Voting Procedures as Instruments for Active Learning in Game Theory Classes: An Experimental Approach

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Abstract: In this Journal, Do and Merz (2007, 74) conveyed that “Introducing real-life voting games into the classroom applies concepts, demonstrates the significance of adopted voting procedures and generates valuable discussion related to the rules of the game…” This paper presents a collective-action experiment comprising two treatments both of which are discussed in Do and Merz (2007): the first mover alternating in an engaged windshield wiper fashion and each player having the same probability of moving first. The experiment is an instrument for integrating strategic elements of repeatedly-played, sequential games into an undergraduate game theory course.

“Order of Vote: The names shall be called in alphabetical order or reversed alphabetical order depending upon a flip of a coin by the clerk, who shall thereafter alternate the order for all further election ballots during the same meeting.”—City of Boulder City Council Agenda Item http://www.bouldercolorado.gov/files/Clerk/Agendas/2010/Mar_31/2A.pdf (last accessed 03/26/2012)

Introduction

This paper presents an experiment prompted by Do and Merz’s (2007) recommendation for using voting procedures adopted by local governments as instruments for active learning in a game theory course. Three subjects repeatedly play a collective-action game requiring a majority of players to approve an action that each player prefers not to support if it otherwise gains approval from other players. One treatment focuses on whether an order of play having the first mover alternating in an engaged windshield wiper fashion (Do and Merz, 2007) poses a strategic disadvantage to the second mover who is “stuck in the middle.” In another treatment, each session has the same three players having the same probability of moving first in each round of play.
We begin with a collective-action game followed by descriptions of the two treatments and the experimental design. The pedagogical discussion centers on classroom logistics involving empirical questions and answers drawn from the experiment. A brief concluding section underscores the attention placed on the order of play and cooperative outcomes within the context described by Do and Merz (2007).

**Collective Action**

The collective-action game (Ordeshook, 1986) requires at least two of three players to vote Yes to approve an action. Player i \((i = 1, 2, 3)\) receives one of four possible payoffs \((\pi_i)\):

\[
w > x > y > z,\]

depending on whether she votes Yes or No and the number \((n)\) of other players choosing Yes:

If Player i votes Yes,

\[
\pi_i = z, \text{ if } n = 0 \\
= x, \text{ if } n = 1 \text{ or } 2.
\]

If Player i votes No,

\[
\pi_i = y, \text{ if } n = 0 \text{ or } 1 \\
= w, \text{ if } n = 2.
\]

Player i’s most preferred outcome is No while the other two players vote Yes. If players vote sequentially with perfect information, predicting how each will vote in a one-shot game is intuitively simple: the first mover chooses No while each of the subsequent two movers choose Yes. There is a first-mover advantage with the first mover “free riding” on the choices of the other players. Thus, when playing a one-shot game, a player is likely to applaud or bemoan when she chooses: “One can envision each member jockeying for an opportunity to vote first. Having a rotating or randomly determined voting order may be the only way to prevent discontent from brewing among council members (Do and Merz, 2007, 66).” Rotating and brewing are symptomatic of repeated play and the expanded strategy
space of repeated play provides an opportunity for reciprocity whereupon “… individuals tend to react to the positive actions of others with positive responses and the negative actions of others with negative responses (Ostrom, 1998, 10).”

**Order of Play**

The experiment addresses strategic elements surrounding the order of play in a game whose rules result in a strategic advantage to a player if the game were played only once. In one treatment, each session has subjects playing multiple rounds under a sequential order of play resembling an engaged windshield wiper (WW): three players are seated along a dais with the roll call taken from left-to-right in the initial round then from right-to-left in the second round and then alternating in the same pattern for multiple rounds. The middle player is never afforded the opportunity to move first.¹

In another treatment, each of the three players has the same probability of moving first in each round of play. The predicted expected payoff over an entire sequence of random (RD) play is the same for each player even though, in any given round, theoretically one player always has a first-mover advantage. Whether windshield wiper, a procedure that, at first glance may appear to be unfair, yields behaviors different from those observed under what many would view as a fair procedure (random) is an empirical question addressed in the experiment.²

¹ This situation brings to mind the 1972 Stealerswheel lyrics: “Clowns to the left of me, jokers to the right, here I am, stuck in the middle…” An order of play alternating alphabetically from, say, A-to-Z, Z-to-A, A-to-Z and so on also results in having a player stuck in the middle.

² Students in an introductory game theory course often learn a connection between behaviors and fairness from ultimatum games where responders are more likely to accept relatively small offers generated by a random device (Camerer, 2003) suggesting that inequality is more tolerable when the process generating the offer is viewed as being impartial.
Experimental Design

Subjects were university undergraduates with little or no game playing experience. None of the subjects had completed, nor were they enrolled in, a game theory course at the time of the experiment. Ten sessions (5 per treatment) were conducted, each of which began with one experimenter going over the instruction sheet (found in the Appendix). Each session consisted of three different players playing multiple rounds and players were never informed of how many rounds would be played in a session and thus they were unaware when play would end. To avoid end-of-game effects, play was terminated when there was time remaining in the session and at least 30 rounds were completed. Each of the 30 subjects was paid an $8 appearance fee prior to participating. Player i’s payoffs for each of the four possible outcomes were: \( w = 2 \), \( x = 1 \), \( y = 0 \), and \( z = -1 \).

To prevent communication, players sat along a table out of sight of each other while occupying separate carrels. Players were given Blue (No) and Red (Yes) cards. No reference was made to actual voting games by public bodies so as not to bias the players by evoking beliefs of civic responsibility. In each round, a player indicated her choice by sliding a Red or Blue card under the front of the carrel. Players were informed that their choices would be publically posted when each player’s choice was made.

At the outset of each session, players were informed that the order of play to be used throughout the session would resemble either an engaged windshield wiper or be determined randomly. A player knew it was her turn to play when an experimenter appeared in front of her carrel, at which time he requested that the player submit a card. When the experimenter retrieved a player’s card, he publicly announced the choice of that player. Thus, a player knew the choices of all earlier players in that round prior to making her choice. The history of play in previous rounds was publicly displayed.

3 We saw no evidence that the number of rounds completed produced an attention-drift (boredom) effect.
Subjects were given opportunities to ask questions about the written instructions as well as the verbal instructions related to the order of play. Questions were rarely asked, which suggests an understanding of the rules of the game.

Suppose the players’ seating arrangement was Smith, Jones and Adams. In the verbal instructions, with WW, the players were told that the first mover would alternate between Smith and Adams and that play would proceed in a windshield-wiper fashion. Jones is stuck in the middle since the orders of play were restricted to [Smith, Jones, Adams] and [Adams, Jones, Smith]. With RD, a toss of a 6-sided die determined the order of play. If the die revealed dots totaling: 1 or 2, Smith moved first and Jones second; 3 or 4, Jones moved first and Adams second; otherwise Adams moved first and Smith second. Thus, each player had a 1/3 probability of choosing first. Since the second mover was not chosen randomly, there were three, rather than six, possible orders of play: [Smith, Jones, Adams], [Jones, Adams, Smith], and [Adams, Smith, Jones].

Sessions averaged 45 minutes. Early in the academic term, subjects could be chosen from students enrolled in a game theory class. Results could then be discussed later in the term. Conducting the experiment during class is not recommended due to potential distractions from the audience.4

Classroom Logistics

Students in a game theory class are provided the experiment’s instruction sheet along with a verbal explanation of each treatment. Students are informed that the unique subgame-perfect equilibrium [No, Yes, Yes] is the equilibrium only to the one-shot, 3-player game. When playing multiple rounds with the same players and the history of play is public

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4 Alternatively, the experiment could be conducted with students spending class time in a computer lab. Software for conducting experiments can be found at http://people.virginia.edu/~cah2k/programs.html and http://www.economicsnetwork.ac.uk/teaching/Software/Experimental%20Economics.
information, repeated play provides an opportunity for reputation building and cooperation among the players resulting in a sharing of the free-rider payoff.

Classroom dialogue generates empirical questions: Do the frequency rates of maximum, per round, group payoff of $4 vary across treatments—(answered in Exhibit 1 below)? Do the frequency rates of the first mover free riding vary across treatments—(answered in Exhibits 2 and 3 below)?

Since each player knew the history of previous rounds of choices made by other players with whom she was permanently matched, many students quickly recognize that opportunities existed for signaling gratitude and resentment. For example, Player 1 chooses Blue followed by Player 2 choosing Blue. By doing so, Player 2 deprives the first mover the opportunity to free ride. This blocking strategy could be interpreted by other players as signaling resentment on the part of Player 2. Paraphrasing Falk and Fischbacher (2006, 310):

Player 2 compares the actual choice of the first mover with the alternative choice the first mover could have chosen. The first mover’s choice of Blue is considered unkind by Player 2 not because it leaves Player 2 with less than the first mover gets, but because the first mover by choosing Red provides Player 2 an opportunity to receive a higher payoff.

Do the frequency rates of blocking by the second mover vary across treatments—(answered in Exhibit 4 below)?

The third mover might view blocking by the second mover as foolish or vindictive. In the current round, if the first and second movers choose Blue, the payoff to the blocking player is independent of what the third mover does. However, in a subsequent round, if the first and second movers play Red and Blue respectively, by choosing Blue the third mover denies the second mover the free-rider payoff. Effectively, the third mover can punish the
second mover for a prior deviation from the equilibrium in the one-shot game. Such punishment might explain the outcome [Yes, No, No]. Do the frequency rates of [Yes, No, No] vary across treatments—(answered in Exhibit 5 below)?

The transition from empirical questions to answers is facilitated through Table 1 providing the descriptive statistics for WW (Sessions I-V) and RD (Sessions VI-X). The first 8 rows of the second column indicate choices for each of the 8 possible orders of play under WW and RD. For example, RBR indicates the first mover played Red, the second Blue and the third Red. Under WW, this outcome occurred 17 times in Session II, which consisted of 40 rounds of play. Outcomes BRR, RBR and RRB are cooperative behaviors resulting in the maximum group payoff of $4. We see that, in Session II, 85% (34/40) of the WW rounds

With the seating arrangement [Smith, Jones, Adams], under WW subsequently either Smith or Adams when moving third can punish Jones for a prior deviation from the equilibrium in a one-shot game. With RD, the order of voting is restricted to [Smith, Jones, Adams], [Jones, Adams, Smith], and [Adams, Smith Jones] and punishing a given second mover for prior deviations from the one-shot equilibrium is reserved to a single third mover. This restriction would be eliminated if the order of play, not just the first mover, were randomize under RD.

The data set of subjects’ choices is available from the authors.

Rapoport (1997) reported results from one-shot, step-level public goods experiments under a positional order protocol: players moved in a prescribed order with their choices unobservable to other players. The public good was provided if at least a simple majority of players contributed (chose Red). The order of play resembled an engaged windshield wiper: a player was assigned the serial position j (j = 1, 2, 3, 4, 5, 6, 7) in one game and then reassigned to position 8 – j in another game. If a player chose as though she was playing a sequential game with perfect information, she would always choose Blue when occupying positions 1, 2 or 3. Overall, 18% of the players in positions 1, 2 and 3 and 38% of the players in positions 5, 6 and 7 chose Red. Rapoport (1997, 127) conjectured that these results were “…due to characteristics of the public goods game and the complexity of the design.”

Gächter et.al (2008) found that punishment leads to cooperation and higher group average payoffs in public goods experiments; Chaudhuri (2011) surveys this literature.
resulted in cooperative behaviors. Under RD, subjects in Session IX had a cooperative rate of 100%, where an equal distribution of the payoffs would have resulted in Player i receiving the $2 payoff in approximately 13 of the 40 rounds. In fact, the distribution of the $2 payoff in Session IX ranged from a high of 16 rounds to one player to a low of 11 rounds to another player.

The mean payoffs per player per round varied considerably within treatments and across treatments. They ranged from a high of $1.33 under RD (Session IX) to a low of $0.37 under WW (Session III). The nonparametric robust rank-order test (Siegel and Castellan, 1988) was used to test for significant differences in means of the two (RD and WW) populations reported in the last five rows of Table 1 (see Exhibits 1-5). Results are summarized as:  

- The player stuck in the middle was not strategically disadvantaged and there was no significant difference in the rates of cooperative outcomes between RD and WW (Exhibit 1).
- The Nash equilibrium outcome of the one-shot game was more prevalent under RD than WW and the mean rates at which the first mover chose Blue were significantly higher under RD than WW (Exhibit 2). Because the Nash equilibrium was more prevalent under RD, the rate at which Blue was played by the second mover was significantly higher under WW than RD (Exhibit 3).

Where statistical significance was lacking, it may be due to small sample sizes. Dependency among rounds is the essence of repetitive play with the same subjects and dependency does not necessarily exclude the possibility of the appearance of a random process determining choices. Runs tests were conducted examining the pattern of cooperative rates within each session. Session IX was a case of only one run, while only session VIII was found to be significantly non-random.
The mean blocking rates of the second mover were not significantly different between the two treatments (Exhibit 4).

Some choices of the third mover resembled a spoilsport reminiscent of author Gore Vidal’s remark: “It is not enough to succeed. Others must fail (Pinker, 1997, 390).” (Exhibit 5)

Other topics are pertinent. Experience might affect cooperative behavior. We compared the first twelve and last twelve rounds of each session within a treatment. Pairing these earlier and later rounds, the Wilcoxon matched-pairs signed-ranks test disclosed no significant experience effect on cooperative behavior for each of the two treatments.

The two treatments involved sequential moves with perfect information. The other polar case of information, simultaneous play, could be a treatment. If players choose without observing the other players’ choices (and with no other method available for coordination) until a round is completed, it is more problematic that repeated play will cause a coordination of choices resulting in the sharing of the free-rider payoff. With simultaneous play, multiple pure strategy equilibria and mixed strategy equilibrium enter the classroom dialogue.9

(Results from a treatment with simultaneous play are available from the authors.)

Finally, the experiment excluded the possibility of some subjects being more informed than others when choosing. Including uncertainty inherent within the information structure would add the possibility of testing for information cascades (Hung and Plott, 2001). Drawing attention to the role of voter information conditions in binary-choice voting games (Dasgupta et al., 2008) would apprise students of complexities not addressed here.

9 Legislative bodies are often confronted with the issue of adopting either a sequential or simultaneous voting procedure. Switching from the former to the latter “removes the stigma associated with the first or last to vote as well as the identification of the tie breaker while having an individual's decision being privately initiated with no inference of influence (http://www.electrovote.com/ElectroVote/general.htm, last accessed 03/28/12).”
Conclusions

This paper presented an experiment examining how the order of play affected behaviors in a repeatedly-played, collective-action game. The practicality of the windshield wiper and random treatments is easily conveyed to students:

“On roll call votes, each councilmember is polled individually for his vote. Many councils are polled in the same order on each roll call, whether this is by alphabetical order or by seating arrangement. However, this can place the first councilmember to vote each time in a difficult position and give the last councilmember an unfair advantage in always knowing what effect his vote will have on the motion. To counteract this problem, some councils have worked out systems of alternating the voting order. In some cases the order is alternated with each meeting, with each roll call at one meeting being taken in the same order. Other councils will vary the roll call with each vote, moving the top man to the bottom and all other names up one space. Occasionally, the person taking the roll is instructed to call names in random order with each vote.”

In this context, it is recommended that students be made aware that cooperative outcomes should be viewed positively in a limited sense since “successful cooperation need not promote the social interest” (McMillan, 1992, 30). Just as higher profits to sellers from cooperation might not benefit buyers, the coordination of choices by public officials might

\[ \text{Conduct of Council Meetings, the Missouri Municipal League (undated).} \]

http://www.mocities.com/documents/ConductOfCouncilMeetingsJul00.pdf (last accessed 05/08/10, web page no longer available. Technical Bulletins are now available for Missouri Municipal League members at http://www.mocities.com/Login.aspx and for nonmembers at a nominal fee.)
not benefit constituents. Moreover, the results are not informative with respect to the reality of legislative bodies playing a sequence of different games under a fixed treatment or logrolling by members prior to voting. Nevertheless, we ascertained that integrating the experiment into the classroom heightens students’ participation while producing an improved understanding of strategic behavior.
Table 1
Descriptive statistics by session for windshield wiper and random play

<table>
<thead>
<tr>
<th>Windshield Wiper (WW)</th>
<th>Sub Total</th>
<th>Random (RD)</th>
<th>Sub Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I II III IV V</td>
<td></td>
<td>VI VII VIII IX X</td>
<td></td>
</tr>
<tr>
<td>3 Reds</td>
<td>RRR</td>
<td>0 0 2 1 0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>BRR</td>
<td>1 16 0 1 25</td>
<td>43</td>
</tr>
<tr>
<td>2 Reds</td>
<td>RBR</td>
<td>8 17 1 12 11</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>RRB</td>
<td>7 1 10 4 0</td>
<td>22</td>
</tr>
<tr>
<td>1 Red</td>
<td>RBB</td>
<td>3 0 6 6 0 15</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>BRB</td>
<td>0 0 0 2 0 2</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>BBR</td>
<td>0 0 0 0 1 1</td>
<td>1</td>
</tr>
<tr>
<td>0 Red</td>
<td>BBB</td>
<td>16 6 21 14 3</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>35 40 40 40 40</td>
<td>195</td>
</tr>
</tbody>
</table>

| Mean Payoff Per Player Per Round |           | 0.58 | 1.13 | 0.37 | 0.53 | 1.19 | 0.76 | 0.57 | 1.10 | 0.57 | 1.33 | 0.70 | 0.86 |
| Coefficient Rate*            |           | 45.7 | 85.0 | 27.5 | 42.5 | 90.0 | 58.5 | 50.0 | 83.3 | 44.4 | 100  | 55.0 | 67.0 |
| Blue Rate of First Mover      |           | 48.6 | 55.0 | 52.5 | 42.5 | 72.5 | 54.3 | 61.1 | 72.2 | 58.3 | 95.0 | 85.0 | 75.0 |
| Blue Rate of Second Mover     |           | 77.1 | 57.5 | 70.0 | 80.0 | 37.5 | 64.1 | 55.5 | 41.7 | 47.2 | 2.50 | 42.5 | 37.2 |
| Blocking Rate of Second Mover |           | 45.7 | 15.0 | 52.5 | 35.0 | 10.0 | 31.3 | 27.8 | 13.9 | 19.4 | 0    | 35.0 | 19.1 |
| Spoilsport Rate of Third Mover|           | 0.25 | 0    | 0.87 | 0.38 | 0    | 0.30 | 0.36 | 0.03 | 0.42 | 0    | 0.17 | 0.20 |

*a*Equals (BRR + RBR + RRB) divided by the total number of rounds in a session.

*b*Equals the number of times the first mover choosing Blue is denied the opportunity to realize the $2 payoff due to the second mover choosing Blue (BBR + BBB) divided by the total number of rounds in a session.

*c*Equals the number of times the third mover prevents another player from realizing the $2 payoff (RBB + BRB) divided by the total number of preventative opportunities (RBB + BRB + RBR + BRR).
Exhibit 1: Cooperative Behaviors

**Dialogue:** A player “stuck in the middle” might be strategically disadvantaged and therefore might display intolerance by deviating from the one-shot game Nash equilibrium.

**Question:** Was the player stuck in the middle strategically disadvantaged relative to the egalitarian pattern of a player receiving the $2 payoff in 33% of the cooperative rounds?

**Answer:** No. Overall, WW resulted in 114 cooperative behaviors of which 49 (43%) had the second-mover realizing the $2 payoff.

**Question:** Was the frequency of cooperative behaviors greater under RD?

**Answer:** Yes; 67% (RD) > 58.5% (WW).

**Question:** Were the mean cooperative rates for the two populations different?

**Answer:** No significant difference (test statistic $U = 0.669$, $\alpha = 10\%$).

Exhibit 2: Play of the First Mover

**Dialogue:** With RD, since each player had an equal opportunity to move first, one might reasonably expect that players would tend to treat each round as a one-shot game resulting in BRR being prevalent. With WW, sharing of the $2 payoff required the first mover periodically to refrain from choosing Blue.

**Question:** Was BRR more prevalent under RD?

**Answer:** Yes, Overall, BRR occurred in 47.8% (90/188) of the RD rounds and 22% (43/195) of the WW rounds.

**Question:** Overall, was the first mover’s Blue rate greater under RD than under WW?

**Answer:** Yes; 75% (141/188) for RD and 54.3% (106/195) for WW.

**Question:** Were the mean Blue rates of the first mover for the two populations different?

**Answer:** Yes, first mover Blue rates were significantly higher under RD than WW (test statistic $U = 2.859$, $\alpha = 2.5\%$).
Exhibit 3: Play of the Second Mover

Dialogue: Because BRR was expected to dominate in RD, we similarly anticipated that the rate at which the second mover played Blue would be less for RD than WW.

Question: Did the second mover chose Blue less frequently under RD?

Answer: Yes, the mean frequency of the second mover choosing Blue was 64.1% (125/195) for WW and 37.2% (70/188) for RD.

Question: Were the mean Blue rates of the second mover for the two populations different?

Answer: Yes, Blue rates by the second mover were significantly lower under RD than WW (test statistic $\hat{U} = 2.064$, for $\alpha = 5\%$).

Exhibit 4: Blocking by the Second Mover

Dialogue: Blocking in WW by the second mover could serve as a signal to the other players to share in the $2$ payoff. With RD, players could reasonably view each round as a one-shot game providing no incentive for the second mover to choose Blue.

Question: Was the mean blocking rate for RD less than the mean rate for WW?

Answer: Yes; 19.1% (RD) < 31.3% (WW)

Question: Were the mean blocking rates for the two populations different?

Answer: No significant difference (test statistic $\hat{U} = 1.037$, $\alpha = 10\%$).
Exhibit 5: Spoilsport Play by the Third Mover

Dialogue: Across WW and RD the first and second mover choices of RB and BR occurred 248 times. These represented opportunities for the third player to be a spoilsport by choosing B thereby penalizing the other players $2 each in addition to penalizing herself $1. Overall the third mover chose to do so on 40 occasions.

Question: Was the overall mean spoilsport rate higher for WW?
Answer: Yes; 30% (WW), 20% (RD).

Question: Were the mean spoilsport rates for the two populations different?
Answer: No significant difference (test statistic $U = 0.094, \alpha = 10\%$).

Question: What might explain spoilsport outcomes RBB and BRB?
Answer: Possibilities include: mistakes by the third mover; retaliation by the third mover; and sinisterness—for the third mover, winning might have meant having others lose.
Appendix

Instructions

You are about to participate in game playing with 2 other players. You have already earned $8.00 for showing up at the appointed time and place. The instructions are simple and, if you follow them, you may earn additional money or you may lose money, but you are guaranteed to leave the session with a positive amount of dollars.

In this session you will be playing multiple decision rounds. In each round, you will be asked to make a choice to play either RED or BLUE. You have been given 2 stacks of white cards. One stack contains cards with a BLUE dot; the other stack contains cards with a RED dot. Each card also contains your randomly determined unique subject number. You were randomly assigned to the seat that you occupy.

You play RED by sliding a RED dot card under the front of your carrel. You play BLUE by sliding a BLUE dot card under the front your carrel. In each round, do NOT slide a card until you are instructed to do so. MAKE SURE YOU SLIDE YOUR CARD WITH THE DOT SIDE FACING DOWN.

Your choice (RED or BLUE) and the choices made by the other two players determine your earnings in each round. The possible payoffs in each round are written on the board and are also found in the following table:

<table>
<thead>
<tr>
<th>Number of Players choosing RED</th>
<th>$Payoff to those choosing RED</th>
<th>$Payoff to those choosing BLUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>-1</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

You have received a Record Keeping Sheet. After each round we will publicly display the choices of all three players. At this time, please write your earnings (positive, zero or negative) in the space provided on your Record Keeping Sheet. Please keep accurate records throughout the experiment. It is important that you do not talk to or otherwise communicate with the other players. This includes showing or making signs of joy (or sadness) when the choices are revealed. To determine your final payoff, five (5) of the completed rounds will be chosen randomly at the end of the session. You will be paid in accordance with the payoff outcomes in each of these 5 rounds.
References


