as cooperative. The number of participants identified as self seeking and the number not classified does not change significantly with the introduction of cheap talk.

5 Discussion

This paper presents evidence on the behavior of individuals who played the finitely repeated allocation and DSE games. The key finding from our experiments is that turn taking arises in the finitely repeated versions of *both* the allocation and DSE games. Turn taking is frequently undertaken by participants in the allocation game, though there are multiple Nash equilibria in payoffs. Similarly, turn taking is frequently undertaken by participants in the DSE game, though it is not an equilibrium strategy in pay-offs. Indeed we found no statistical difference between the frequency in which turn taking was conducted in the allocation and DSE games.

Using the theory analysis we have presented, we show the observed behaviour of participants is consistent with the presence in our experiment of three behavioural types: cooperative, competitive and self seeking types.[6] Three experimental findings suggest that some participants (around 40% without cheap talk and 65% with cheap talk) behave in a manner consistent with cooperative preferences. First, the presence of turn taking is suggestive of cooperative preferences, as cooperative preference transform the DSE game in payoffs to a coordination game in utilities. Second, the observation that some player continue turn taking into the last round is consistent with cooperative preferences. This is because the benefit of continued cooperation (i.e. turn taking) to these participants outweighs the financial disadvantages to them of continuing turn taking. Third, previous findings suggest that the introduction of cheap talk is likely to reinforce pro-social preferences, of which cooperative preferences could be thought of as an example.

[6]Note our experiment is not designed to directly observe cooperative and competitive preferences per se, but the behavior associated with them. Indeed, in the context of altruism, Andreoni et al (2008) noted that "we only know when we don't see it".

We observed that some participants (approximately 20%) in DSE treatments without cheap talk behaved in a manner consistent with competitive preferences. However, competitive play vanished in our DSE game treatments with the introduction of cheap talk. The decline in competitive behaviour with the introduction of cheap talk was approximately the same as the increase in cooperative behavior with the introduction of cheap talk. This suggests that both those exhibiting cooperative and competitive behaviors have socially orientated preferences, but the social context (cheap talk vs no communication) determines how these preferences are expressed in some participants.

The findings from the DSE game treatments also point to the presence of self seekers preferences (around 20% with cheap talk and 16% with cheap talk): these are participants who found it rational to mimic cooperators by adopting turn taking to the final or penultimate round. The introduction of cheap talk only slightly reduced the proportion of participants using this strategy, though not significantly. This suggests these participants, while aware that some other participants respond to social influences, were relatively insensitive to social influence themselves. The proportion of self seeking behaviour decreased as a proportion of the population, though not significantly, with the introduction of cheap talk. This suggests the proportion of the population who does not have socially orientated is not strongly affected by this change in social context.

We found it difficult to classify the remaining participants (approximately 20% of the no communication treatments). These participants exhibited both self seeking and cooperative behavior. In these case participants may either have been acting reciprocally (which is not modelled in our theory) or learning by doing which behaviors best suited their preferences.

Overall, due to the apparent heterogeneity of preferences, there is no single interpretation of play in the finitely repeated allocation and DSE game. This is particularly true of the DSE game without cheap talk, where behavior varied markedly from the (unique) Nash equilibrium in payoffs. The incorporation of cheap into the DSE game appears to have resulted in competitive behavior being largely replaced by cooperative behavior. So cheap talk reduced the heterogeneity in behaviour, thereby reducing the complexity of observed behaviours in the finitely repeated DSE game.

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Appendices

A Mathematical Proofs

A.1 Proof of lemma 1

Proof of lemma 1. Straightforward application of backward induction utilising proposition 1 shows that when either competitive or self seeking types are matched with other competitive or self seeking types, the only equilibrium set of strategies given assumption 1 is (T, T).

Now consider matchings involving one or more cooperative types. Turn taking which extends to the final round will require one of the partners to play S in the penultimate round. We now consider whether this is optimal play when each of the three player types is matched with a cooperative player.

A self seeking player would play S in the penultimate round if they are partnered with a cooperative player,and it is their turn to play S, as their payoff from continuing turn taking exceeds playing T in the final two rounds, i.e. $X > 2Z$.

A cooperative player would play S in the penultimate round if they are partnered with another cooperative player, and it is their turn to play S, as their utility from turn taking in the final two rounds exceeds playing T in the final two rounds. $X + 2B > 2Z$.

Now consider the self seeker's strategy in round $R-n$. First suppose n is odd. If the self seeking player were to play S, then under turn taking they play T in the last period. Then the player would play S in this period (continue turn taking), rather than end turn taking, if:

$$\frac{(n+1)X}{2} > (n+1)Z \tag{8}$$

or $X - 2Z > 0$. Suppose n is even. Then self seekers play S if:

$$\frac{nX}{2} + Z > (n+1)Z \tag{9}$$

or $X - 2Z > 0$. Thus self seeking players would continue turn taking in all rounds.

Now consider the cooperator's strategy in round $R-n$. If n is even then a cooperative play will S in period $R-n$ and then will continue turn taking up to the last period (in which they play S) as:

$$\frac{nX}{2} + (1-\alpha)X + (n+1)B > (n+1)Z \tag{10}$$

Similarly if n is odd a cooperative player will S in period $R-n$ and then will continue turn taking up to the last period (in which they play T) as:

$$\frac{nX}{2} + (n+1)B > (n+1)Z \tag{11}$$

□

A.2 Proof of proposition 3

Proof of proposition 3. 1. Clearly self seeking and cooperative players would only consider playing S in the penultimate round if it was believed that there is a sufficient probability their partner would play S in the final round, i.e. is competitive. First consider the case of a competitive player. This player's gains greater utility from playing S (T) in the penultimate round if:

$$(1-\alpha)X - F + \lambda^m_{R-1}\alpha X + (1-\lambda^m_{R-1})Z > (<)2Z \tag{12}$$

Thus, by assumption 1, a competitive player would play T in the penultimate round if:

$$F > (1-\alpha)X + \lambda^m_{R-1}\alpha X - (1+\lambda^m_{R-1})Z \equiv F^*_{R-1}. \tag{13}$$

Observe that $F^*_{R-1} < F^*$, so that under assumption 1 competitive players always play T in the penultimate round.

Consider round $R-n$, where $n \geq 2$. We now show a competitive player will choose T in round $R-n$ if they choose T in all rounds following $R-n+1$. Under this assumption, a competitive player would choose T if:

$$(1-\alpha)X - F + \lambda^m_{R-n}\alpha X + (1-\lambda^m_{R-n})Z + (R-r-1)Z < (R-r)Z \tag{14}$$

or:

$$F(1-\alpha)X + \lambda^m_{R-n}\alpha X - (1+\lambda^m_{R-n})Z > F^* \tag{15}$$

Thus, under assumption 1, competitive players choose T in each round.

2. If there is a sufficient history turn taking, a cooperative player will treat playing S in the penultimate round and T in the final round, if it is their turn to do so, as a cooperative act. In this case the cooperative player will play S in round $R-1$ and T in round R (as opposed to T in both rounds)provided:

$$(1-\alpha)X + B + \lambda^o_{R-1}\alpha X + (1-\lambda^o_{R-1})Z + B > 2Z \tag{16}$$

or:

$$B > B^* - \frac{1}{2}([Z-(1-\alpha)X] - \lambda^o_{R-1}[\alpha X - Z]) \equiv B^*_{R-1} \tag{17}$$

Note that $B^* > B^*_{R-1}$, so under assumption 17 the cooperative participant plays S in the penultimate period when it their turn to do so.

Consider round $R-n$, where $n \geq 2$.If n is even then a cooperative play will S in period $R-n$ and then will continue turn taking up to the last period (in which they play S),while cooperation continues, and when $B > B^*_R$. If n is odd a cooperative player will S in period $R-n$ and then will continue turn taking up to the last period (in which they play T).

3. Turn taking will require one of the partners to play S in the penultimate round. We now consider whether this is optimal play for each of the three player types.

A self seeking player would play S in the penultimate round if:

$$(1-\alpha)X + \lambda^s_{R-1}\alpha X + (1-\lambda^s_{R-1})Z > 2Z \tag{18}$$

or:

$$\lambda^s_{R-1} > \frac{Z-(1-\alpha)X}{\alpha X - Z} = 1 - \frac{[\alpha X - Z] + [2Z - X]}{\alpha X - Z} \equiv \lambda^*_{R-1} \tag{19}$$

Hence $\lambda^*_{R-1} \in (0,1)$. Note that turn taking must therefore be uninterrupted in all rounds $r > I$ otherwise the self seeking player could infer that their partner was not cooperative.

Now consider the self seeking strategy in round $R-n$. Suppose there is an uninterrupted history of rounds $I < r < R-n$. First suppose n is odd. If the self seeking player were to play S, then under turn taking they play T in the last period. Suppose if turn taking continues that 4 holds. Then, as no new information available to the self seeking play during rounds $[r, ..R-1]$, then $\lambda^s_{R-n} = \lambda^s_{R-1}$. Under these conditions the self seeking participant would play S in round $R-n$ as:

$$\frac{(n-1)X}{2}) + (1-\alpha)X + \lambda^s_{R-1}\alpha X + (1-\lambda^s_{R-1})Z > (n+1)Z \tag{20}$$

or:

$$\lambda^s_{R-n} > \frac{Z-(1-\alpha)X - \frac{n-1}{2}(X-2Z)}{\alpha X - Z} \equiv \lambda^*_{R-n} \tag{21}$$

Now $\lambda^*_{R-n} < \lambda^*_{R-1}$, so if (4) holds, self seeking player would be willing to continue turn taking.

Suppose n is even. If (4) holds, both self seekers and cooperative types play S in the penultimate round. Thus a self seeker will play S in round $R-n$ if it is their turn to do so if:

$$\frac{nX}{2} + Z > (n+1)Z \tag{22}$$

or:

$$n(X-2Z) > -2Z \tag{23}$$

The self seeking player will play S if there is an uninterrupted history of turn taking from round I. Then a self seeking player would be willing to continue turn taking in all rounds up to the final round.

□

B A three round DSE game

Three rounds is required to illustrate the properties of two important perfect Bayesian equilibrium in a finitely repeated DSE game with more than one type. For this illustration it is useful to assume there are only self seeking and cooperative type players (i.e.$\mu = 0$).

B.1 A separating equilibrium

Define the following set of strategies and beliefs of participants in the three round DSE game:.

Strategy and Belief set 3S: In round 1 self seekers play T and cooperative participants play S, and all participants believe the probability their partner is cooperative is λ (corresponding with the proportion of cooperative types in the population). Then:

- if the outcome in round 1 is (T, T) then both (self seeking) participants play T in the subsequent two round, and believe with probability 1 that their partner is self seeking.
- if the outcome in round 1 is (T, S) then play is (S, T) in round 2 and (T, S) in round 3. Participant 1 believes their partner is cooperative and participant 2 believes their partner is self seeking
- if the outcome in round 1 is (S, S) then both cooperative types randomise to achieve coordination for turn taking in round 2, and randomise again in round 3 if coordination is not achieved in round 2. In rounds 2 and 3 both participants believe with probability 1 that their partner is cooperative.

Then:

Proposition 5. *Strategy and Belief set 3S is a perfect Bayesian equilibrium if λ is sufficiently close to 1.*

Observe that proposition 5 shows that set of strategies 3S represents a separating equilibrium as participants signal their type in round 1. Its proof is as follows:

Proof of proposition 5. Proposition 1 applies to the pay in the final round (round 3) of the three round DSE game. Observe that strategy and belief set 3S satisfies Proposition 1.

Now consider the conditions under which strategy 3S is an equilibrium strategy for each type. First, it has been assumed that actions of cooperative types in strategy 3S is viewed as cooperative play by cooperative type participants, so deviating from it will lower their utility. Thus it represents an equilibrium strategy for them.

We now consider the conditions under which self seeking types to have no incentive to deviate from strategy 3S. The payoff from conforming to the above strategy is:

$$\lambda X + \alpha X + 3(1 - \lambda)Z \tag{24}$$

If the self seeking player deviates by playing S in round, and T in the final two round, the expected payoff is:

$$(1-\lambda)X + Z + \lambda V^R \tag{25}$$

where V^R is the expected payoff from playing against a randomising type cooperative type. Note that, assuming cooperative types play T with probability ψ_i in round i, $V^R = (1-\psi_2\psi_3)\alpha X + (1+\psi_2\psi_3)Z$

The self seeking player does not deviate from the equilibrium in round 1 provided:

$$\lambda X + \alpha X + 3(1-\lambda)Z > (1-\lambda)X + Z + \lambda V^R \tag{26}$$

or

$$\lambda > \frac{X-2Z}{X-2Z+(1+\alpha)X-V^R} \equiv \lambda_s^* \tag{27}$$

As $(1+\alpha)X > V^R$, then $0 < \lambda_s^* < 1$. Hence self seeking players do not have an incentive to deviate provided λ is sufficiently large.

Thus Strategy and Belief set 3S is an equilibrium strategy and belief profile if $\lambda > \lambda_s^*$. □

B.2 A semi-pooling equilibrium

Define the following set of strategies and beliefs for participants in the three round DSE game:

Strategy and belief set 3P: In round 1 cooperative participants play S and self seekers play T with a probability p_1 , and all participants believe the probability their partner is cooperative is λ (corresponding with the proportion of cooperative types in the population).Then:

- if the outcome in round 1 is (T,T) then both (self seeking) players play T in the subsequent two round, and believe with probability 1 that their partner is self seeking in these rounds.

- if the outcome in round 1 is (T,S). Participant 1 (who must be self seeking) plays S in round 2 and T in round 3. If participant 2 is self seeking they play T in rounds 2 and 3. If player 2 is cooperative they play T in round 2 and S in round 3. Participant 2 believes their partner is self seeking with probability 1 in rounds 2 and 3. Participant 1 believes there is a probability λ_{TS} that their partner is cooperative in rounds 2 and 3.

- if the outcome in round 1 is (S,S) then a cooperative type randomises in round 2, playing T with probability ψ_2. In round 3 the cooperative type (i) takes their turn if coordination is achieved in round 2 or (ii) plays T in round 3 if coordination is not achieved in round 2. Self seeking types play T in rounds 2 and 3. Both participants believes there is a probability λ_{SS} that their partner is cooperative in round 2. In round 3 a participant believes and λ_{SST} that their partner is cooperative with probability λ_{SST} they played T in round 2 and are certain their partner is cooperative if they played S in round 2.

Then:

Proposition 6. *Strategy and belief set 3P forms a perfect Bayesian equilibrium if* $\lambda_2^* < \lambda < \lambda_M^*$ *where:*

$$\lambda_M^* \equiv \frac{2X - 3Z + \psi_2(\alpha X - Z)}{X - 2Z} \tag{28}$$

and:

$$\lambda_{TS} = \lambda_{SS} = \frac{\lambda}{\lambda + p_1(1-\lambda)} \tag{29}$$

where:

$$p_1 = \frac{(1+\lambda\psi_2\alpha)X - (1+\lambda\psi_2)Z}{(1-\lambda)(2X-3Z)} \tag{30}$$

An increase in α *increases* p_1.

Observe that proposition 6 shows that set of strategies 3P represents a semi pooling equilibrium as only self seeking types play T in round 1 but both types of participants play S in round 1. Hence only seek seekers playing T unambiguously signal their type 1.
Note that it is necessary that $\lambda_2^* < 0.5$ if this equilibrium identified in proposition 6 is to exist, however this need not be the case.

Proof of proposition 6. Note that the self seeking player who mimics a cooperative player in round 1, and who is paired with a self seeking player who does not mimic a cooperative player, will achieve a payoff from that strategy of $X + Z$ from that strategy as opposed to $3Z$ if they had played the Nash equilibrium.

Again, it is assumed that the actions adopted by cooperative types in strategy 3P is viewed as cooperative by cooperative type participants, so deviating from it will lower their utility.

We now turn to identify whether the play in strategy 3P is optimal of self seeking players. First observe that it is necessary that (4) holds if a self seeking participant is to play S in the second round as required by the above strategy. Hence it is necessary that $\lambda > \lambda_2^*$ to hold if strategy 3P is to be an equilibrium strategy.

The expected pay-off for the self serving types from playing T in round 1 is:

$$\lambda(X + \alpha X) + p_1 3(1-\lambda)Z + (1-p_1)(1-\lambda)(X+Z) \tag{31}$$

If the self seeking player plays S in round 1, their expected pay-off is:

$$p_1(1-\lambda)(X+Z)+(1-p_1)(1-\lambda)2Z+\lambda[(1-\psi_2)\alpha X+(1+\psi_2)Z] \tag{32}$$

The self seeking player is indifferent between playing T and S in round 1:

$$\lambda(X+\alpha X)+p_1 3(1-\lambda)Z+(1-p_1)(1-\lambda)(X+Z)=p_1(1-\lambda)(X+Z)+(1-p_1)(1-\lambda)2Z+\lambda((1-\psi_2)\alpha X+(1+\psi_2) \tag{33}$$

or:

$$p_1=\frac{(1+\lambda\psi_2\alpha)X-(1+\lambda\psi_2)Z}{(1-\lambda)(2X-3Z)} \tag{34}$$

Note that $p_1>0$. We require that $p_1<1$ for the pooling equilibrium, i.e:

$$\lambda<\frac{2X-3Z+\psi_2(\alpha X-Z)}{X-2Z}\equiv\lambda_M^* \tag{35}$$

This establishes that strategy and belief set 3P forms a semi-pooling perfect Bayesian equilibrium if $\lambda_2^*<\lambda<\lambda_M^*$.

Partial differentiation of (34) with respect to α shows that p_1 is increasing in α. Note this conclusion assumes ψ_2 is independent of α, which is reasonable if B is sufficiently large relative to monetary payoffs for cooperative types.

□

C A two round allocation game

Two rounds is sufficient to illustrate the key properties of two important perfect Bayesian equilibrium in a finitely repeated allocation game with more than one type. At initial node, N_0, participants are assumed to know the true distribution of types in the population. In the second round, the participants will be at one of the four possible nodes: N_{km} where $k=T,S$.

For this illustration it is useful to assume there are only self seeking and competitive type players (i.e. $\lambda=0$).

C.1 An equilibrium in which self seeking types mimic competitive types

Define the following set of strategies and beliefs:

Strategy and belief set 2M: In round 1 cooperative players play S and self seekers play T with a probability p_1, and all participants believe the probability their partner is competitive

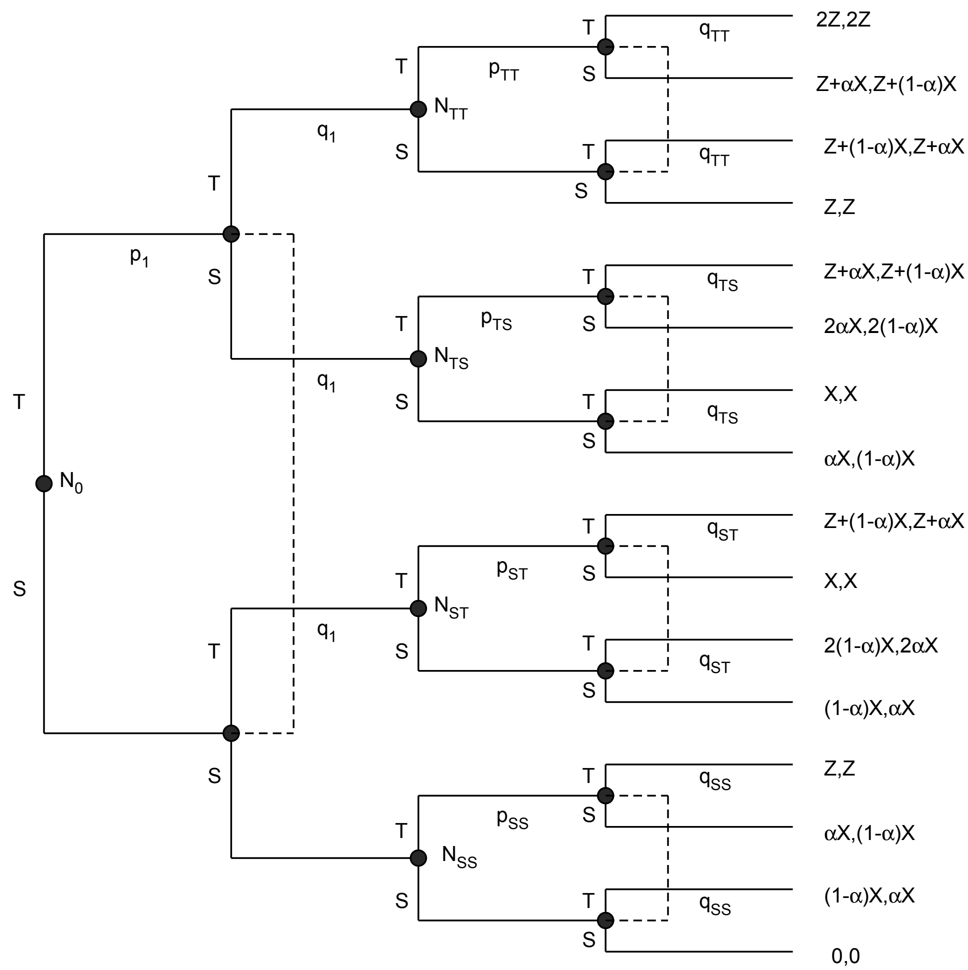


Figure 1: The two round game

is μ (corresponding with the proportion of cooperative types in the population). Then in round 2:

- at node N_{TT} then self seeking players randomise and competitive types play T, and both participants believe with probability μ_{TT} that their partner is competitive.
- at node N_{TS} Participant 1 (who is either self seeking or competitive) plays T and participant 2 (who is self seeking) plays S. Participant 1 believe participant 2 is competitive with probability 1, while participant 2 believes particiapnt 1 is competitive with probability μ_{TS}.
- at node N_{ST} Participant 1 (who is self seeking) plays S and participant 2 (who is either self seeking or competitive) plays T. Participant 2 believe participant 1 is competitive with probability 1, while participant 1 believes particiapnt 2 is competitive with probability μ_{TS}.
- at node N_{SS} Both participants (who are self seeking) randomise, and both participants believe their partner is self seeking with probability 1.

Then:

Proposition 7. *Strategy 2M is a perfect Bayesian equilibrium in the two round allocation game if:*

$$\mu < \frac{\alpha^2(1+\alpha)}{2(1-\alpha(1-\alpha))} \tag{36}$$

and:

$$\mu_{TT} = \mu_{TS} = \frac{\mu}{\mu + (p_1(1-\mu))} \tag{37}$$

where:

$$p_1 = \frac{\mu(1-\alpha)(\alpha-2) + (1-\mu)\alpha(1+\alpha)}{2(1-\mu)(1-\alpha(1-\alpha))} \tag{38}$$

Proposition 7 shows that strategy 2M is a semi pooling equilibrium, as only self seeking types play S in round 1 but both types of participants play T in round 1. Its proof is as follows.

Proof of proposition 7. Playing T at all nodes maximises the utility of competitive types, so they have no incentive to deviate from the actions detailed in strategy 2M.

It remains to show that strategy 2M is an equilibrium one for self seeking types. First consider the self seeking types choice of strategy at node N_{TT}. Let q_{TT} be the probability the self seeking type's partner plays T. In order for the self seeking participant to be indifferent between playing T and S it is necessary that $q_{TT} = \alpha$. Note that, at node N_{TT}, the probability that the partner is competitive is given by (37). Consequently the probability that the self seeking participant plays T at node N_{TT}, p_{TT} is given implicitly by:

$$q_{TT} = \frac{\mu + p_{TT}(p_1(1-\mu))}{\mu + (p_1(1-\mu))} \tag{39}$$

or:

$$p_{TT} = \frac{\alpha(\mu + p_1(1-\mu)) - \mu}{(p_1(1-\mu))} \tag{40}$$

Note $p_{TT} < 1$. However to ensure that $p_{TT} > 0$ we require that:

$$\alpha(\mu + p_1(1-\mu)) > \mu \tag{41}$$

That is, it is optimal to randomise at node N_{TT} only if competitive types are a sufficiently small fraction of the population.

Now consider the self seeking types choice of strategy at node N_{TS}. In this case the partner (who must be self seeking) will play S. Thus it is optimal for the self seeking player to play T.

The expected payoff from playing T in round 1 is therefore:

$$(\mu + p_1(1-\mu))\alpha(1-\alpha)X + (1-p_1)(1-\mu)2\alpha X \tag{42}$$

Now consider the self seeking participants pay-off from playing S in round 1. At the node N_{ST} the partner could be either self seeking or competitive. However playing S signals that the participant is self seeking. So the partner will play T in round 2 and it is optimal for the participant to play S.

At the node N_{SS} the partner is self seeking, and will randomise, playing T with probability α. The expected payoff is $(1-\alpha)\alpha X$

The expected payoff from playing S in round 1 is:

$$(\mu + p_1(1-\mu))2(1-\alpha)X + (1-p_1)(1-\mu)\alpha(1-\alpha)X \tag{43}$$

Hence the self seeking participant is indifferent between T and S in round 1 if:

$$(\mu+p_1(1-\mu))\alpha(1-\alpha)X+(1-p_1)(1-\mu)2\alpha X = (\mu+p_1(1-\mu))2(1-\alpha)X+(1-p_1)(1-\mu)\alpha(1-\alpha)X \tag{44}$$

Which yields (38). It is readily shown from (38) that $0 < p_1 < 1$. Hence strategy 2M is a perfect Bayesian equilibrium provided (41) holds,that is provided 36 holds.

□

C.2 An equilibrium in which self seeking types turn take

Define the following set of strategies and beliefs:

Strategy and belief set 2T: In round 1 competitive players play T and self seekers play T with a probability p_1, and all participants believe the probability their partner is competitive is μ (corresponding with the proportion of cooperative types in the population). Then in round 2:

- at node N_{TT} then self seeking players randomise and competitive types play T, and both participants believe with probability μ_{TT} that their partner is competitive.
- at node N_{TS} Participant 1 plays S if self seeking and plays T if competitive, and participant 2 (who is self seeking) plays T. Participant 1 believe participant 2 is competitive with probability 1, while participant 2 believes particiapnt 1 is competitive with probability μ_{TS}.Participant 2 believe participant 1 is competitive with probability 1, while participant 1 believes particiapnt 2 is competitive with probability μ_{TS}.
- at node N_{ST} Participant 1 (who is self seeking) plays T and participant 2 plays S if self seeking and plays T if competitive.
- at node N_{SS} Both participants (who are self seeking) randomise , and both participants believe their partner is self seeking with probability 1.

Then:

Proposition 8. *Strategy 2T is a perfect Bayesian equilibrium in the two round allocation game if $\mu < \alpha/2$ and:*

$$\mu_{TT} = \mu_{TS} = \frac{\mu}{\mu + (p_1(1-\mu))} \tag{45}$$

where:

$$p_1 = \frac{1-2\mu}{2(1-\mu)} \tag{46}$$

Proposition 8 shows that strategy 2T is a semi pooling equilibrium, as only self seeking types play S in round 1 but both types of participants play T in round 1. Its proof is as follows.

Proof of proposition 8. Again it is optimal for competitive players to play T at each node. We now consider w show that strategy 2T is an equilibrium one for self seeking types.

First consider the self seeking types choice of strategy at node N_{TT}. Let q_{TT} be the probability the self seeking type's partner plays T. In order for the self seeking participant to be indifferent between playing T and S it is necessary that $q_{TT} = \alpha$. Note that, at node

N_{TT}, the probability that the partner is competitive is given by (37). Consequently the probability that the self seeking participant plays T at node N_{TT}, p_{TT} is given implicitly by:

$$q_{TT} = \frac{\mu + p_{TT}(p_1(1-\mu))}{\mu + (p_1(1-\mu))} \tag{47}$$

or:

$$p_{TT} = \frac{\alpha(\mu + p_1(1-\mu)) - \mu}{(p_1(1-\mu))} \tag{48}$$

Note $p_{TT} < 1$. However to ensure that $p_{TT} > 0$ we require that:

$$\alpha(\mu + p_1(1-\mu)) > \mu \tag{49}$$

That is, it is optimal to randomise at node N_{TT} only if competitive types are a sufficiently small fraction of the population.

Now consider the self seeking types choice of strategy at node N_{TS}. In this case the partner (who must be self seeking) will play T. Thus it is optimal for the self seeking player to play S.

The expected payoff from playing T in round 1 is therefore:

$$(\mu + p_1(1-\mu))\alpha(1-\alpha)X + (1-p_1)(1-\mu)X \tag{50}$$

Now consider the self seeking participants pay-off from playing S in round 1. At the node N_{ST} the partner could be either self seeking or competitive. However playing S signals that the participant is self seeking. So the partner will play S in round 2 and it is optimal for the participant to play T.

At the node N_{SS} the partner is self seeking, and will randomise, playing T with probability α. The expected payoff is $(1-\alpha)\alpha X$

The expected payoff from playing S in round 1 is:

$$(\mu + p_1(1-\mu))X + (1-p_1)(1-\mu)\alpha(1-\alpha)X \tag{51}$$

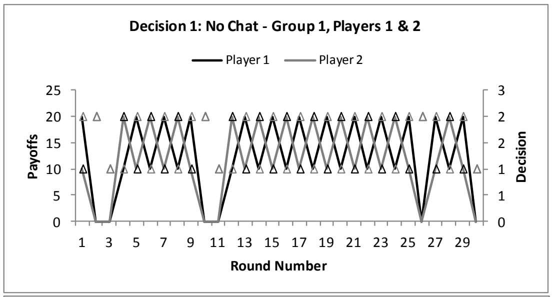
Hence the self seeking participant is indifferent between T and S in round 1 if:

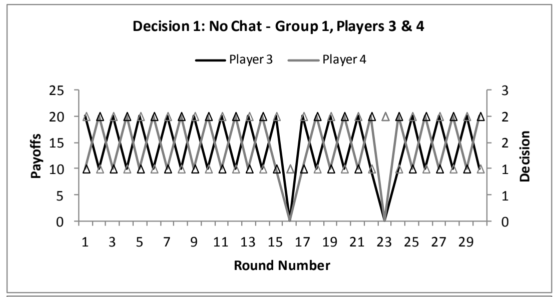
$$(\mu+p_1(1-\mu))\alpha(1-\alpha)X+(1-p_1)(1-\mu)X = (\mu+p_1(1-\mu))X+(1-p_1)(1-\mu)\alpha(1-\alpha)X \tag{52}$$

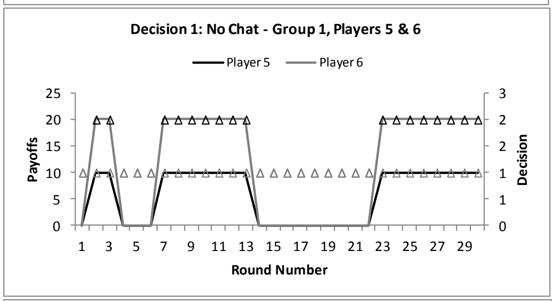
which yields (46). Substituting (46) into (49) shows we require $\mu < \alpha/2$ for strategy and belief set 2T is to be a perfect Bayesian equilibrium. $\square$

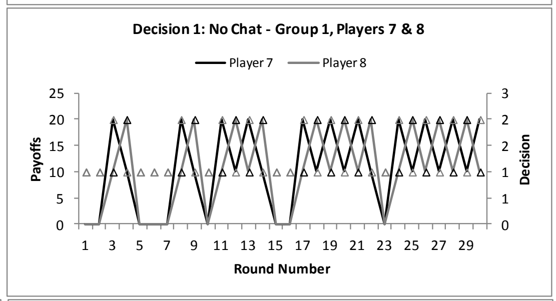
D Data Appendix

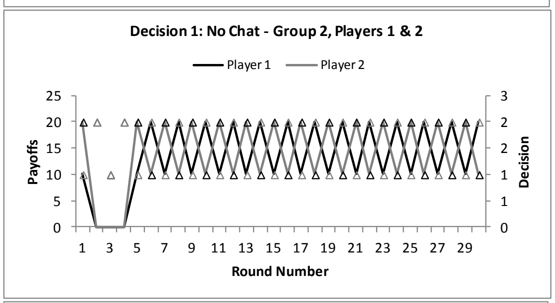
Treatment (Decision) 1

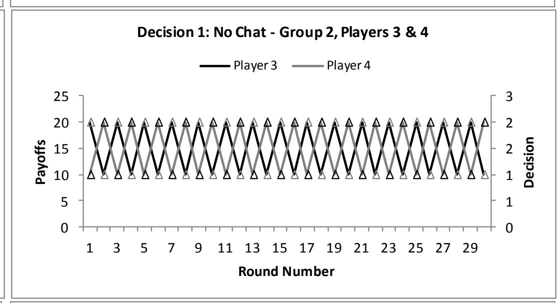


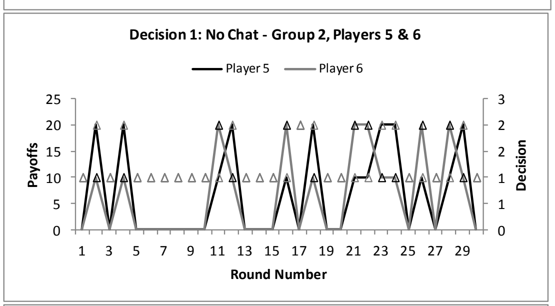


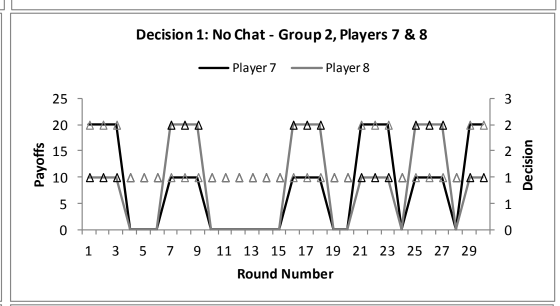


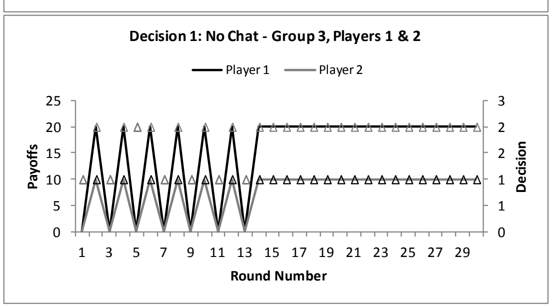


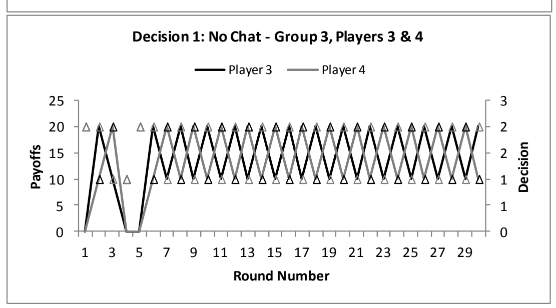




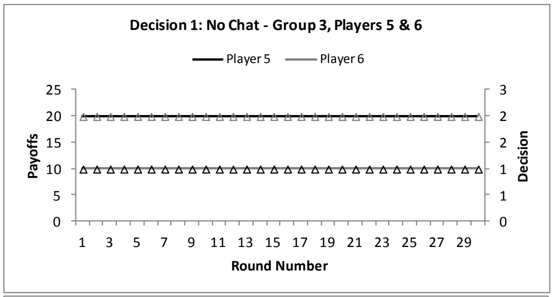


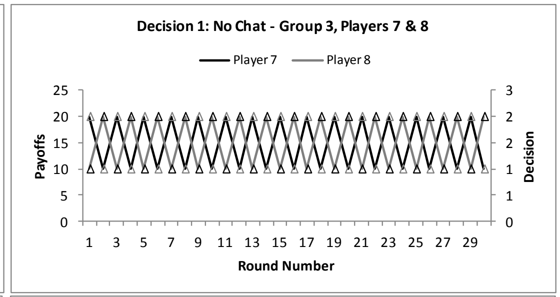


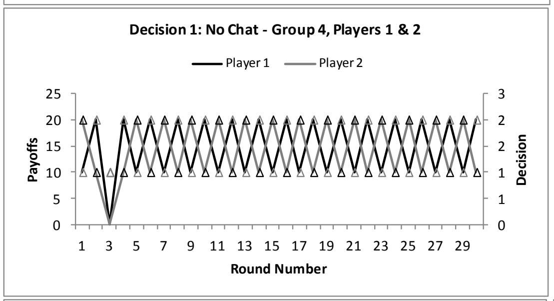


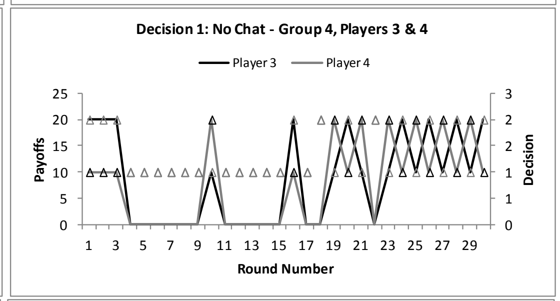


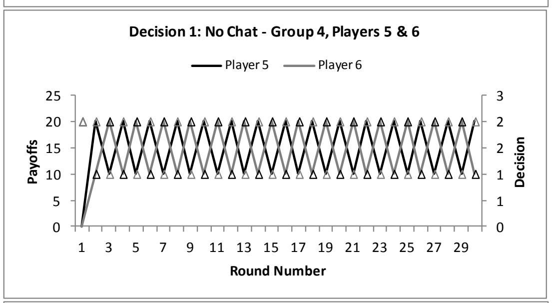
Treatment (Decision) 1

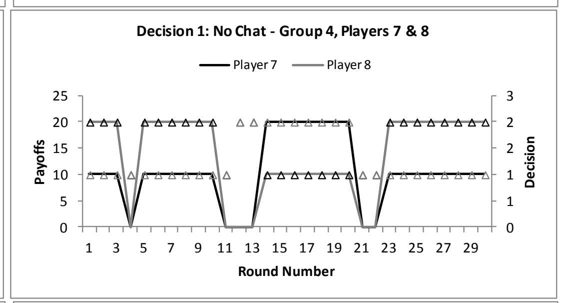


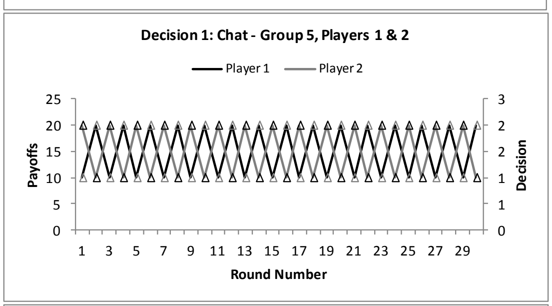


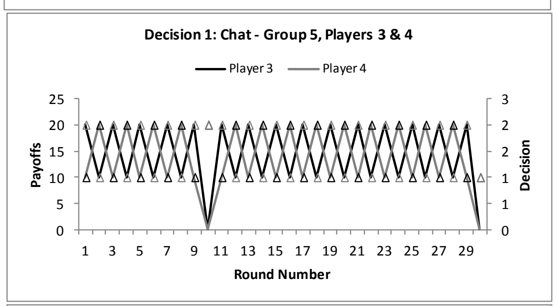


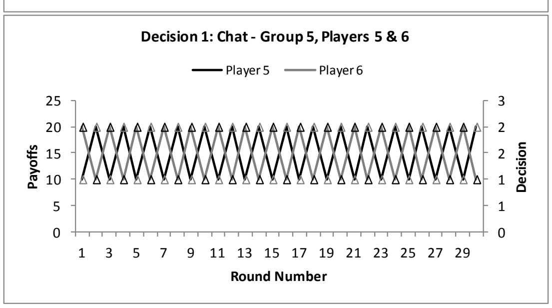


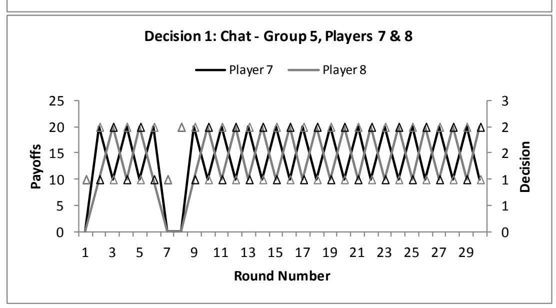




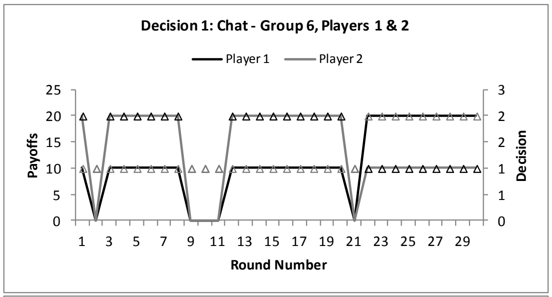


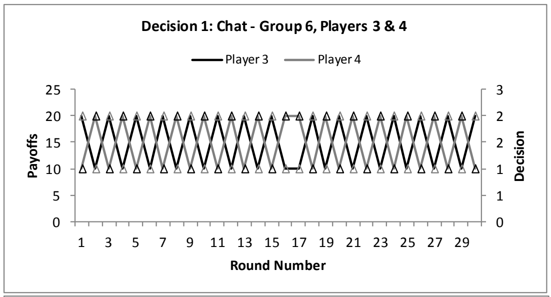


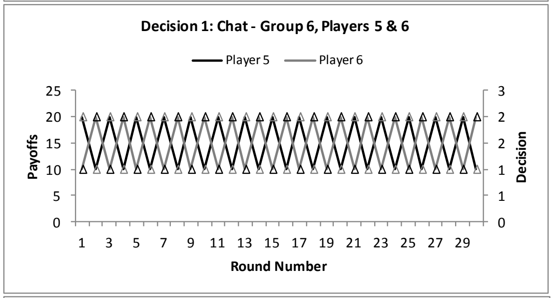


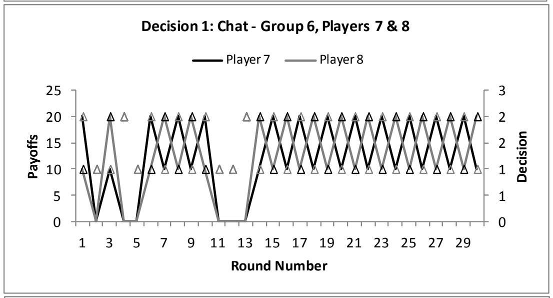


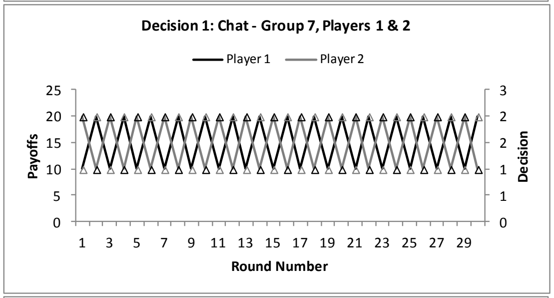
Treatment (Decision) 1

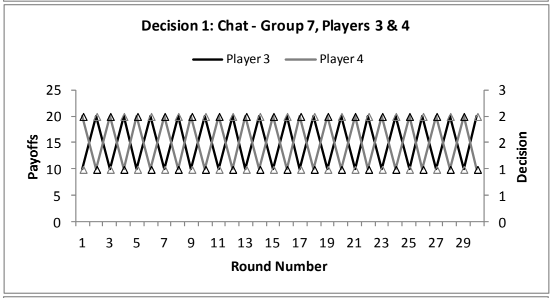


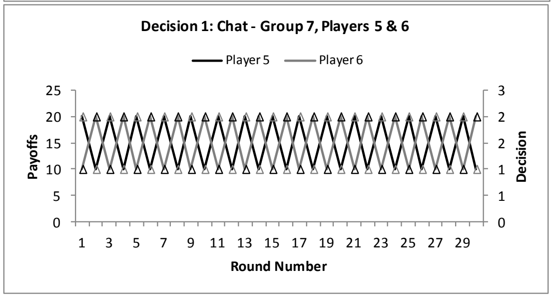


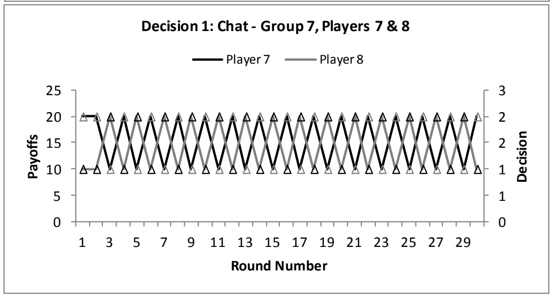












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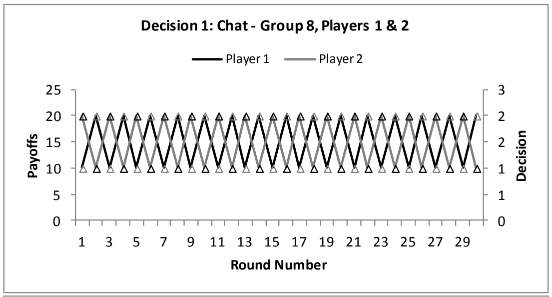

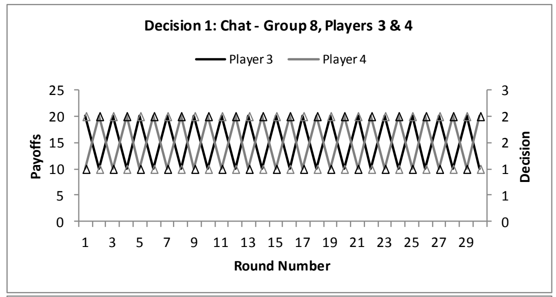

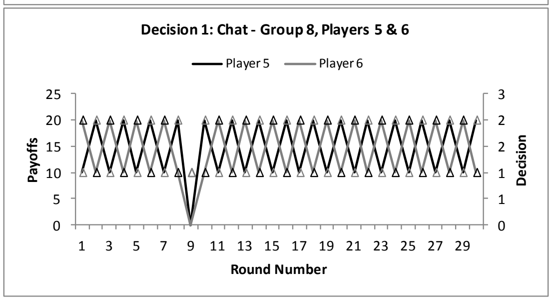

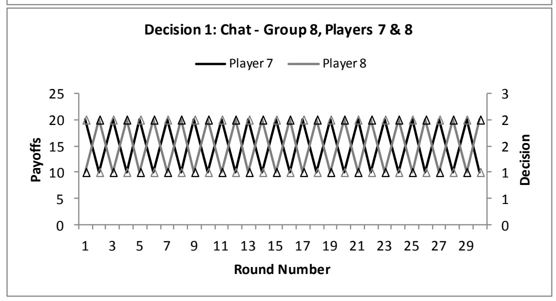

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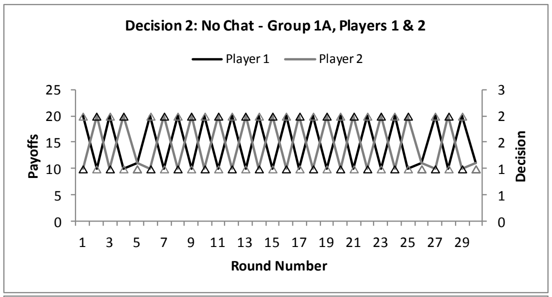
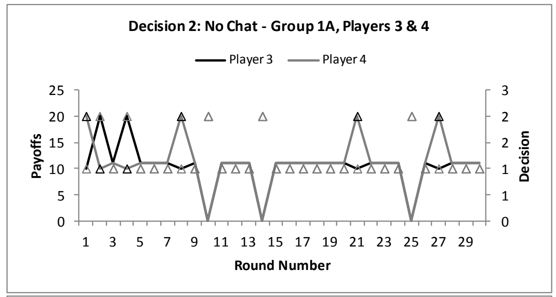
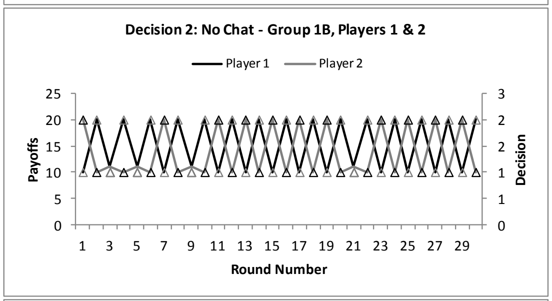
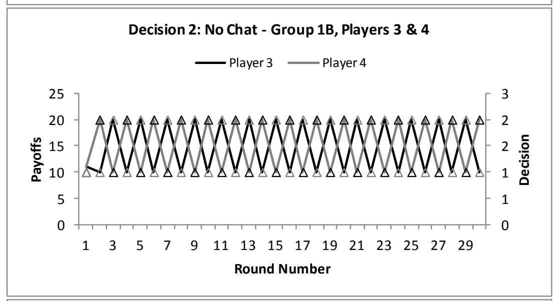
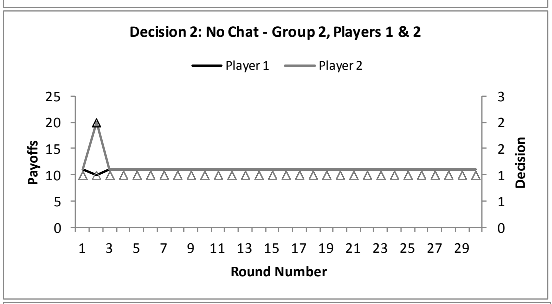
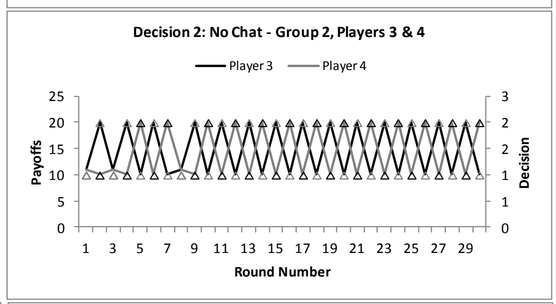


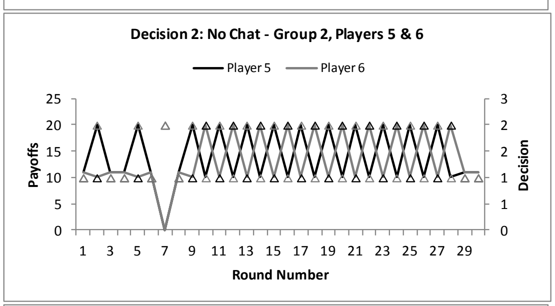


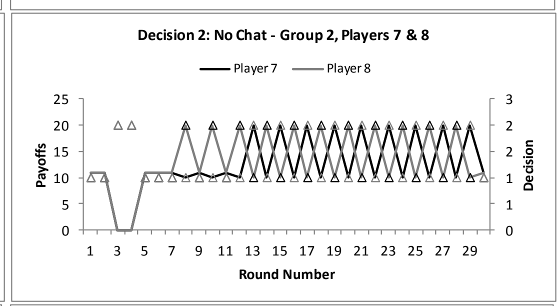


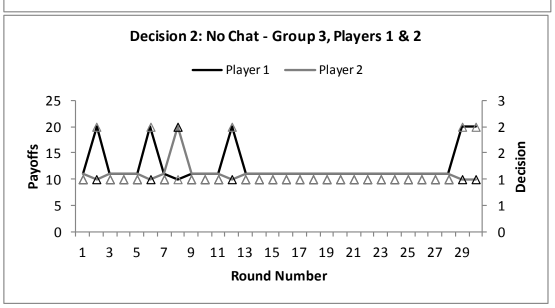


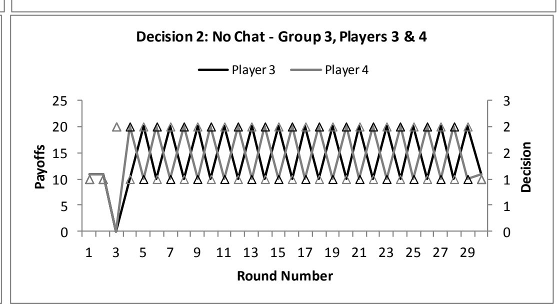




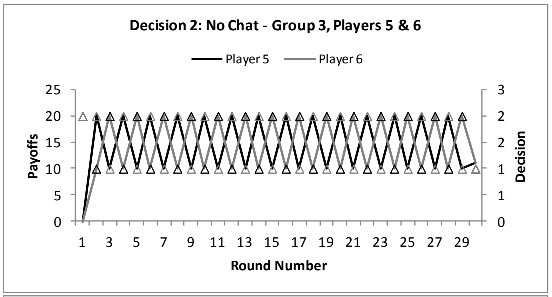


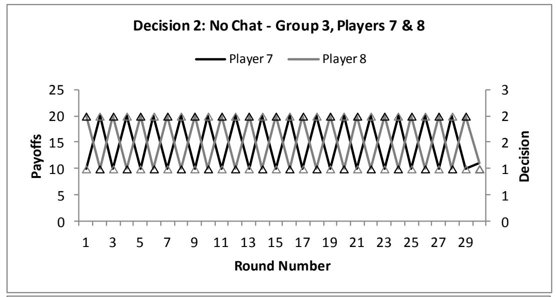


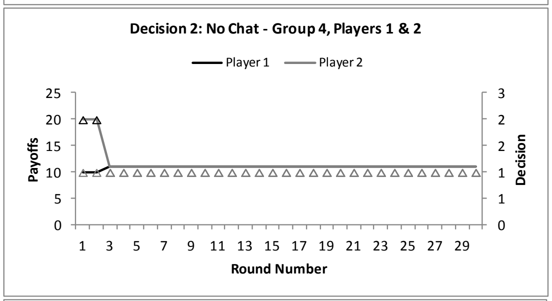


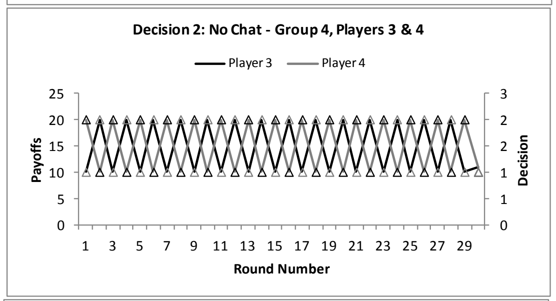


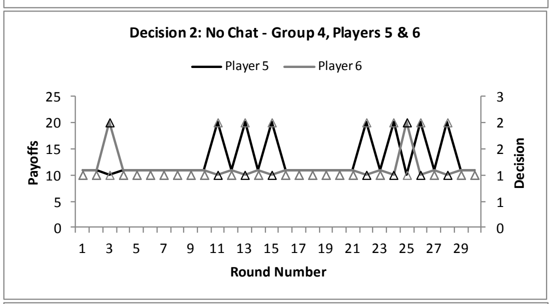
Treatment (Decision) 2

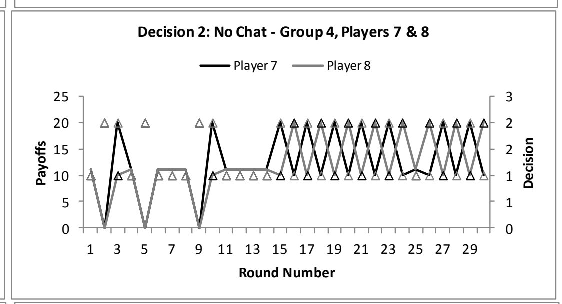


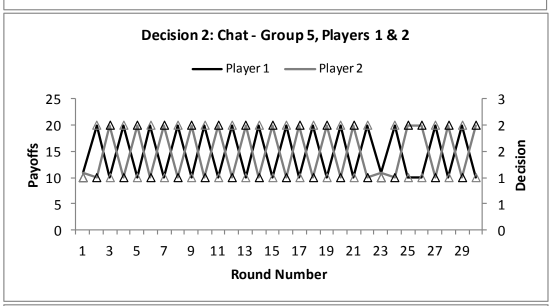


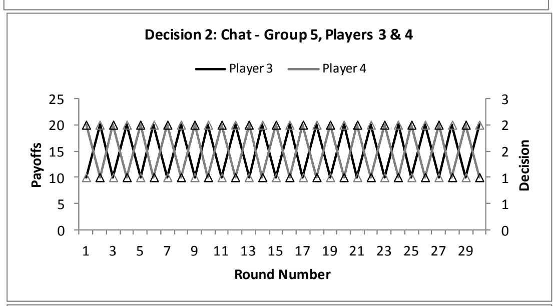


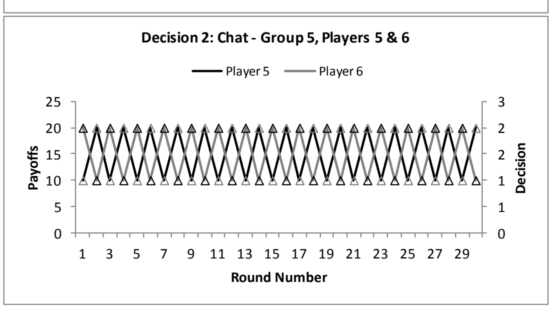


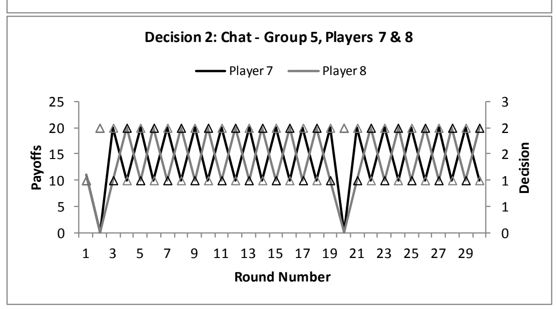




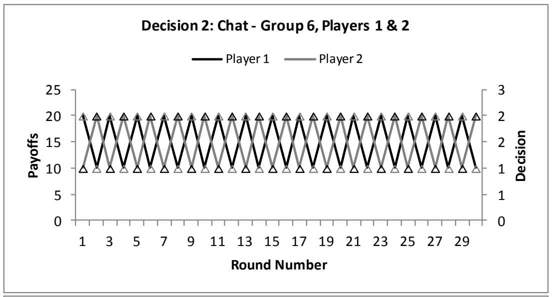


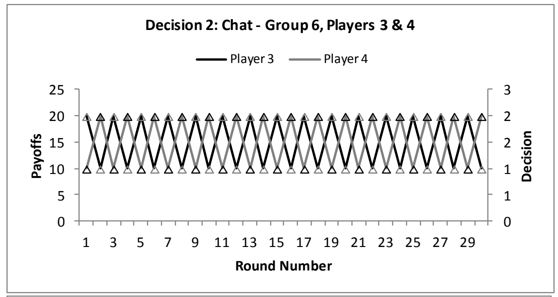


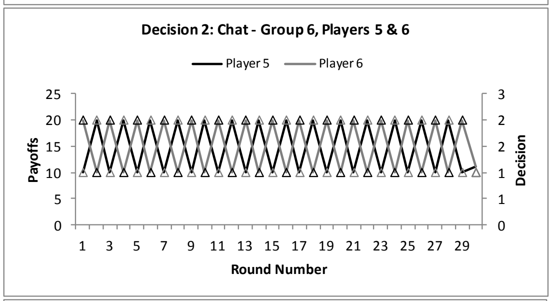


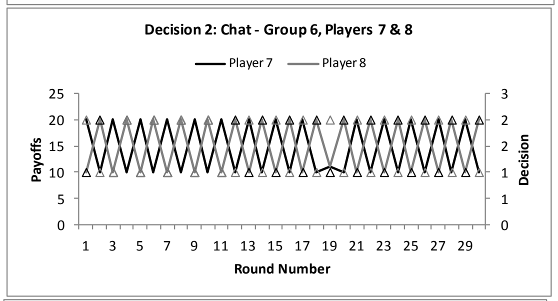


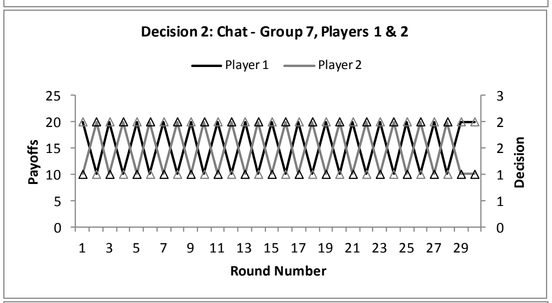
Treatment (Decision) 2

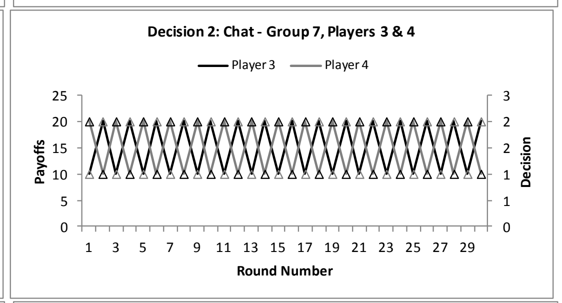


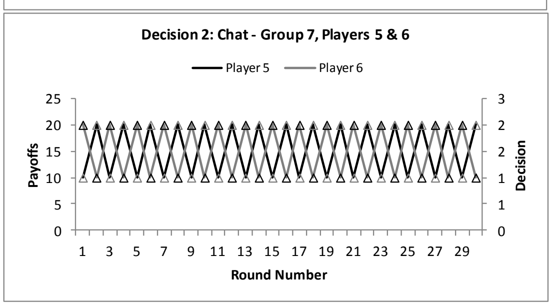


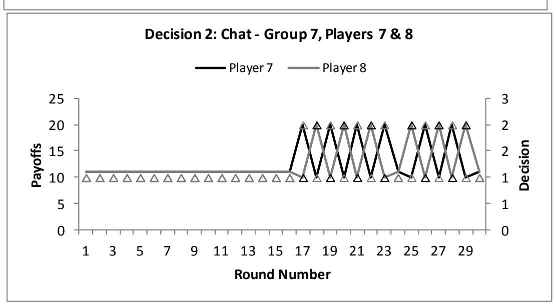












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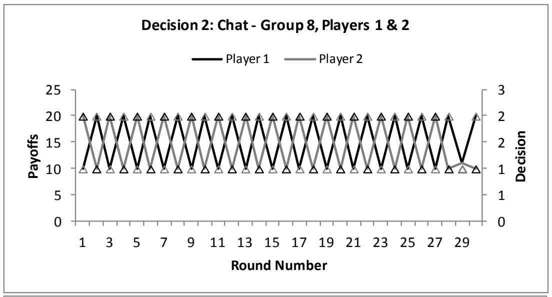

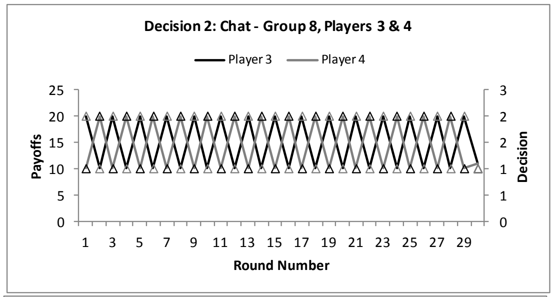

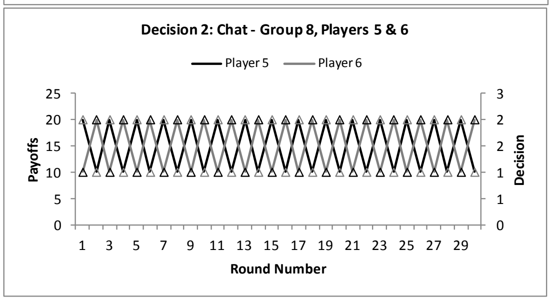

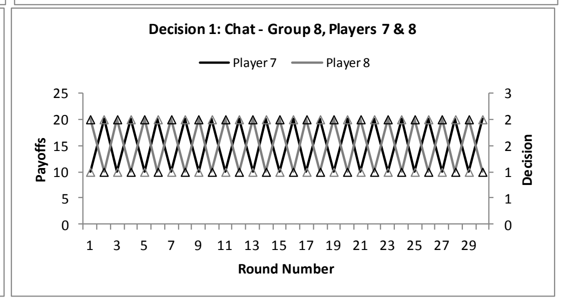

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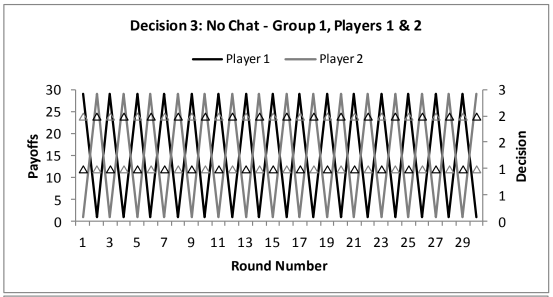
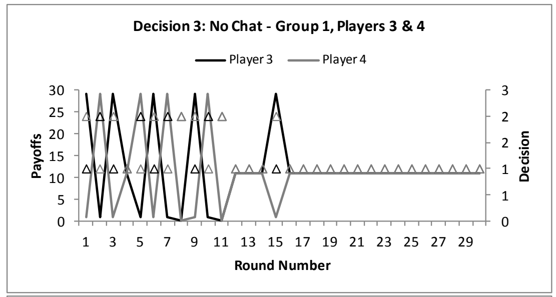
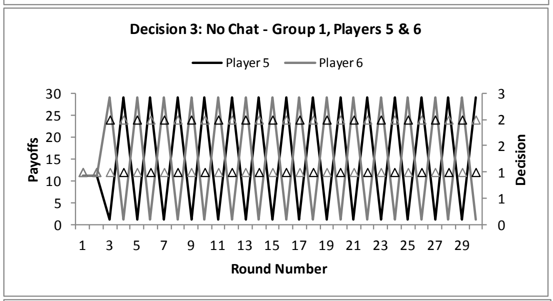
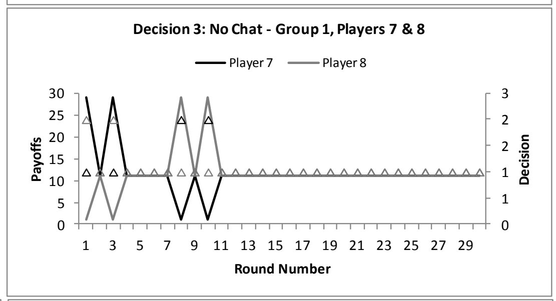
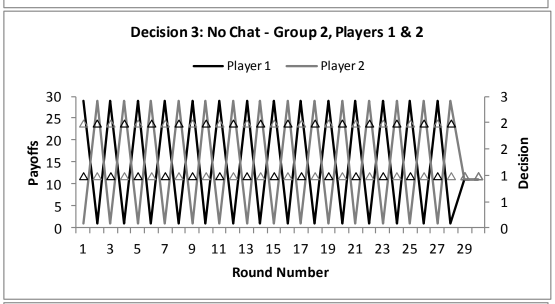
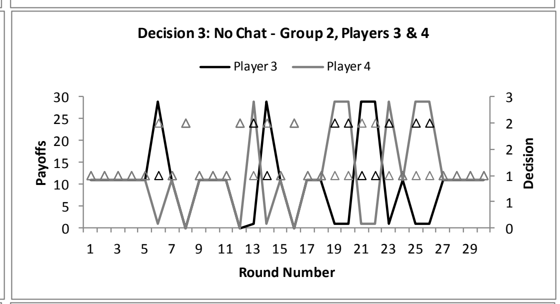


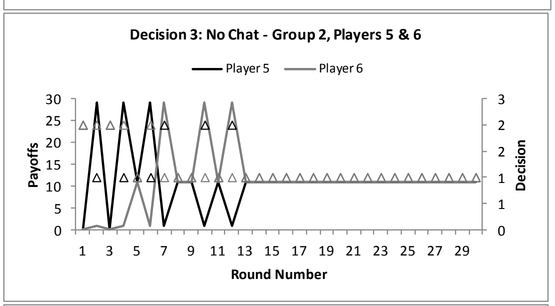


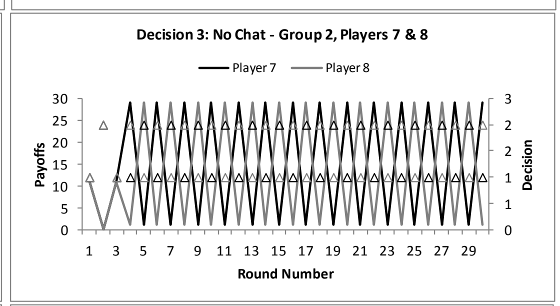


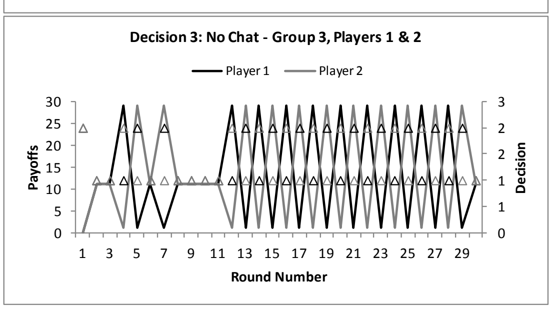


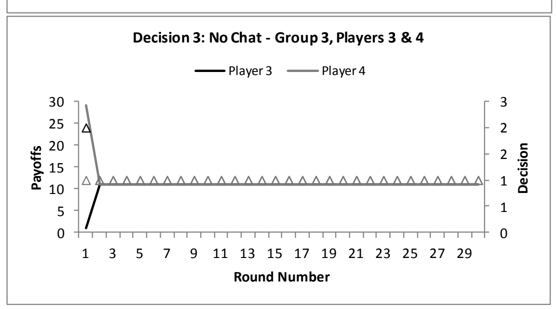




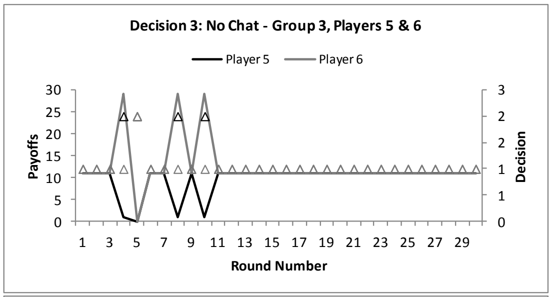


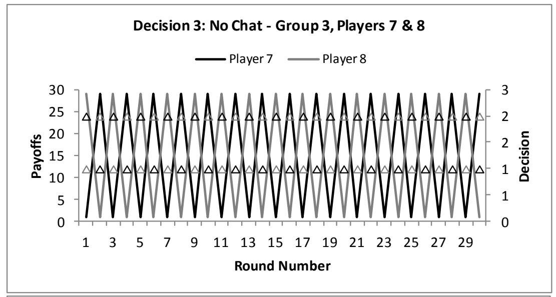


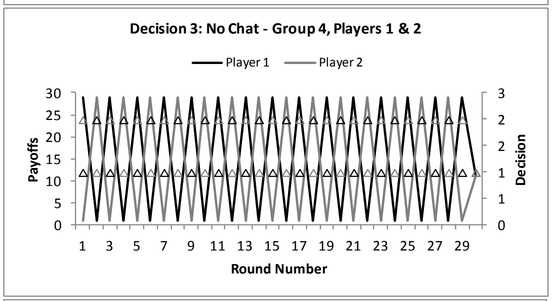


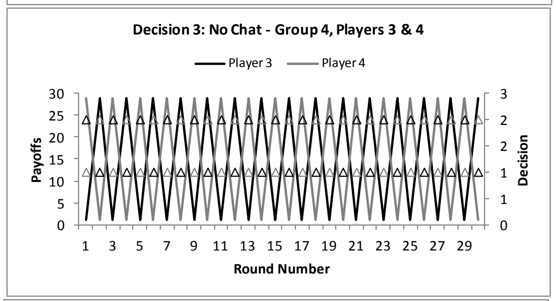


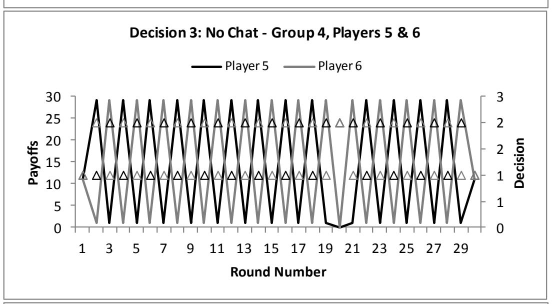
Treatment (Decision) 3

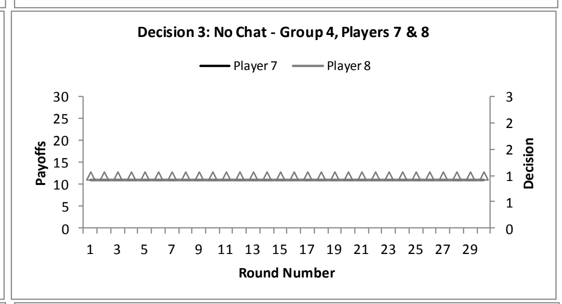


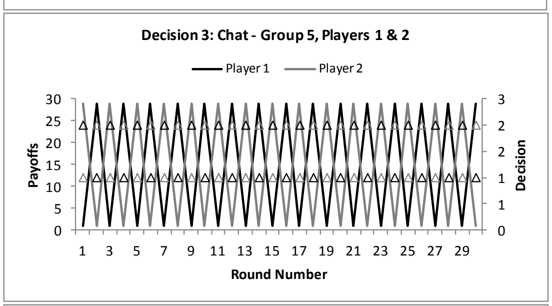


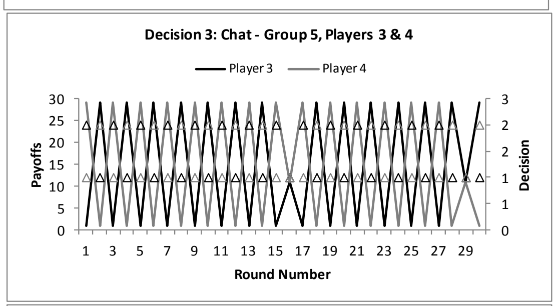


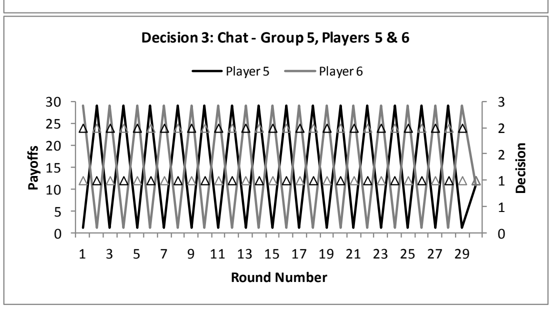


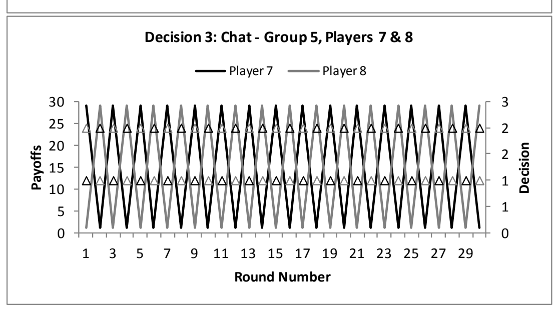




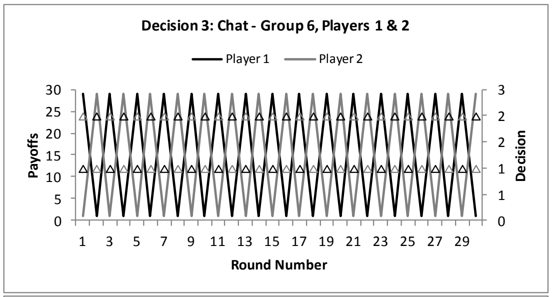


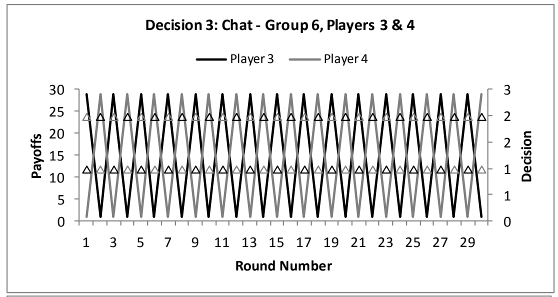


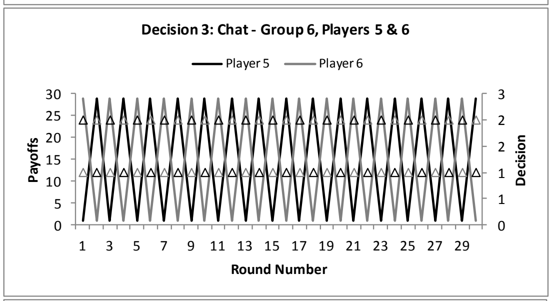


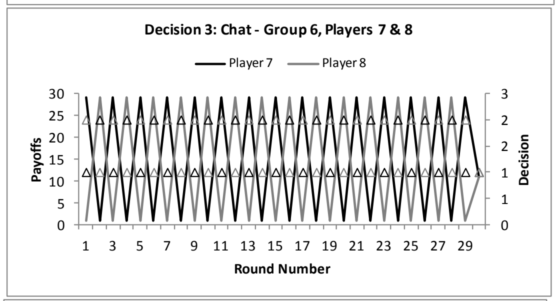


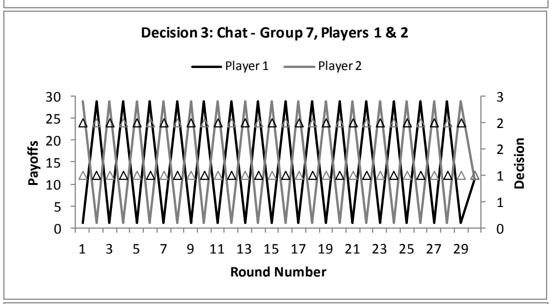
Treatment (Decision) 3

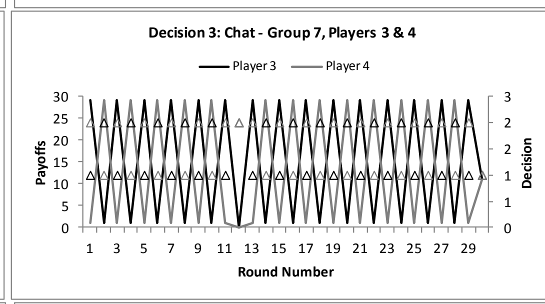


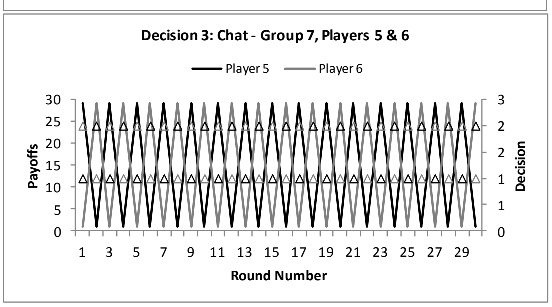


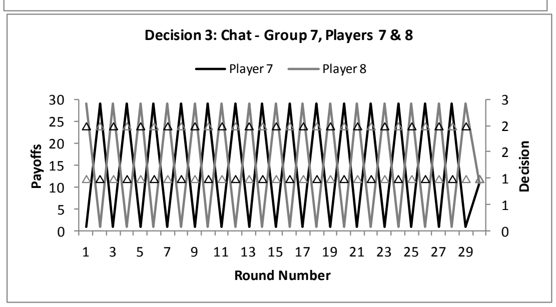




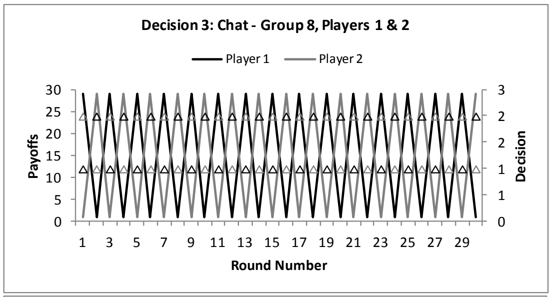


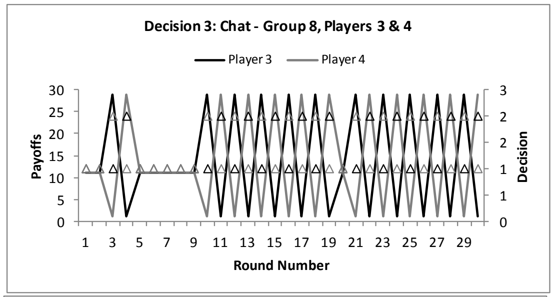


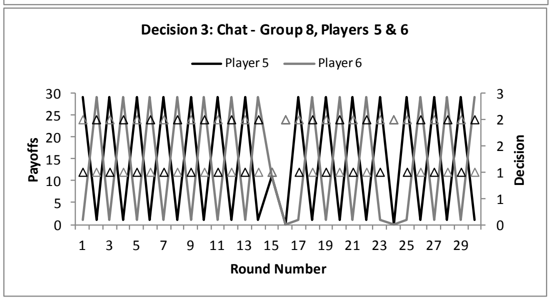


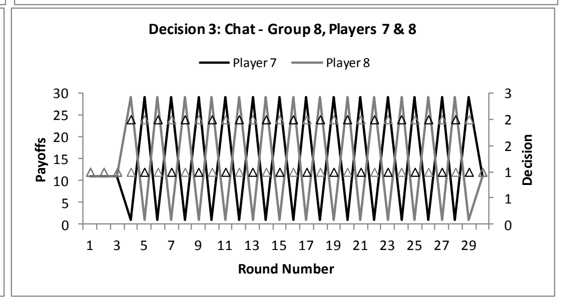


Treatment (Decision) 3

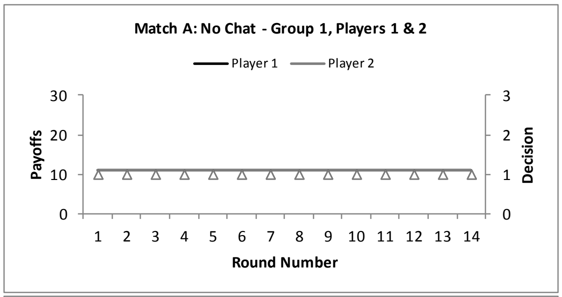


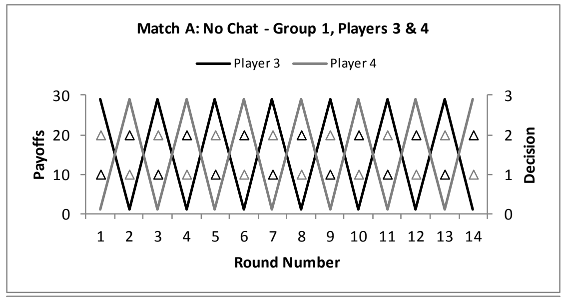


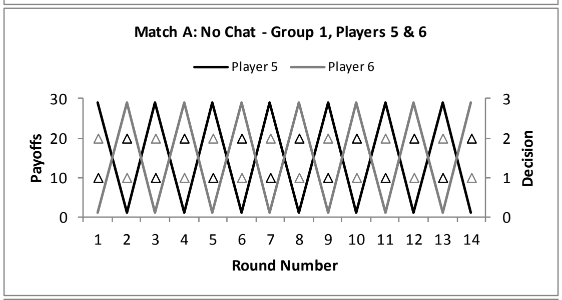


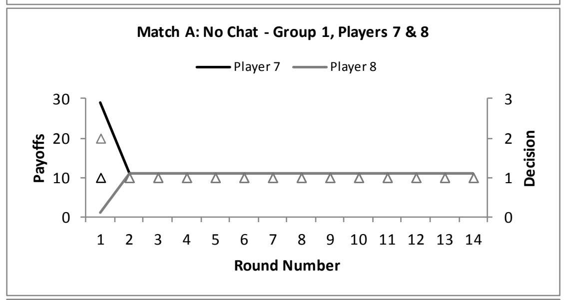


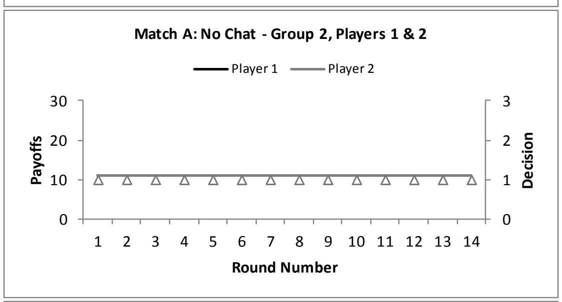
Repeated matching: first match (A)

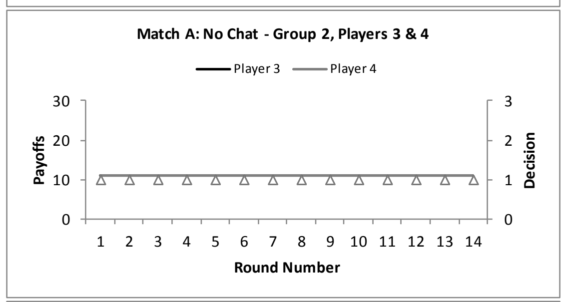


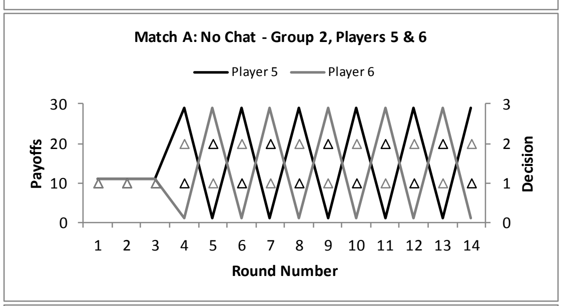


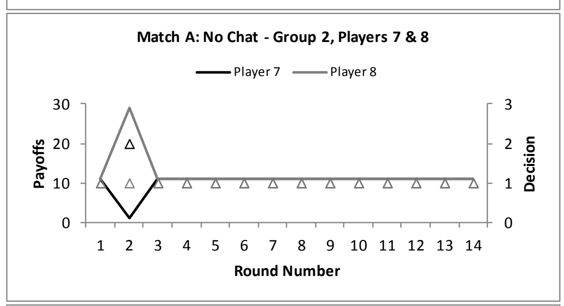


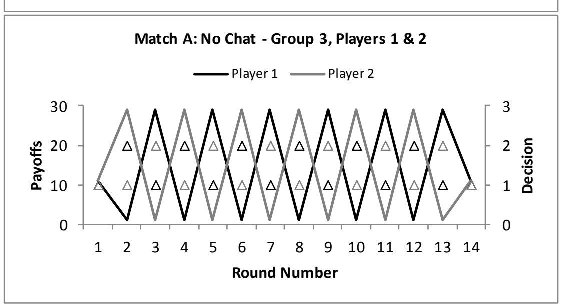


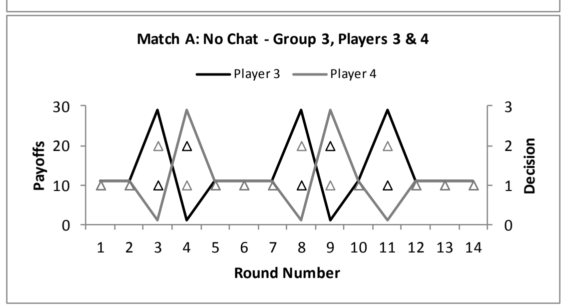












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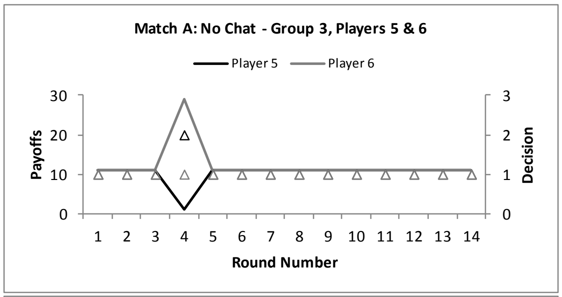
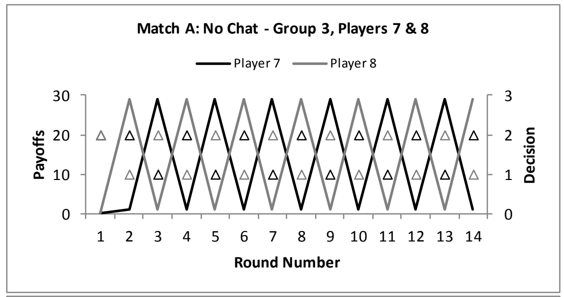
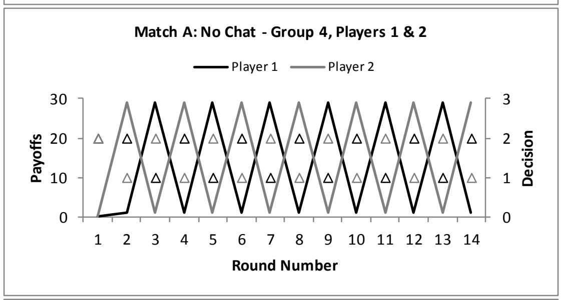
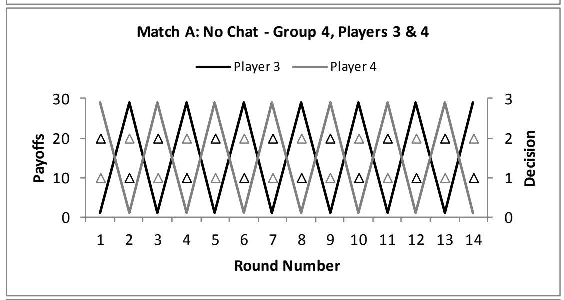
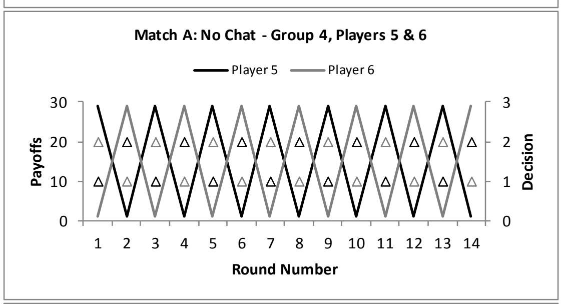
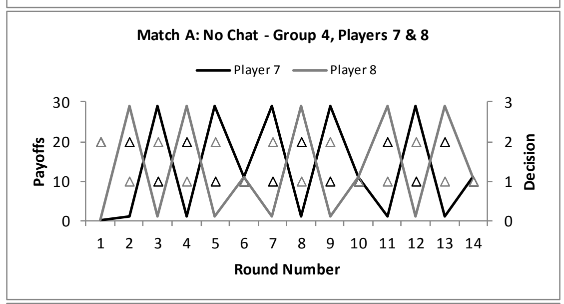


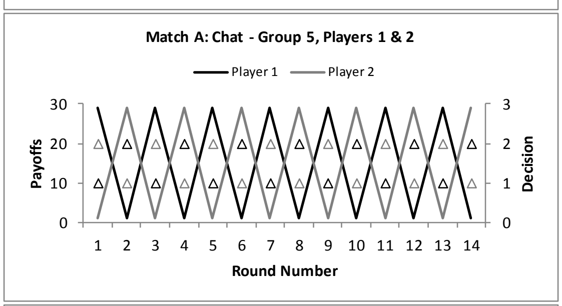


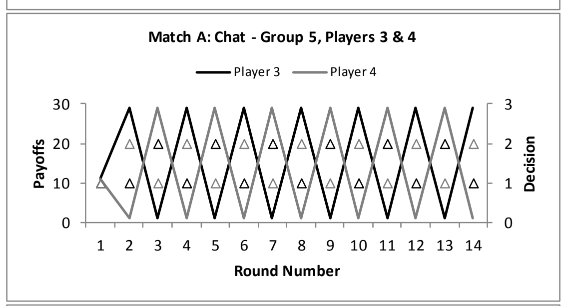


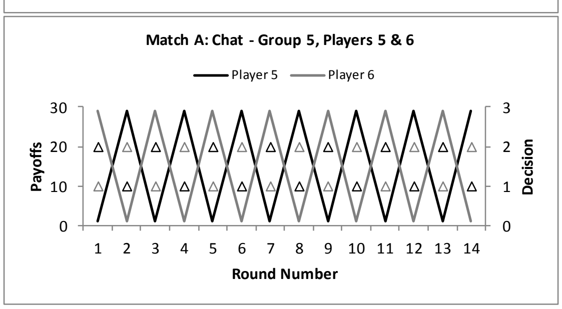


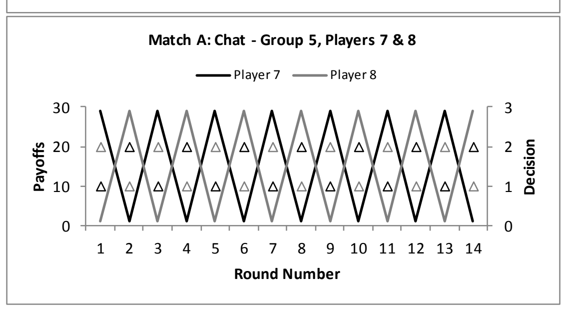




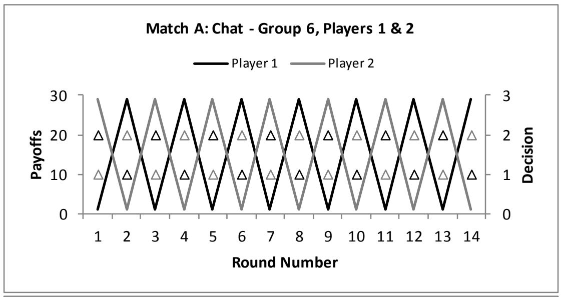


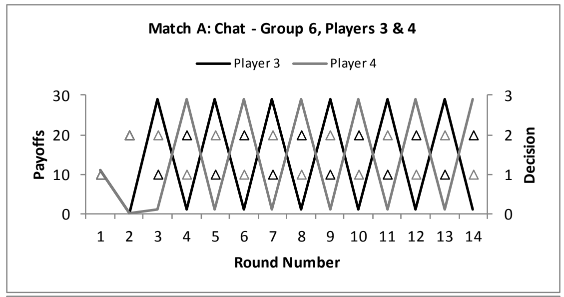


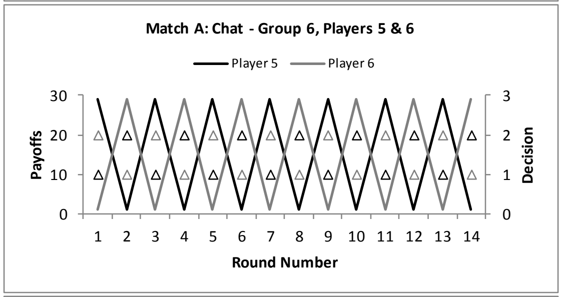


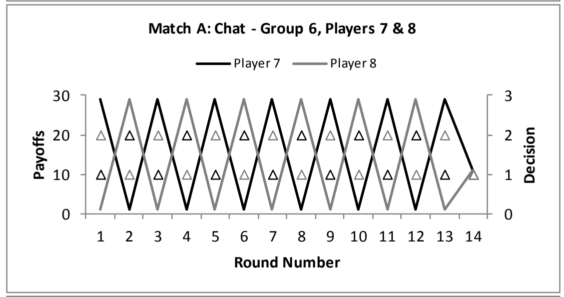


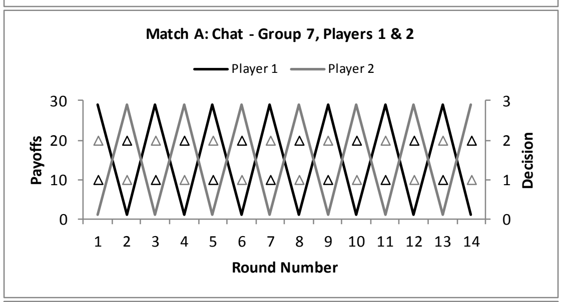
Repeated matching: first match (A)

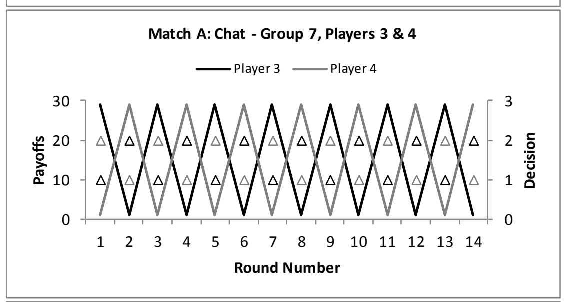


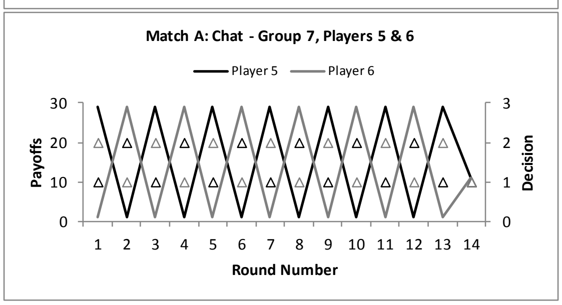


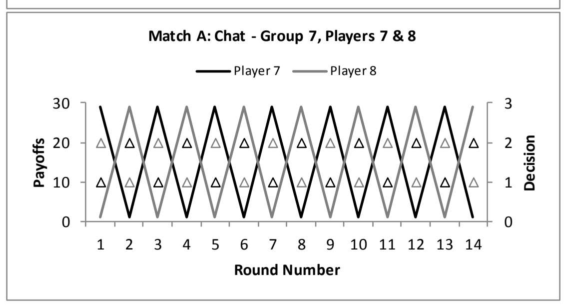












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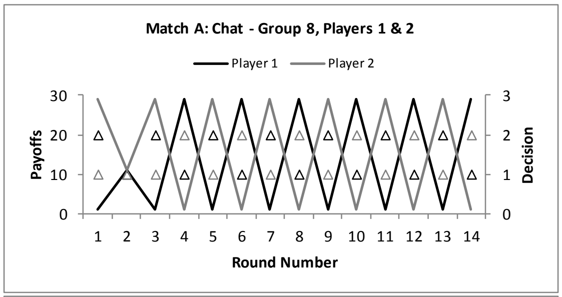
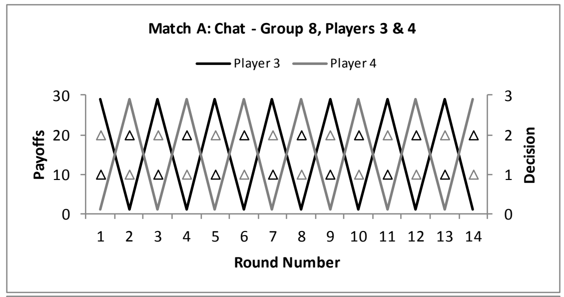
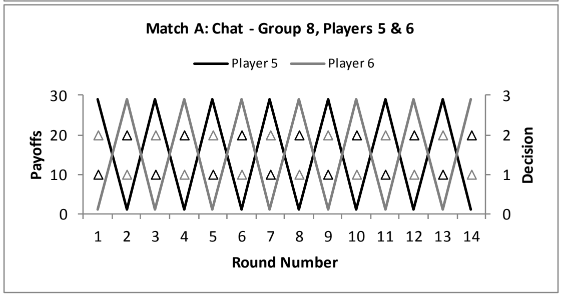
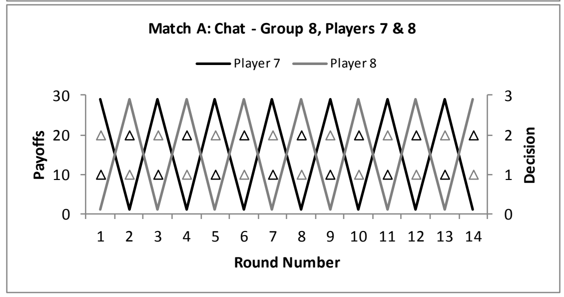
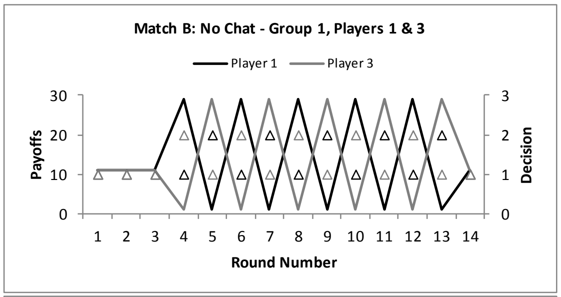


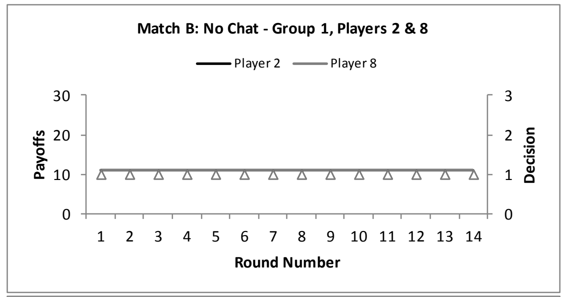


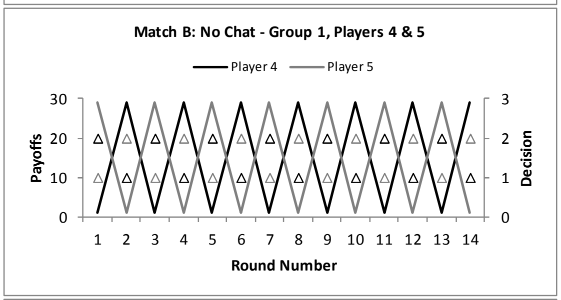


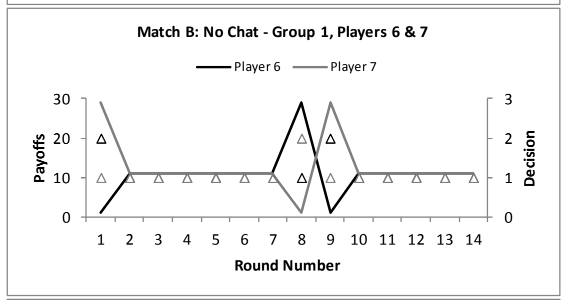


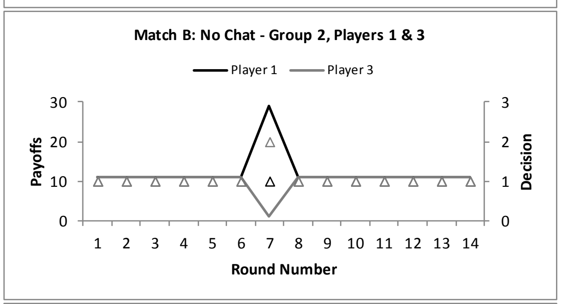
Repeated matching: second match (B)

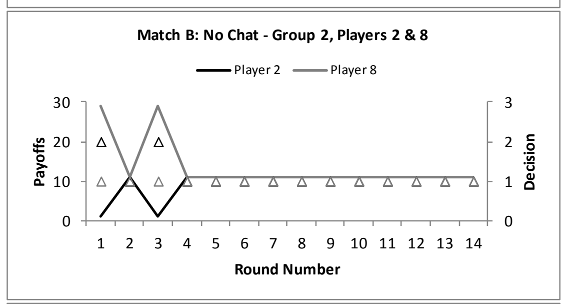


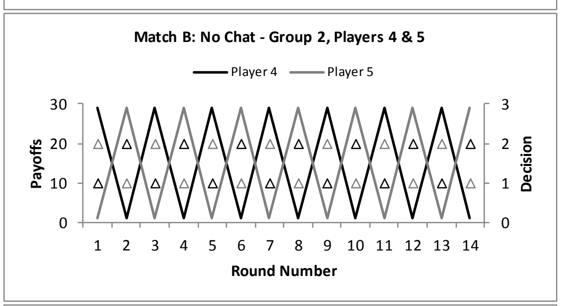


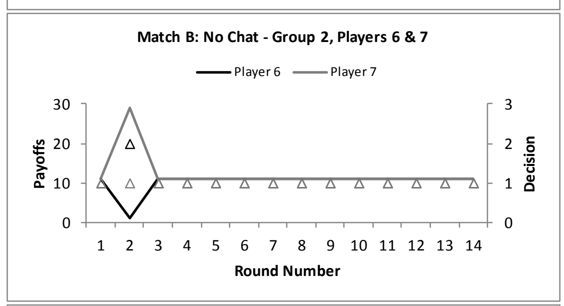


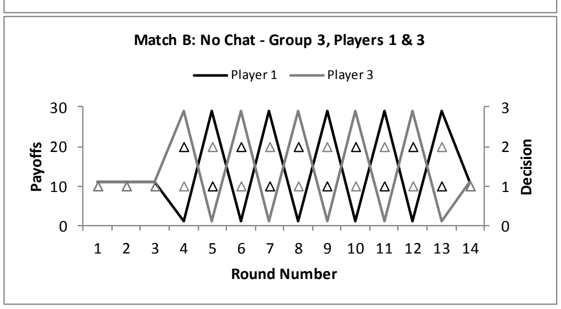


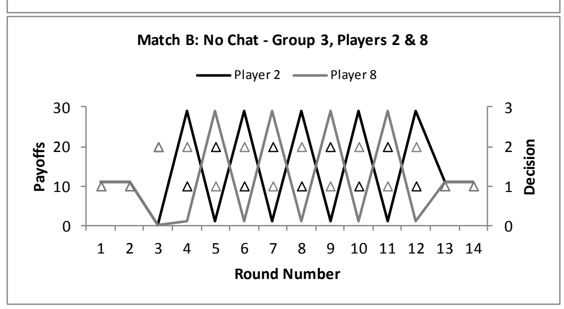




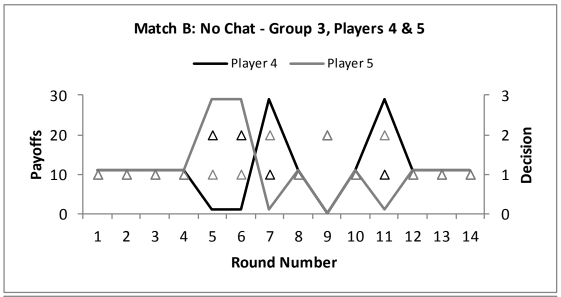


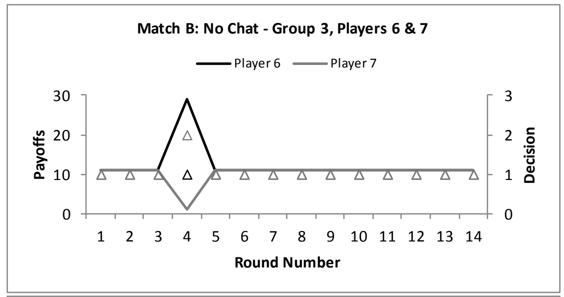


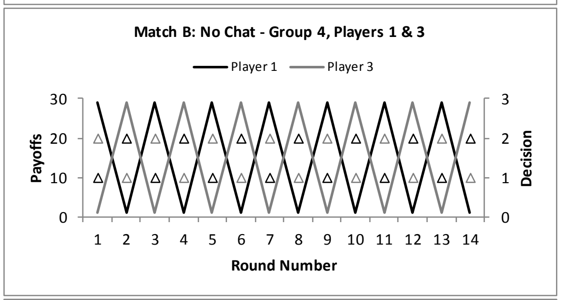


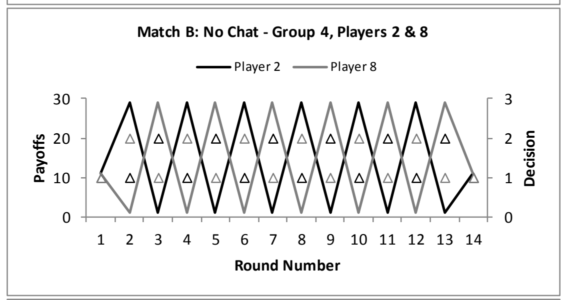


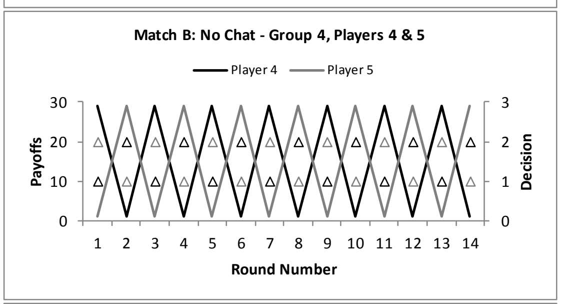
Repeated matching: second match (B)

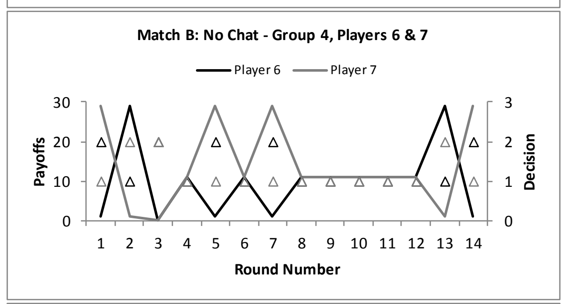


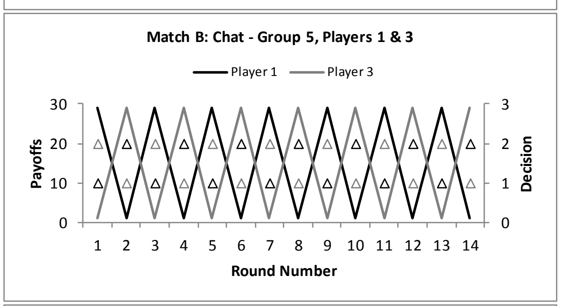


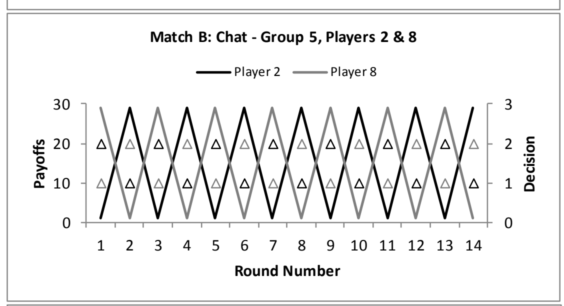


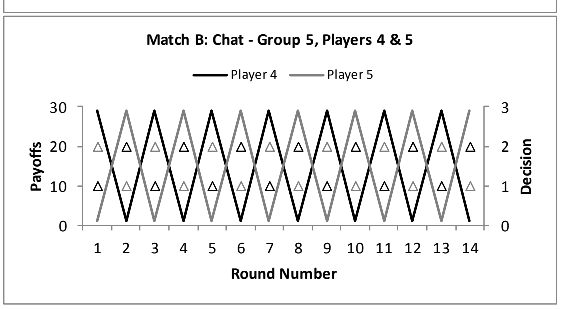


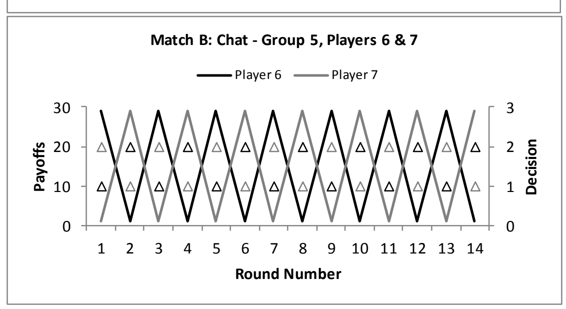




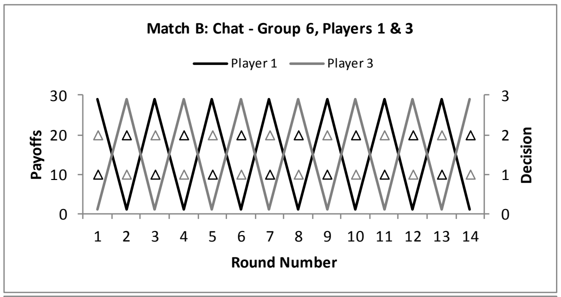


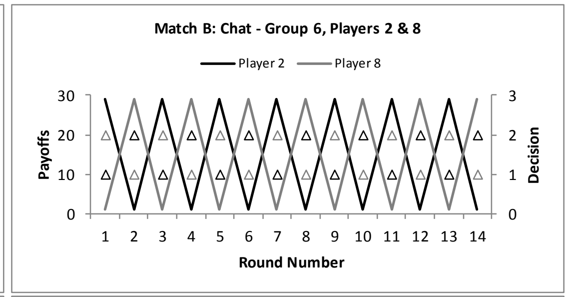


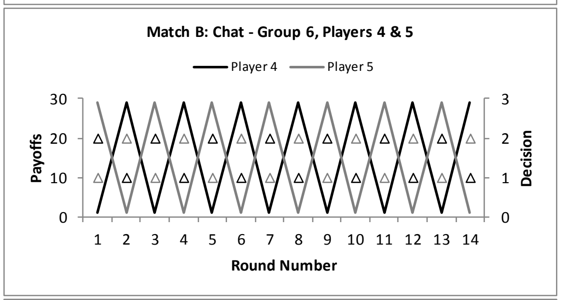


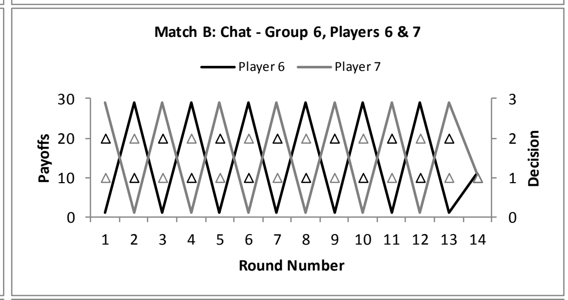


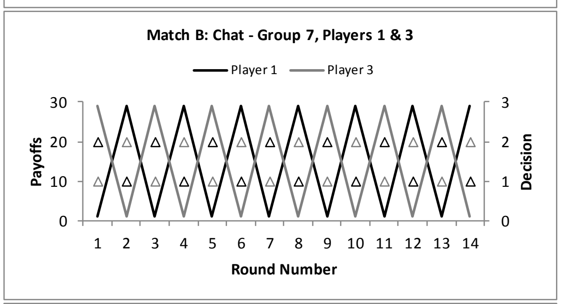
Repeated matching: second match (B)

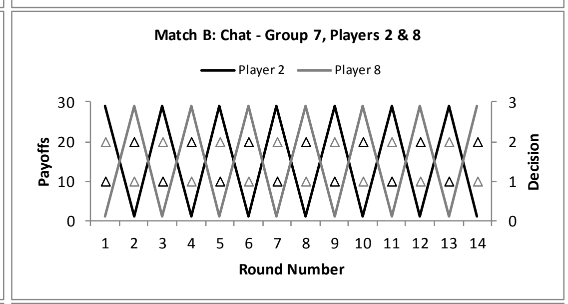


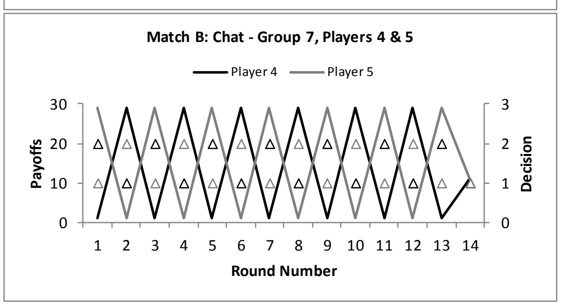


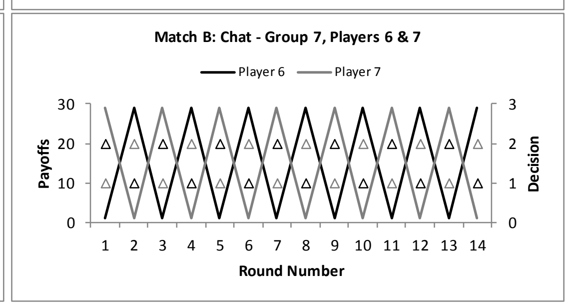




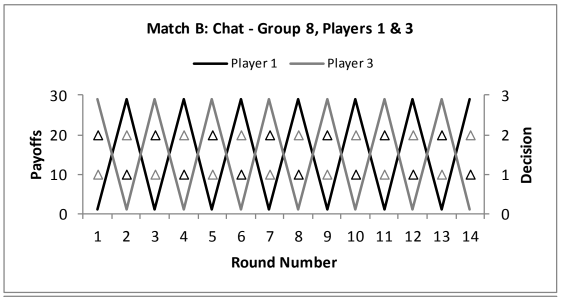


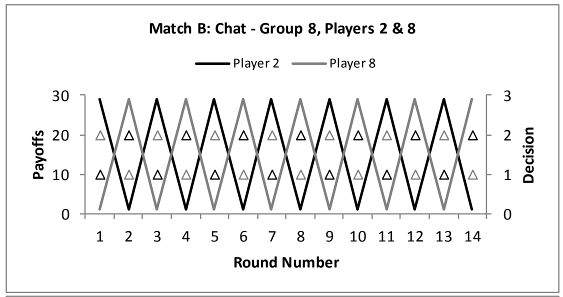


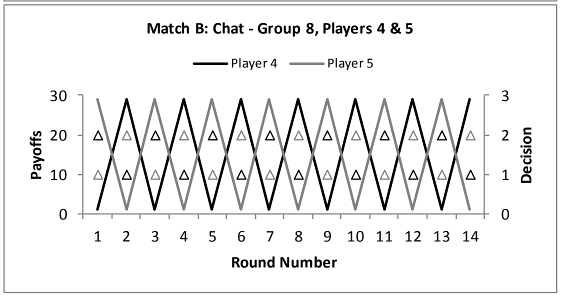


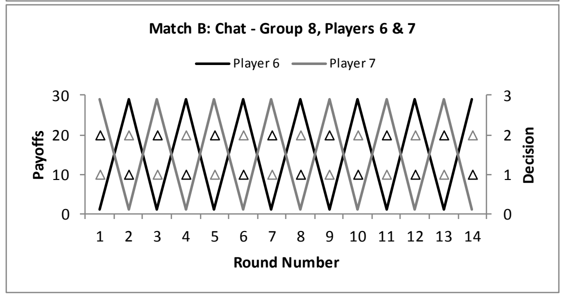


Repeated matching: second match (B)

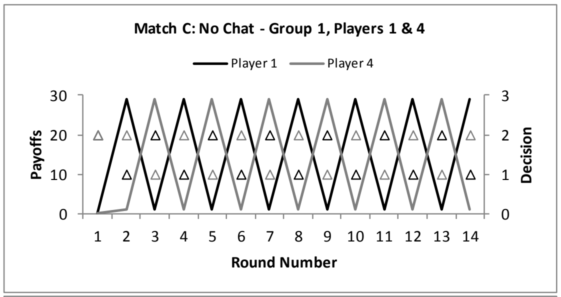


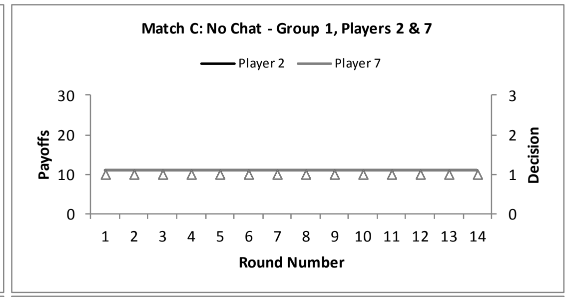


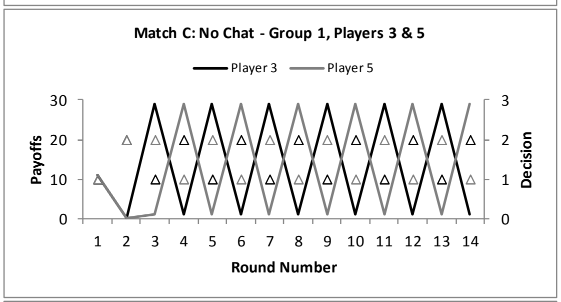


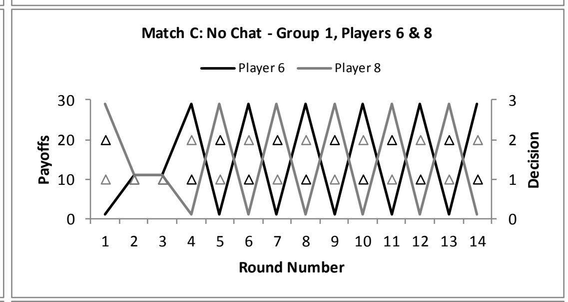


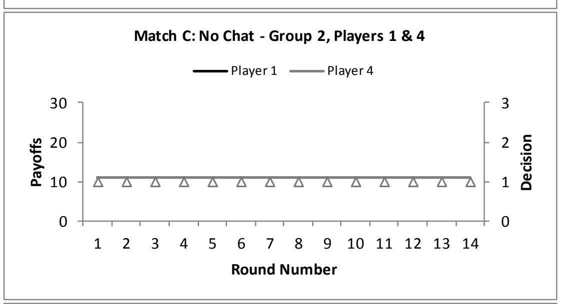
Repeated matching: Third match (C)

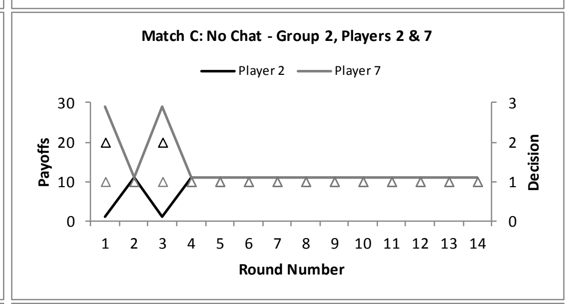


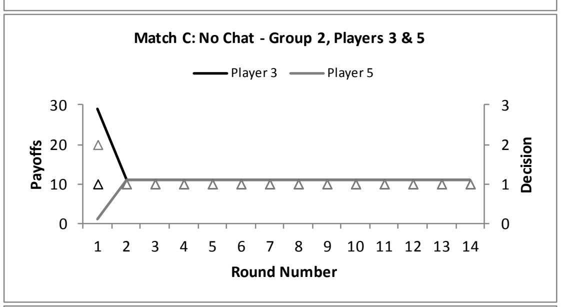


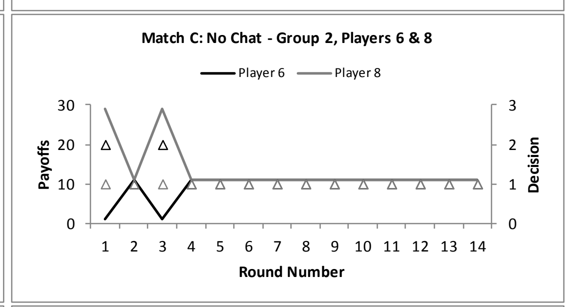


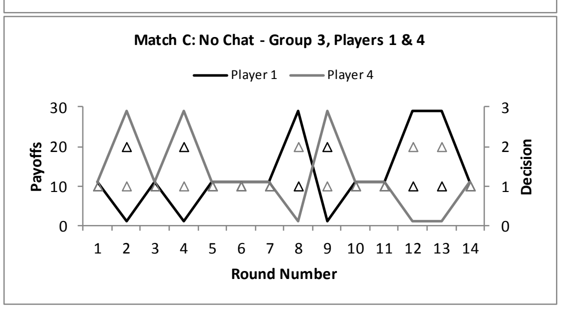


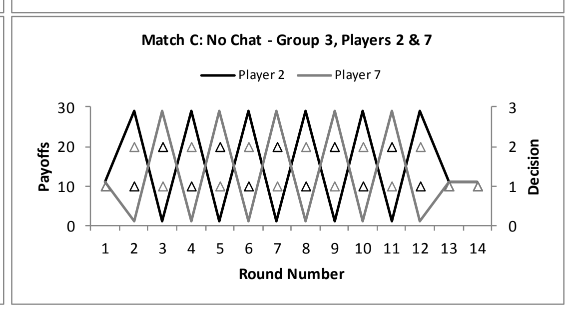




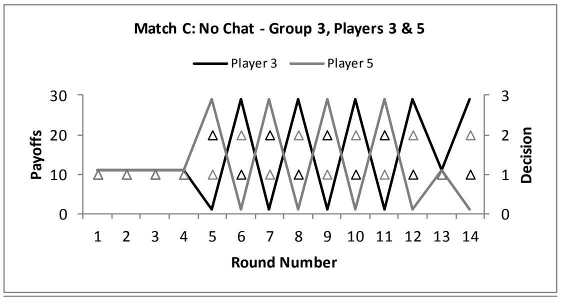


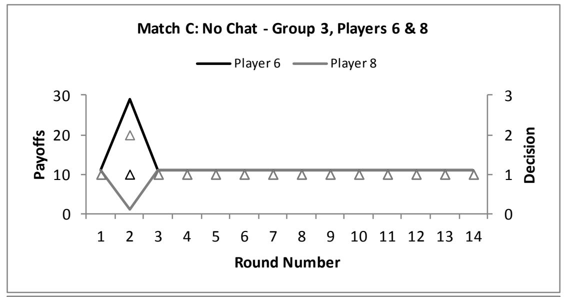


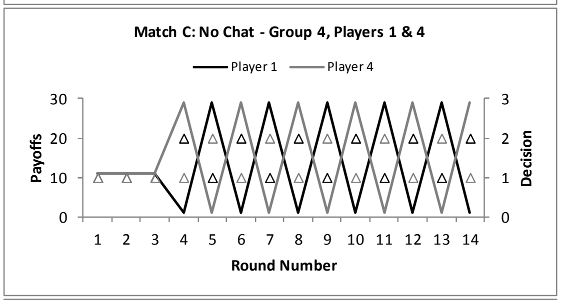


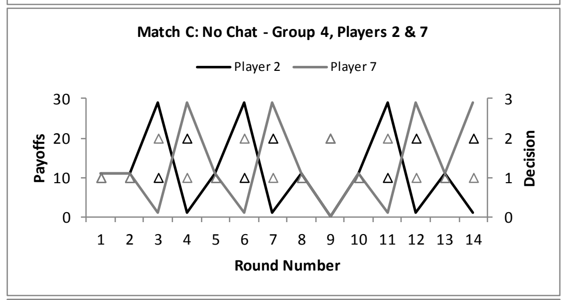


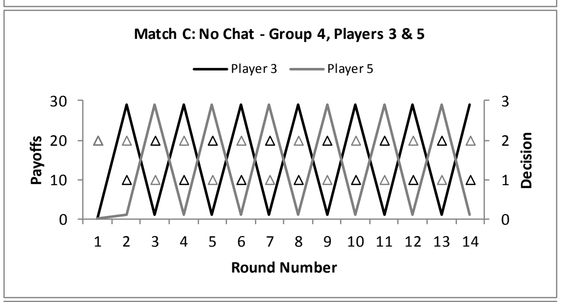
Repeated matching: Third match (C)

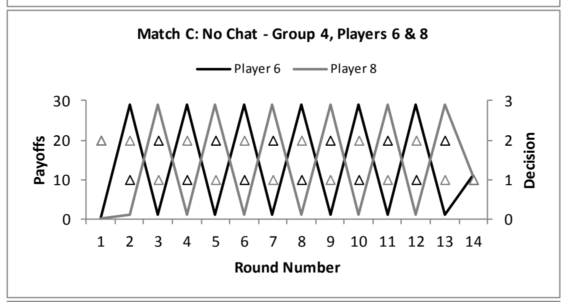


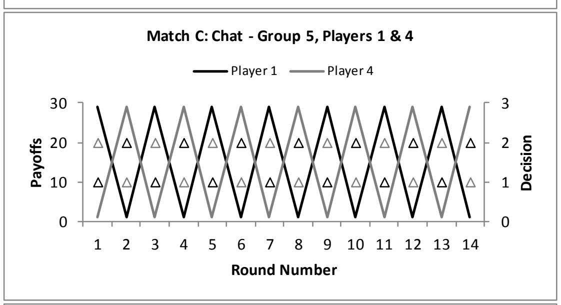


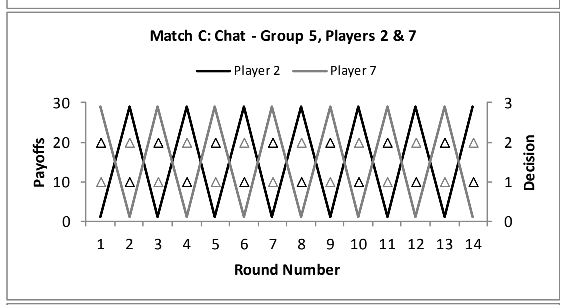


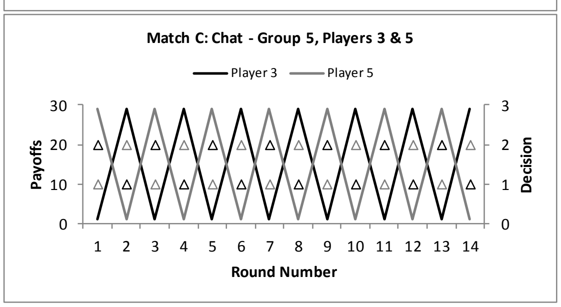


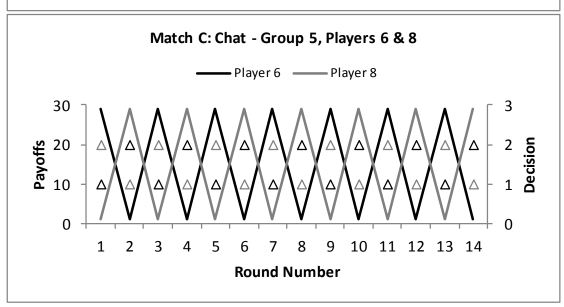




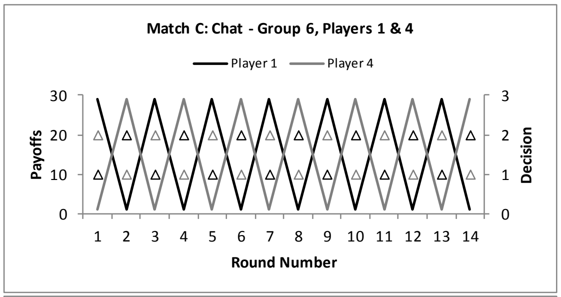


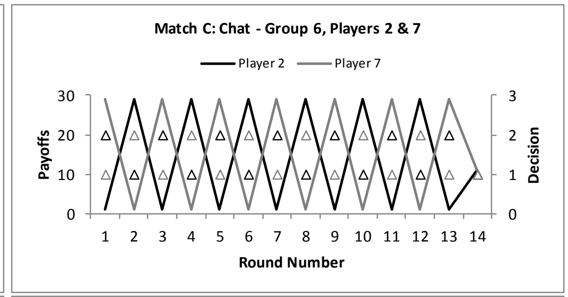


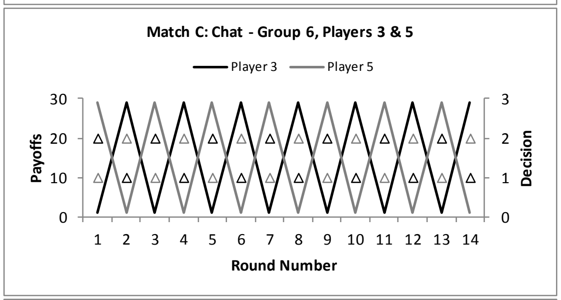


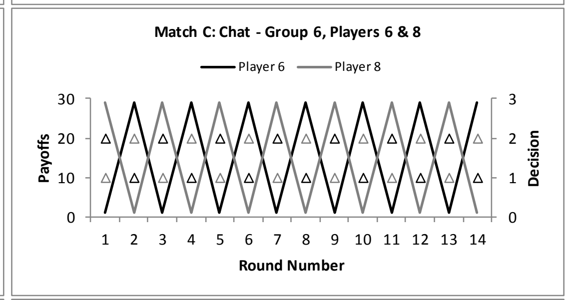


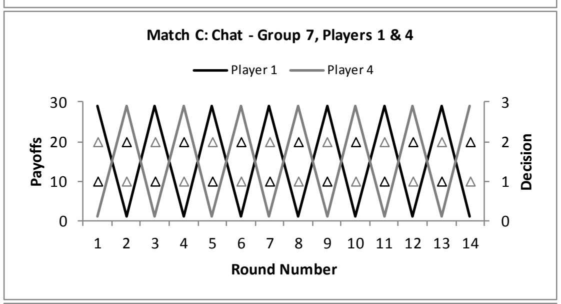
Repeated matching: Third match (C)

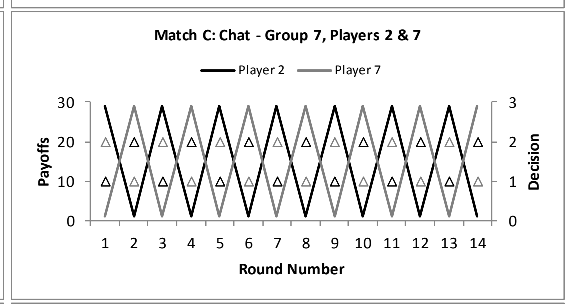


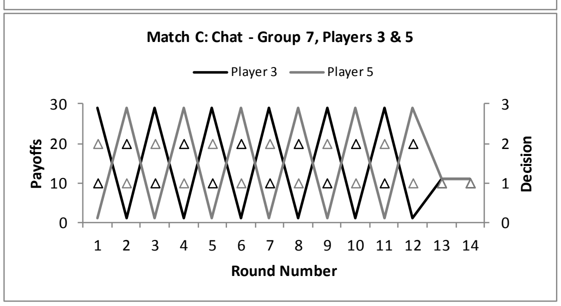


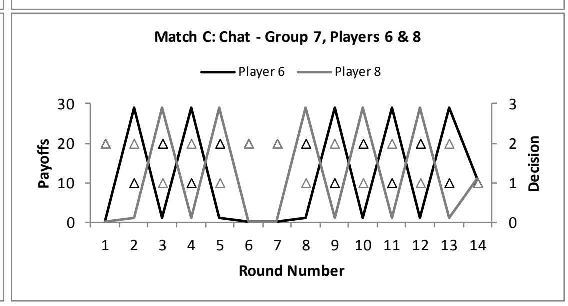




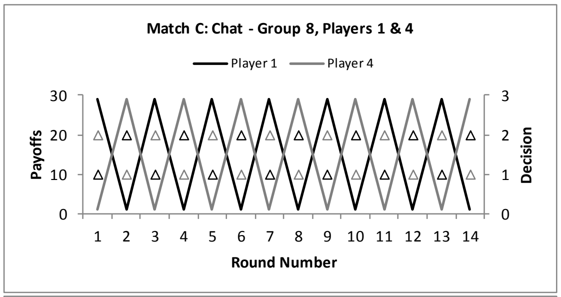


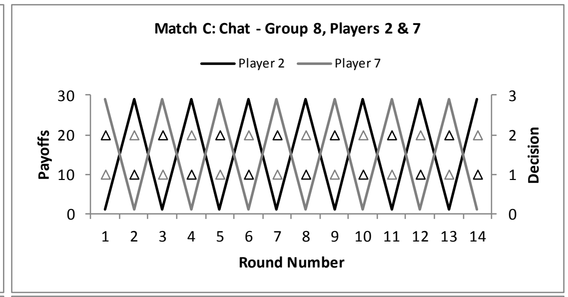


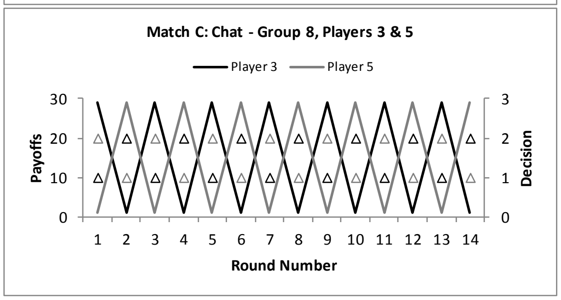


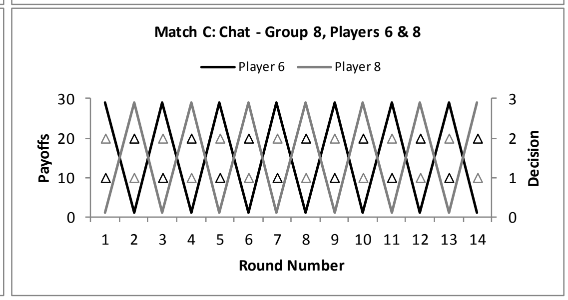


Repeated matching: Third match (C)

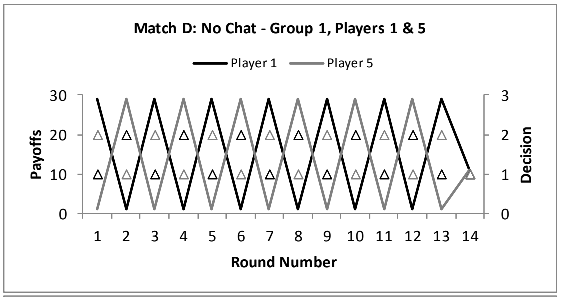


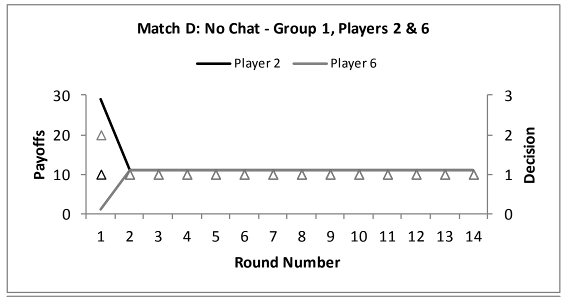


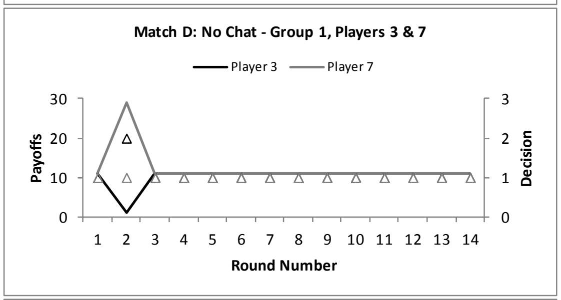


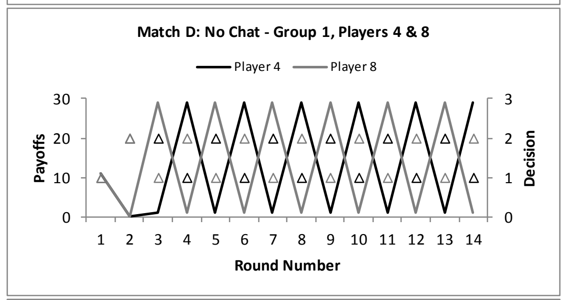


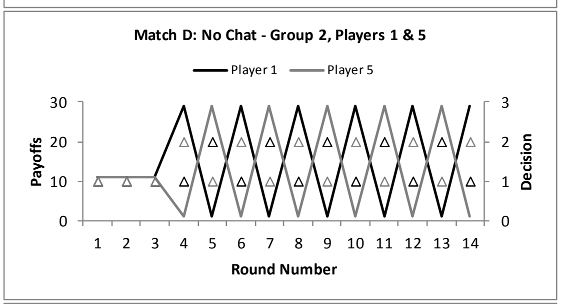
Repeated matching: Fourth match (D)

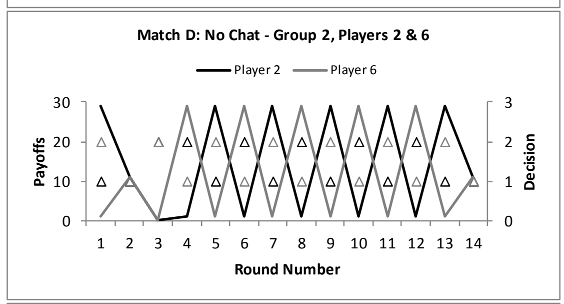


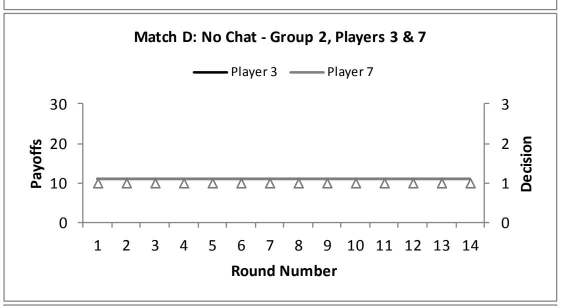


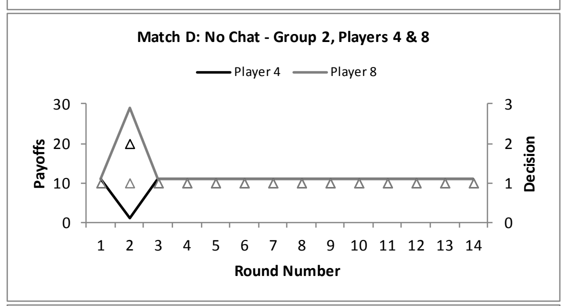


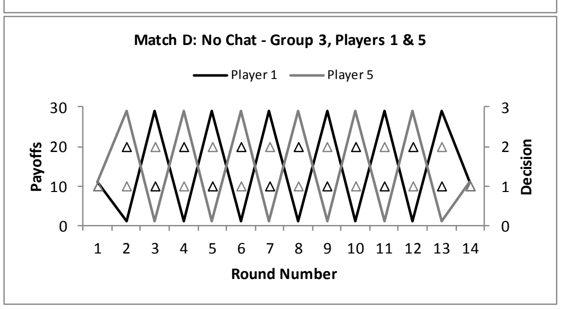


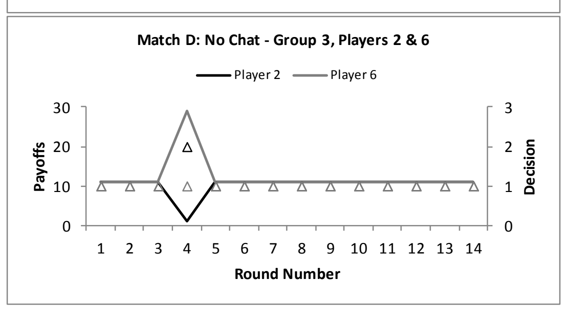




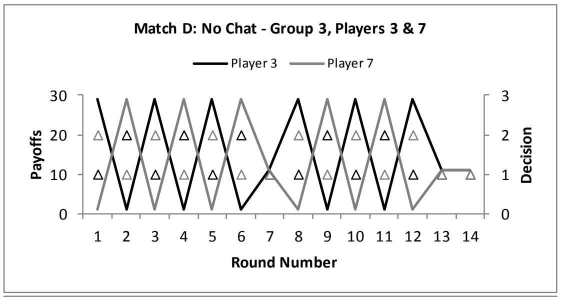


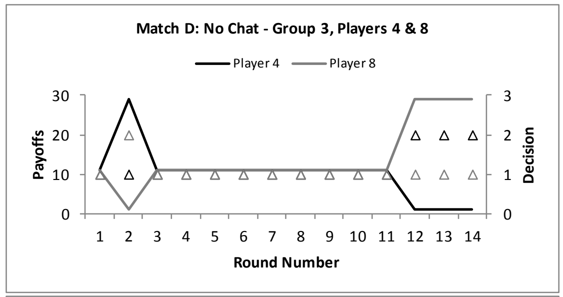


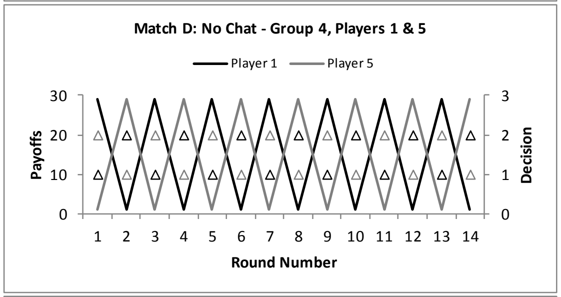


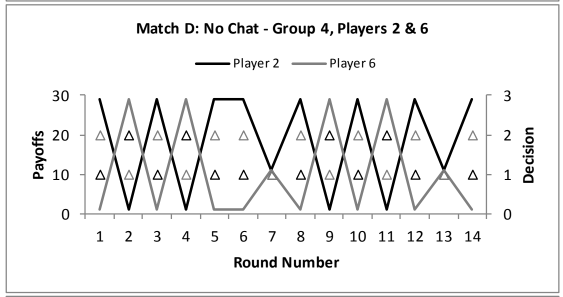


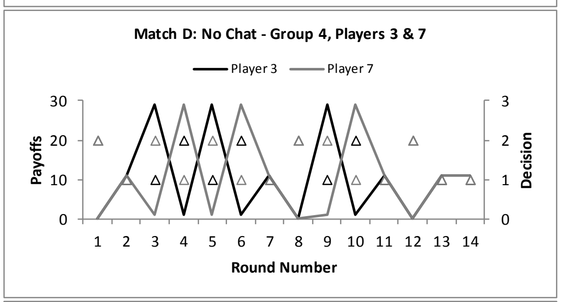
Repeated matching: Fourth match (D)

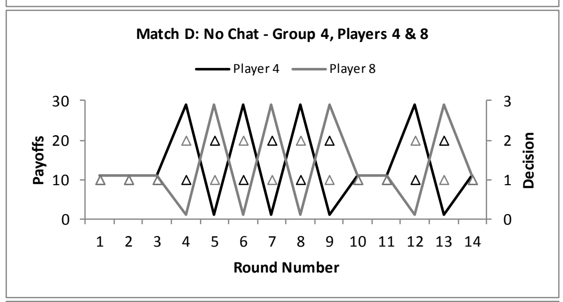


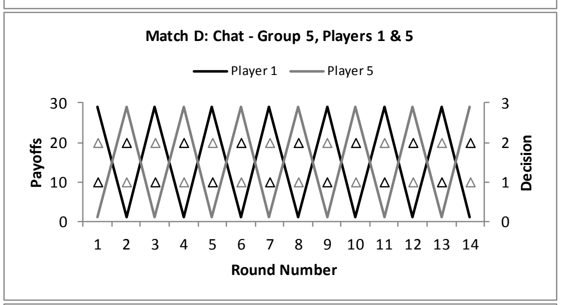


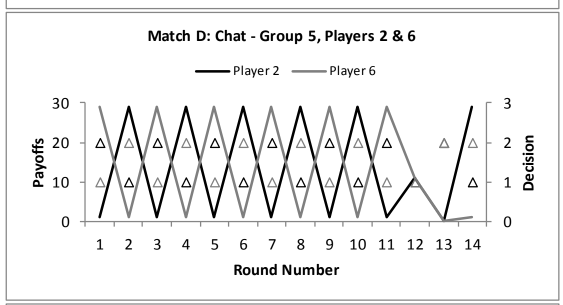


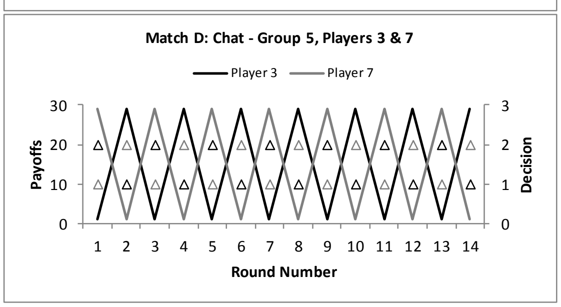


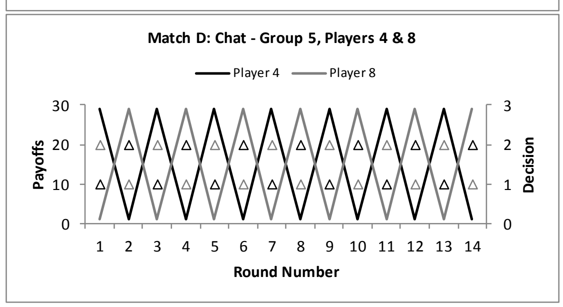




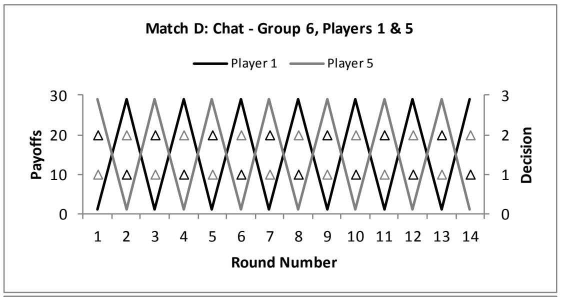


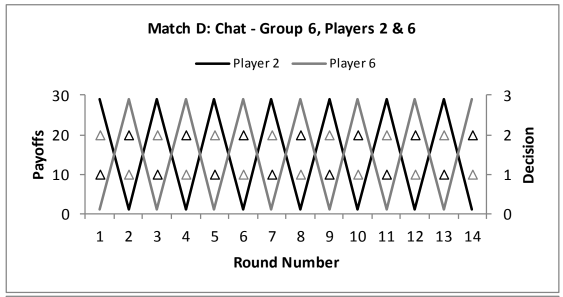


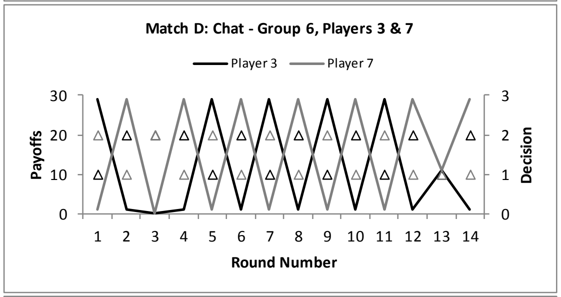


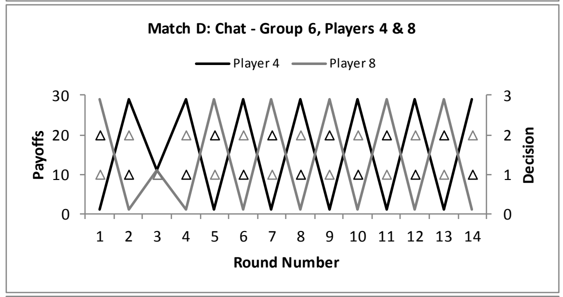


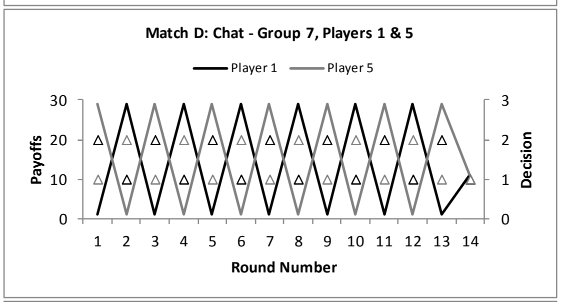
Repeated matching: Fourth match (D)

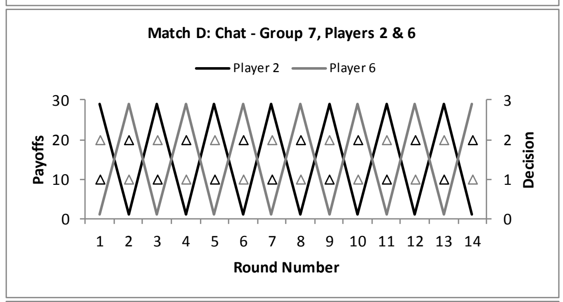


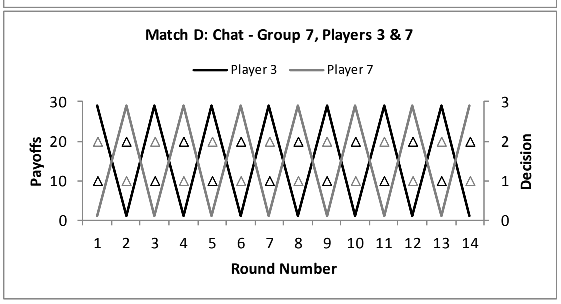


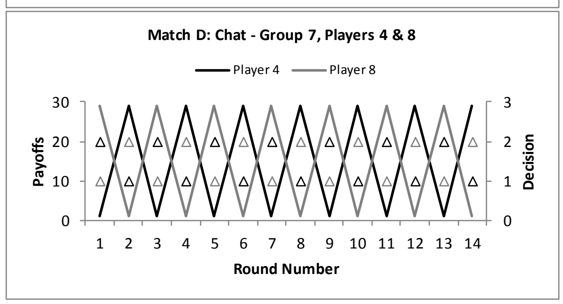




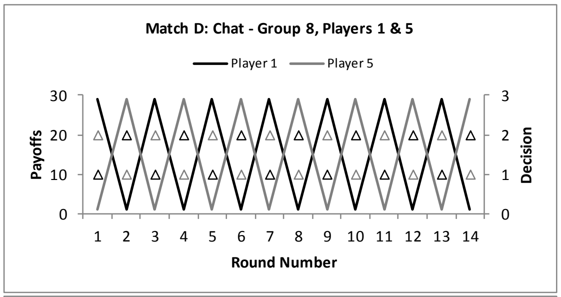


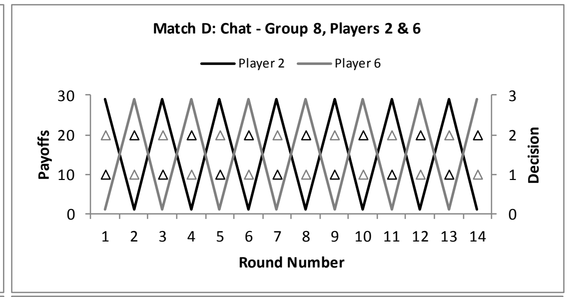


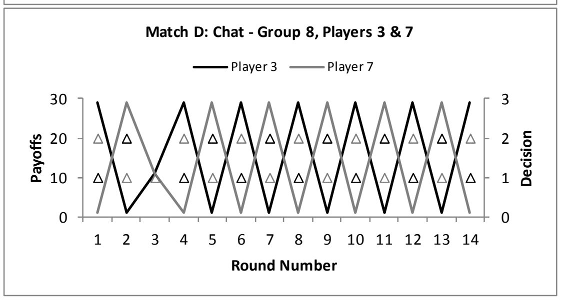


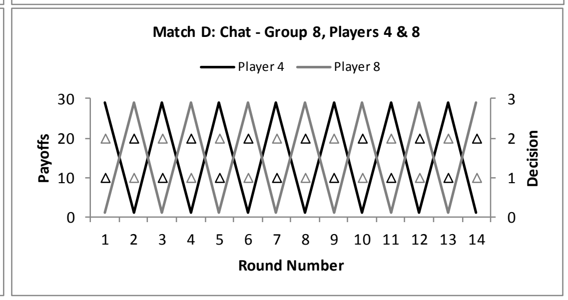


Repeated matching: Fourth match (D)

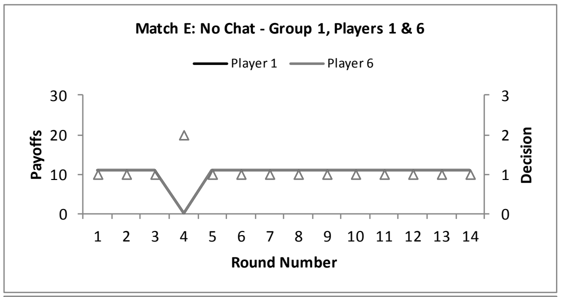


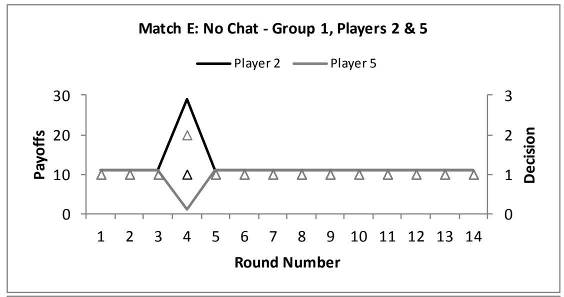


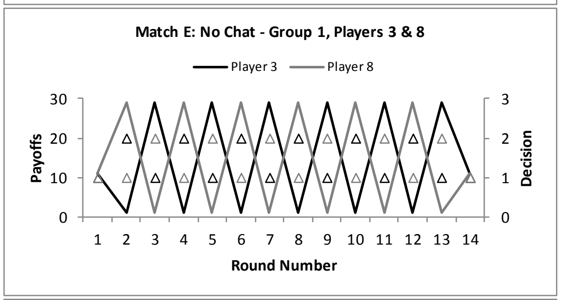


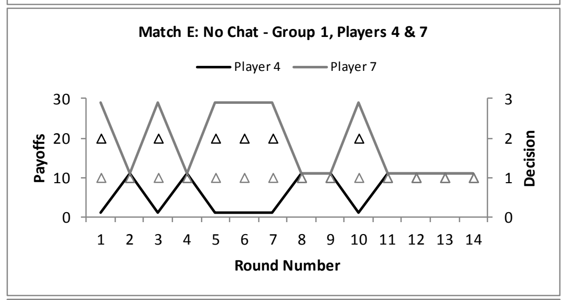


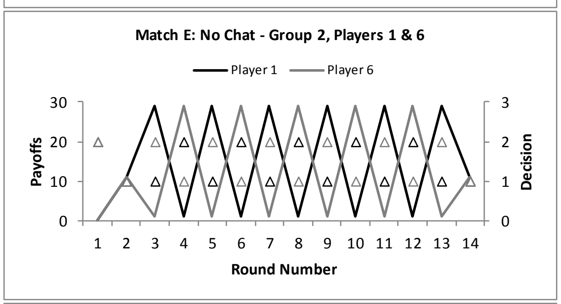
Repeated Matching: Fifth match (E)

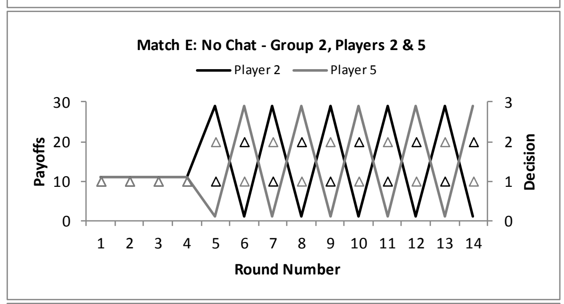


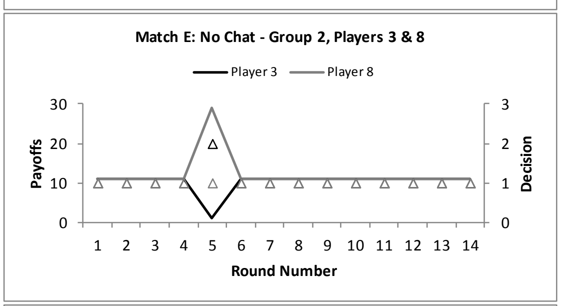


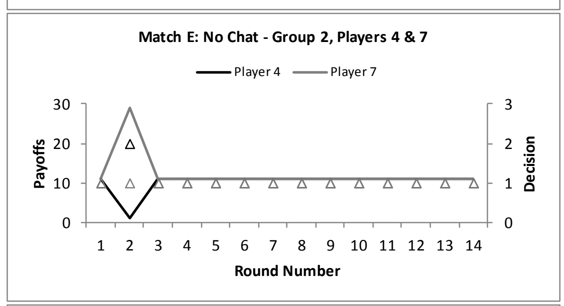


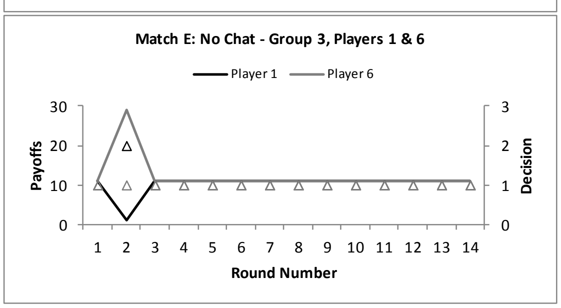


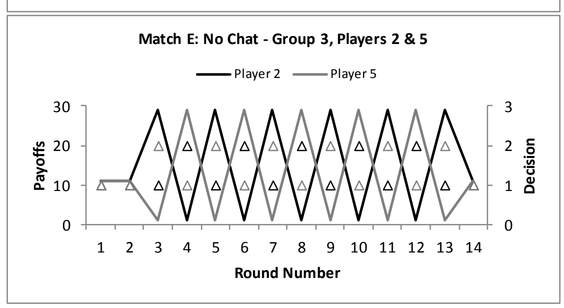




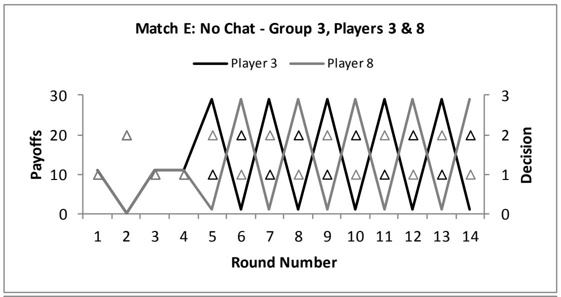


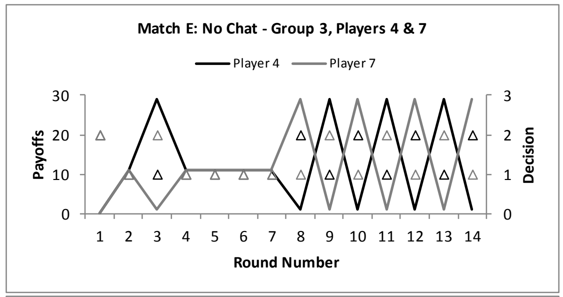


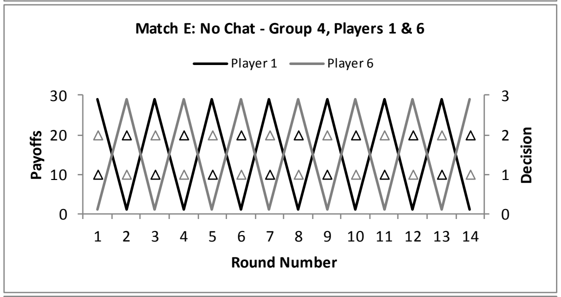


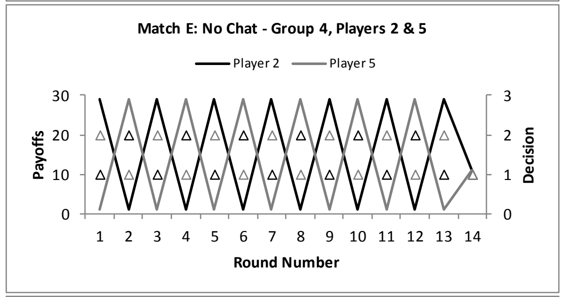


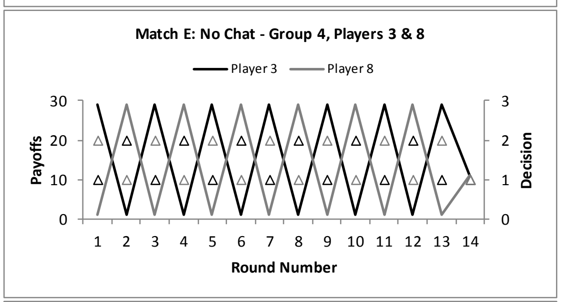
Repeated Matching: Fifth match (E)

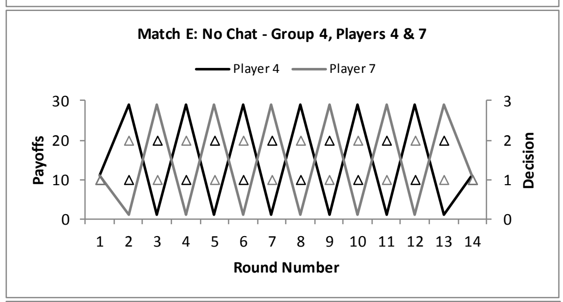


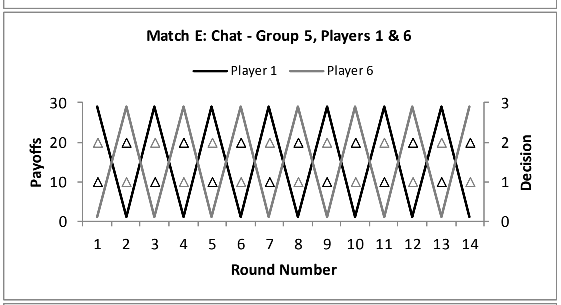


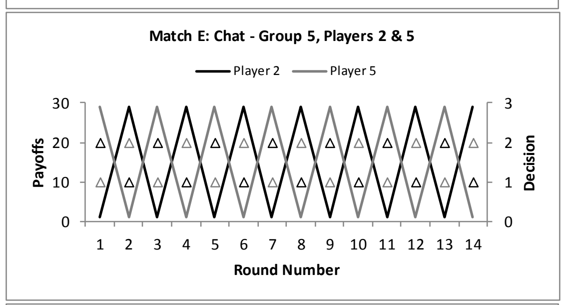


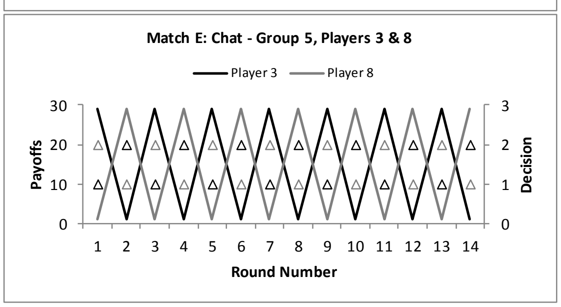


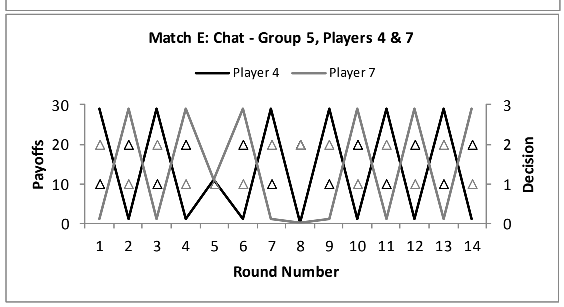




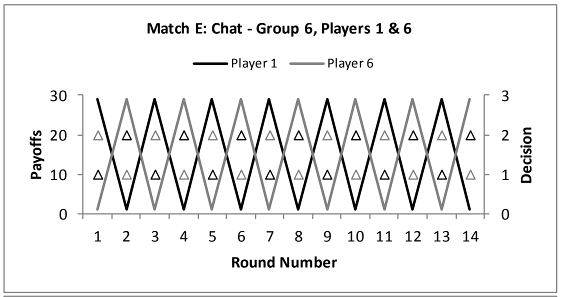


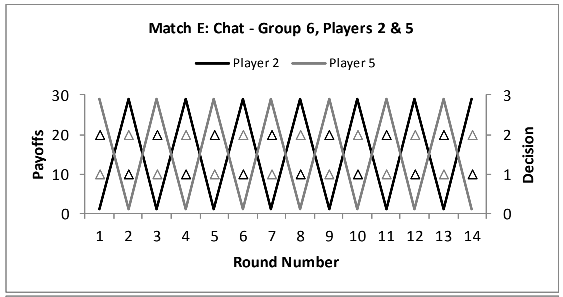


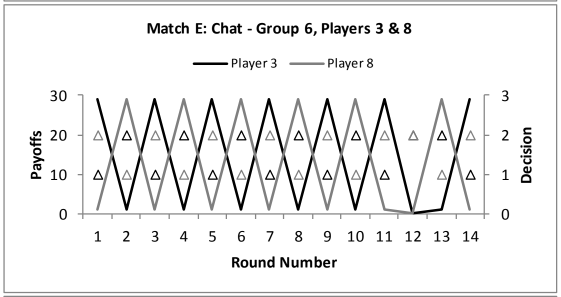


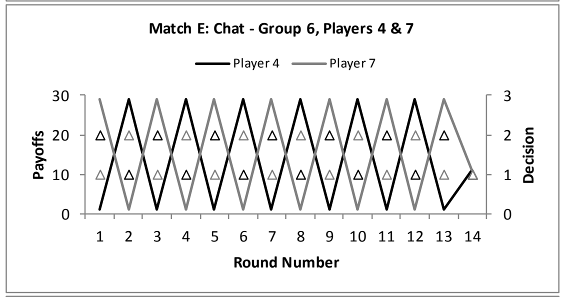


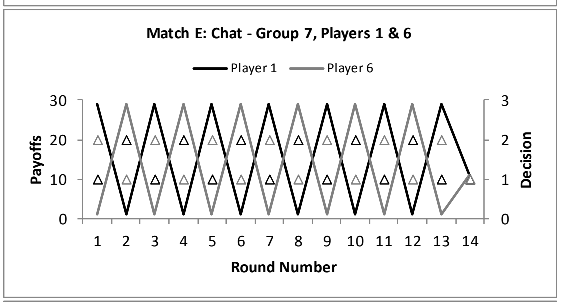
Repeated Matching: Fifth match (E)

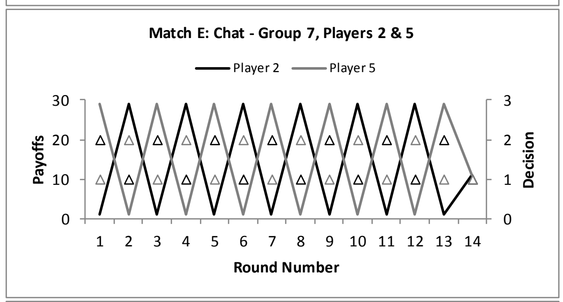


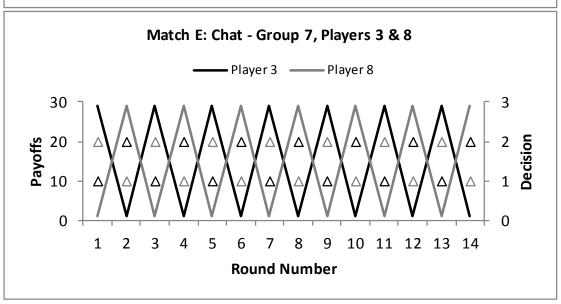


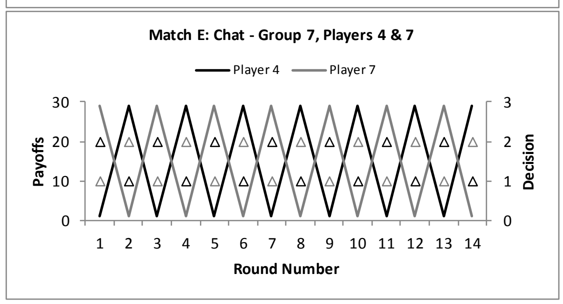




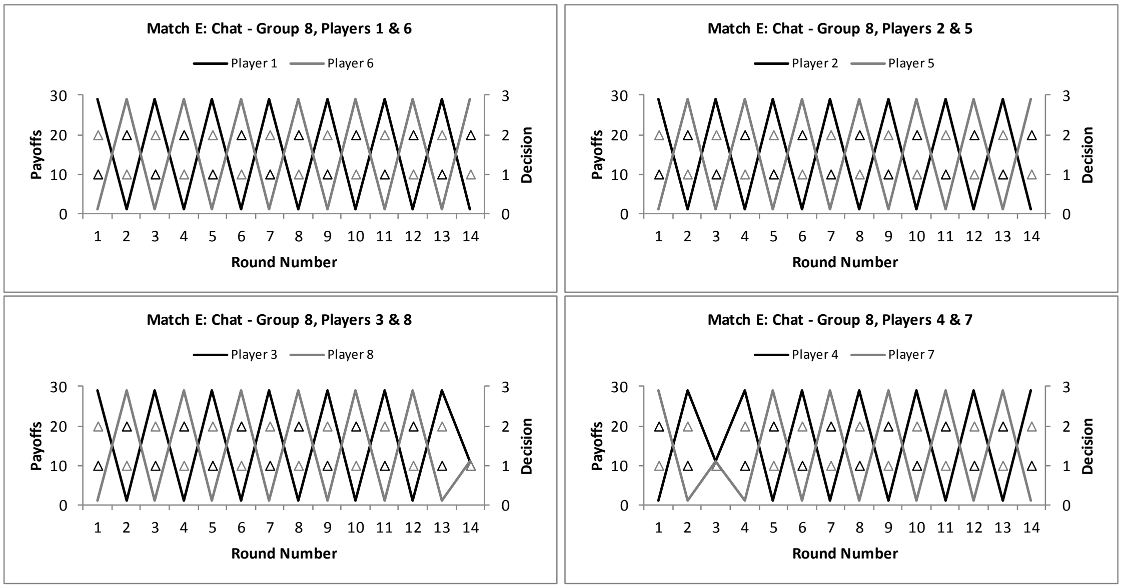








Repeated Matching: Fifth match (E)



E Instructions

Instruction File

About this Experiment

If you follow the instructions and make sound decisions based on the information you are provided with, you may earn money that will be paid to you in cash at the end of the session.

What to do:

1. **Read through the instructions carefully.**
2. **After reading the instructions, you will be taken to a short quiz that will test your comprehension of the instructions.**
3. **Correctly answering ALL of the quiz questions will give you a unique password that you can use to login to the experiment.**

Overview of this experiment

This experiment is concerned with the way people make decisions.

To begin:

- You can choose between two options.
- You are paired with another player.
- Your payoff depends on your choice and that of your paired player.
- There will be a number of independent rounds.

Experimental Rules

You are being paid to participate in this experiment. Failure to comply with these rules will result in the forfeiture of earnings from this session and you will not be allowed to participate in future sessions.

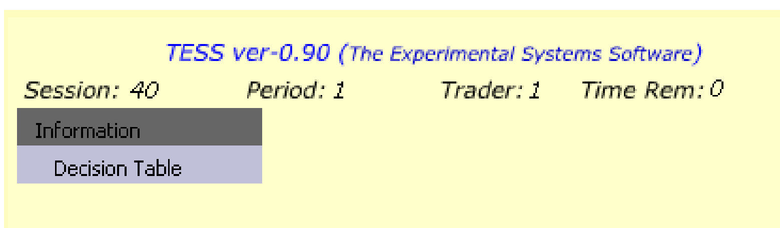
1. **Talking is not permitted during the experiment: You must not share *any* information with others during the experiment**
2. **Only the experiment windows are permitted to be open during the experiment: You are not permitted to operate other software such as email or internet during the experiment**
3. **You may ask questions of the instructor during the experiment**

Instructors can answer questions about procedures but cannot provide you with advice about decisions or trading. You must make decisions and develop strategies by yourself.

At the Start

Once you have successfully completed the quiz, you will be taken the login screen where you will enter your Player Number (provided to you by the instructor) and Password (obtained when you successfully complete the quiz).

Once you have entered your Player Number and Password you will see the following screen:



By clicking on the "information" tab you can access information about your choices. You can choose from the following menu selections:

- **Decision Table** This table provides you with information on the payoffs from each set of decisions you and your partner make.

Decision Table

Clicking on the "DECISION TABLE" information tab will show you the payments that you and your paired player receive as a result of the decisions you and your paired player make in each round. The payments are measured in experimental dollars. Each experimental dollar is worth AUD $0.06.

You will be assigned the role of either player A or B for the duration of the experiment. Your decision will be to choose either option A1 or A2 if you are player A, or option B1 or B2 if you are player B. The payment in the particular round to player B is the first number in each cell in the decision table and the payment to player A is the second number in each cell.

Decision Table: Session: 40 Player: A

Total player's income $10		
	A1	A2
B1	0,0	20,10
B2	10,20	0,0

Round	Your Decision	Their Decision	Payoff

EXAMPLES ONLY:

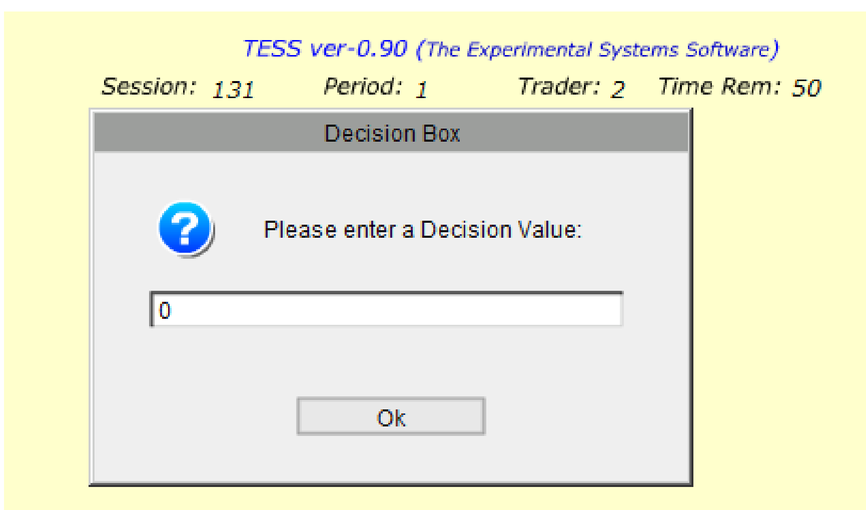
Example 1:
If Player A chooses A2 and Player B chooses B1 then Player A earns 10 experimental dollars and Player B earns 20 experimental dollars.

Example 2:
If Player A chooses A1 and Player B chooses B1 then Player A earns 0 experimental dollars and Player B earns 0 experimental dollars.

Procedure

Step 1 – Making a decision

For each round in the experiment, you will be asked to enter a decision. In order to make a decision, you must enter an appropriate value in the decision box. Enter a value of "1" for decision #1 (A1 or B1 depending on your role) or a value of "2" for decision #2 (A2 or B2 depending on your role). You will have 30 seconds to make a decision.



Step 2 – Review decisions and income earnings

On the conclusion of the decision period, your decision table will be updated with a summary of your decision, the decision of your paired player and your payment for that round.

Step 3 - Repeat of Steps 1-2

Thirty (30) rounds with the procedure described above will be conducted. EACH ROUND IS INDEPENDENT. Decisions are only valid in the current round. The decision table will be the same in each round.

Step 4 – Conclusion of experiment

IMPORTANT: At the conclusion of the experiment you will be paid in cash the sum of the income you earned each round in addition to the turn up fee of AUD $10.

Before you start the quiz

You are being paid to participate in this experiment. Failure to comply with these rules will result in the forfeiture of earnings from this session and you will not be allowed to participate in future sessions.

1. ***Talking is not permitted during the experiment: You must not share any information with others during the experiment***
2. ***Only the experiment windows are permitted to be open during the experiment: You are not permitted to operate other software such as email or internet during the experiment***
3. ***You may ask questions of the instructor during the experiment***

Instructors can answer questions about procedures but cannot provide you with advice about decisions or trading. You must make decisions and develop strategies by yourself.

Now that you have read the instructions – please click on the quiz located on your desktop.

Quiz

When all of your answers are correct, you will receive your password for the experiment.

The quiz uses the following decision table

Decision Table: Session: 40 Player: A

Total player's income $10		
	A1	A2
B1	0,0	20,10
B2	10,20	0,0

Round	Your Decision	Their Decision	Payoff

Question 1 Which of the following is true:

A. The player assigned role A can choose between B1 and B2 as they see fit.

B. The player assigned role A must choose A2.

C. The player assigned role B can choose B1 or B2 as they see fit.

Your answer:

Question 2 Which of the following is true:

A. The player assigned role A must choose A1 if they chose A1 in the previous round.

B. The player assigned role A must choose A2 if they chose A1 in the previous round.

C. The player assigned role B can choose B1 or B2 as they see fit, irrespective of what action they chose in the previous round.

Your answer:

Question 3 If the player assigned role A chooses A1 in the 7th round and the player assigned role B chooses B2 in the 7th round then:

A. the payment from the decision period in the 7th round is:
(i). 20 experimental dollars to player A,
(ii). 10 experimental dollars to player B.

B. the payment from the decision period in the 7th round is:
(i). 20 experimental dollars to player B,
(ii). 10 experimental dollars to player A.

C. the payment from the decision period in the 7th round is:
(i). 0 experimental dollars to player B,
(ii). 0 experimental dollars to player A.

Your answer:

Question 4 If the player assigned role A chooses A2 in the 15th round and the player assigned role B chooses B2 in the 15th round then:

A. the payment from the decision period in the 15th round is:
(i). 20 experimental dollars to player A,
(ii). 10 experimental dollars to player B.

B. the payment from the decision period in the 15th round is:
(i). 20 experimental dollars to player B,
(ii). 10 experimental dollars to player A.

C. the payment from the decision period in the 15th round is:
(i). 0 experimental dollars to player B,
(ii). 0 experimental dollars to player A.

Your answer:

Question 5 The experiment consists of:

A. 15 rounds, each with an identical decision table.
B. 30 rounds, each with an identical decision table.
C. 30 rounds, each with differing decision tables.

Your answer:

When you have all the answers correct, the session manager will give you a unique password

Once you have your password, click on the experimental icon on your desktop

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