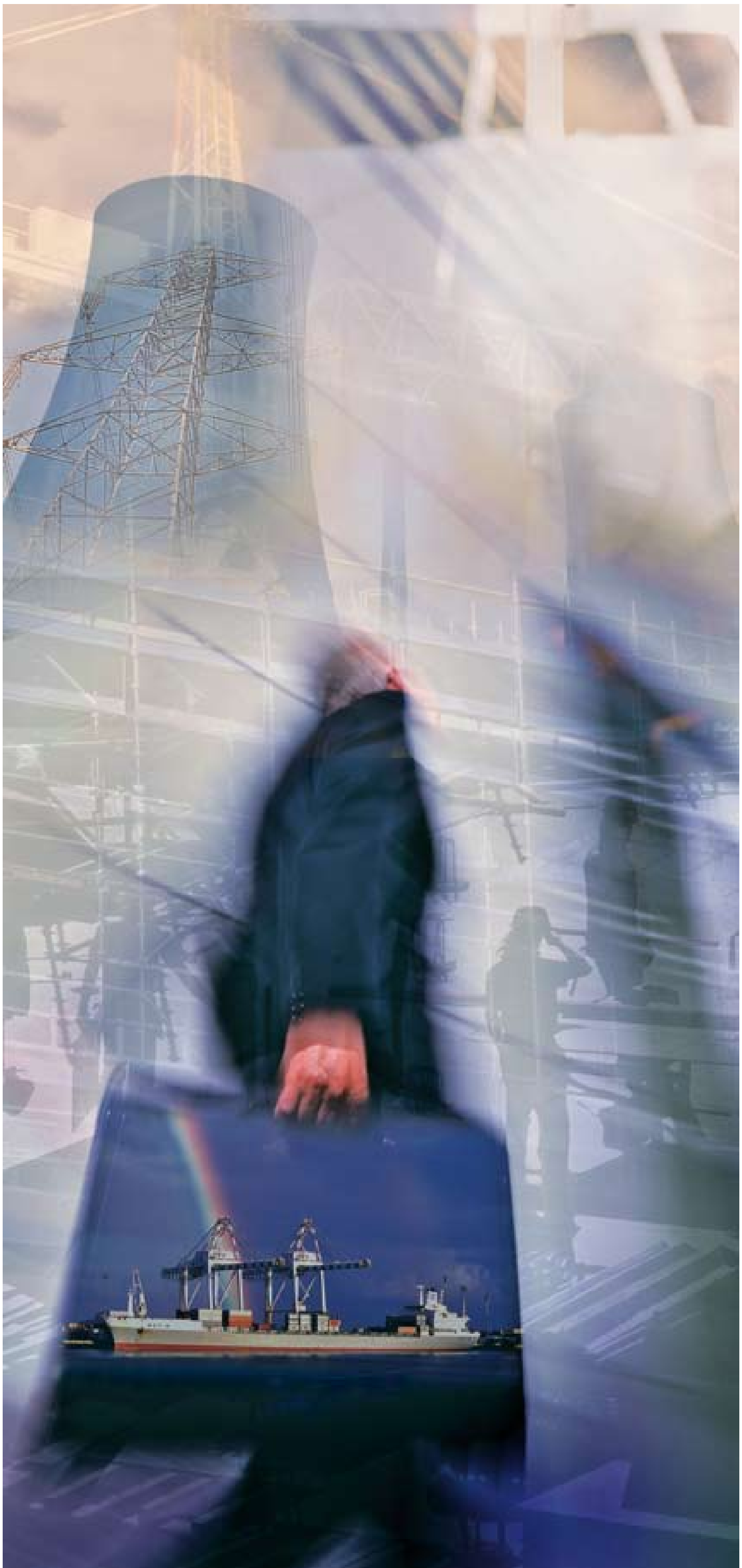

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Welcome

The Economic Society of Australia warmly welcomes you to the Gold Coast, Queensland, Australia for the 37th Australian Conference of Economists.

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GPO Box 1170
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Stuck in the Middle: An Experimental Study on Sharing a Strategic Advantage in a Binary Choice Game

Alan J. Brokaw, Patrick Joyce and Thomas E. Merz*

School of Business and Economics
Michigan Technological University
1400 Townsend Drive
Houghton, Michigan USA 49931-1295

*Merz is the corresponding author: temerz@mtu.edu, Voice 906-487-2805,
Fax 906-487-2944.

Stuck in the Middle: An Experimental Study on Sharing a Strategic Advantage in a Binary Choice Game

Alan J. Brokaw, Patrick Joyce and Thomas E. Merz

Abstract: This paper reports results from experiments on non-cooperative, 3-person, binary-choice, repeated games. With the first mover alternating in a windshield wiper fashion, the unique subgame-perfect equilibrium in a one-shot game never affords the player stuck in the middle the opportunity to free ride. Under the expanded strategy space of repeated play, the player stuck in the middle may adopt a strategy of blocking the first mover from free riding thereby eliciting responses resulting in a sharing of the free-rider payoff. Our experiments (i) indicate that the free-rider payoff was not reserved for the first mover and (ii) shed light on the ramifications of adopted orders of play for a repeated-interaction game applicable to real-life voting by legislators.

Keywords Experiments·Repeated Play·Reciprocity

Stuck in the Middle: An Experimental Study on Sharing a Strategic Advantage in a Binary Choice Game

"Clowns to the left of me,
Jokers to the right, here I am,
Stuck in the middle..."
Stealerswheel lyrics (1972)

1 Introduction

This paper reports results from laboratory experiments on non-cooperative, 3-person, binary-choice games modelled after Ordeshook (1986): a member of a legislature when voting prefers to be in the minority with the motion passing on the favorable votes of the other two members. With roll call (sequential) voting, the predicted play is intuitively simple: the first mover votes no and realizes her most preferred payoff, and the other players receive a lesser payoff. The game exhibits a first-mover advantage with the first mover free riding on the votes of the other players.

This free-rider prediction is a unique equilibrium only in a one-shot game. With repeated play, the adopted order of play could cause discontent among the players. We examine how behaviors respond when the rules prevent one player from ever moving first. Does this "disadvantaged" mover, the one *stuck in the middle*, occasionally vote no to signal her willingness to block the opportunity of the first mover to free ride? Does the first mover ever vote yes to allow the disadvantaged player an opportunity to be the lone no voter? Do behaviors differ when the order of play is randomly determined?

These questions apply to real-life games. Voting rules adopted by municipal governments exhibit a wide diversity in the order of roll call voting. Our experimental findings shed light on ramifications of the adopted order of play within a repeated-interaction game.

In Section 2, we present the binary-choice model and summarize results from related work conducted by other experimenters. Section 3 describes our experimental design and Section 4 presents our findings. We conclude in Section 5.

2 A Binary-Choice Model

Consider a noncooperative n-person, binary (Red or Blue) choice game where n is any odd integer ≥ 3 and $m = \frac{n+1}{2}$ players constitutes a majority of n. Player i receives one of four possible playoffs: a > b > c > d. The dollar payoff to each choice is assumed to be contingent on whether a minimal number, m, of Red choices is realized. In particular, Player i realizes her most preferred payoff, a, when (1) at least m *other* players choose Red and (2) she chooses Blue. As shown in Table 1, if exactly m – 1 other players choose Red, Player i prefers Red; otherwise she prefers Blue.

Erev and Rapoport (1990), Rapoport (1997) and Suleiman (1997) described the binary-choice game in Table 1 as a step-level public goods game, in which a public good is provided if at least m players contribute (Red). Ordeshook (1986) described it as a voting game in which at least m elected officials must vote yes (Red) in order to raise their pay.[1] Player i prefers to "free ride" by choosing Blue when at least m other players choose Red.

Table 1 Possible Payoffs to Player i

	Number of **other** players choosing Red		
Player i's Choice	m - 2	m – 1	m or more
Red	d	b	b
Blue	c	c	a

With simultaneous [SIM] play, players make their choices at the same time. There are $\frac{n!}{m!(n-m)!)}$ pure strategy Nash equilibria with each having m players choosing Red and n – m choosing Blue, any one of which Pareto dominates the other pure strategy Nash equilibrium of n players choosing Blue. Players face a coordination problem. In any pure strategy equilibrium in which different combinations of exactly m players chooses Red, Player i prefers the equilibrium in which she chooses Blue to ones in which she chooses Red.

[1] The idea that a player prefers one outcome but would like to vote in opposition to it is not limited to legislative pay raises.

With n = 3, Table 2 presents the SIM game in normal form (* indicating pure strategy equilibrium) when player 3 plays Red or when she plays Blue.[2]

Table 2 Normal Form of Simultaneous Play

3 Plays Red (R)

1 \ 2	Red	Blue
Red	**b,b,b**	**b,a,b** *
Blue	**a,b,b** *	**c,c,d**

3 Plays Blue (B)

1 \ 2	Red	Blue
Red	**b,b,a** *	**d,c,c**
Blue	**c,d,c**	**c,c,c** *

If the game is played sequentially with previous choices observable [SEQ], players move in a specified order observing the earlier choices. The unique subgame-perfect equilibrium has each of the first n – m players choosing Blue followed by each of the remaining m players choosing Red. For example, when n = 3, the predicted play is [B, R, R]; with n = 5, the predicted play is [B, B, R, R, R] and so on.

Erev and Rapoport (1990) provided results from a 5-player, step-level public goods game experiments. Their first experiment consisted of 15 *one-shot* sequential games with perfect information. The sub-game perfect equilibrium solution occurred in 20% of the games; overall 73% of the choices were consistent with the game-theoretical model. Their second experiment assigned 60 subjects into 12 groups. Each group played 8 different games, 4 SIM and 4 involving sequential choices under varied informational conditions. The sixth game in the 8-game sequence was the same game played in the first experiment. The sub-game perfect equilibrium occurred in 50% of the games; overall 90% of the choices were consistent with the game-theoretical model. Since the outcomes of the eight games were not announced until

[2] Rapoport (1997) used the dollar payoffs a = 6.6, b = 4.4, c = 2.2 and d = 0. The experiments below adopt Ordeshook's (1986) assumed payoffs of a = 2, b = 1, c = 0 and d = -1, which produce a unique mixed strategy equilibrium of choosing Red and Blue 50% of the time with an expected payoff of $0.50.

the end of the experiment, subjects were, in essence, playing a sequence of *one-shot* games.

Below we report results from experiments using three informational protocols (conditions): SIM, SEQ and sequential play with unobservable choices [HYBRID].[3] In SEQ and HYBRID, an order of play is imposed with players knowing their position, j, in the sequence (j = 1, 2, …, n). The difference is that player j knows the choices of players 1, 2, …, j – 1 in SEQ while, in HYBRID, she chooses with no information about the earlier choices of players 1, 2, …, j – 1. The differences in these protocols arise from different treatments of the basic game described by the payoff structure in Table 1: (1) Is there a prescribed serial assignment of play? (2) Does a player observe the choices of earlier players? The differences in the treatments for each of these protocols are shown in Table 3.

Table 3 Protocols and Treatments

Protocol	Treatment	Answer
SIM	1. Is there a prescribed serial assignment of play?	No
	2. Does a player observe the choices of earlier players?	No
HYBRID	1. Is there a prescribed serial assignment of play?	Yes
	2. Does a player observe the choices of earlier players?	No
SEQ	1. Is there a prescribed serial assignment of play?	Yes
	2. Does a player observe the choices of earlier players?	Yes

A claim of game theory (von Neumann and Morgenstern 1947) is that SIM is equivalent to HYBRID; knowing when players choose chronologically is of no value when players are uninformed about previous choices. Camerer (2003) summarizes experimental studies involving *one-shot*, battle-of-the-sexes games that cast doubt on this claim. In coordination games in which players prefer a different pure strategy equilibrium, simply informing players of the timing of choices, with later-choosing players not knowing choices of earlier players, alters behavior toward the subgame-perfect equilibrium when previous choices are observable. "…players tend to coordinate on the first-mover's preferred outcome, so there is a tacit—almost telepathic—first-mover advantage (Camerer, 2003, p.367)."[4] If timing matters as

[3] Weber et al. (2004) examined timing effects in 3-person, weak link coordination games. Each 3-player group participated in one of the three protocols.

[4] Weber et al. (2004) examined timing effects in a 3-player stag hunt game in which all players have identical payoffs in all pure strategy Nash equilibria, one of which unanimously Pareto dominates all other equilibria . When players move sequentially with observable movers, the unique subgame-perfect equilibrium is independent of which player chooses earlier: "…, designating one player as the "first mover" does not make one equilibrium focal simply by making that player salient and highlighting that

Camerer asserts, then HYBRID will be more like SEQ than SIM. Players choosing later in the sequence will anticipate that the earlier n – m players will each choose Blue. Expecting this, each of the remaining m players choose Red.

Rapoport (1997) reported experimental results from *one-shot*, step-level public goods games using the HYBRID protocol.[5] A player is assigned the serial position j (j = 1, 2, 3, 5, 6, 7) in one game and then reassigned to position 8 – j in another game. If a player chooses as though HYBRID is the same as SEQ, then she will *always* choose Blue when occupying positions 1, 2 or 3. Rapoport's experimental results rejected this hypothesis. 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 his finding of only a minority of players realizing a first-mover advantage, when players moved in a prescribed order, with their movers unobservable to other players, is "…due to characteristics of the public goods game and the complexity of the design."

Interestingly, some public bodies have adopted a roll call voting procedure similar to Rapoport's serial assignment procedure. Visualize n elected members of a public body occupying seats on a dais. When called upon, each must publicly cast either a Blue (No) or Red (Yes) vote. Rules state that on the first vote, the roll will be taken from left-to-right; on the second vote, from right-to-left, and alternating in the same pattern for multiple rounds. Do and Merz (2007) labeled this system the "windshield wiper" procedure. As in Rapoport (1997), if a player was assigned position j (j = 1, 2, …, n) in the previous round of play, she will be assigned to position (n + 1) – j in the next round. With n being any odd integer ≥ 3, the unique sub-game perfect equilibrium never affords the player *stuck in the middle* (the median voter) the opportunity to "free ride." She and all who follow choose Red, while all those preceding the median player choose Blue.

The unique subgame-perfect equilibrium [B, R, R] is only the equilibrium to the one-shot, 3-player SEQ game. Since members of public bodies play multiple rounds with the same players and the history of play is public information, repeated play provides an opportunity for reputation building and cooperation among the players.

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player's preferred equilibrium (p. 30)." Their experimental results found that HYBRID choices were more consistent with SEQ choices than with SIM choices. This "pure timing" effect was derived using fixed matching in each of the 3-player groups. Within a group, the same person was the first mover in each round. Using a random matching procedure, Li (2007) failed to replicate the timing effect of Weber et al.

[5] What we call HYBRID, Rapoport called *positional order protocol*.

With repetition of the stage game, the first-mover advantage may vanish. Suppose Player 2 is stuck in the middle and adopts a strategy of playing Blue in round t + 1, if the player to her **left** (Player 1) played Blue in round t, otherwise she plays Red. Furthermore, suppose Player 1 acts as though Player 3 is to his left. This being the case, the best response of Player 1 and Player 3 is to adopt the same strategy as Player 2. Player i plays Blue in round t + 1, if the player to the **left** of Player i played Blue in round t, otherwise Player i plays Red. With the first mover alternating between Player 1 and Player 3, this equilibrium would have the following choice pattern (first mover denoted by ^).

Table 4 A Reciprocal Equilibrium

Round of play	Player 1	Player 2	Player 3
1	B^	R	R
2	R	B	R^
3	R^	R	B
4	B	R	R^
5	R^	B	R
6	R	R	B^
…	…	…	…

With the windshield wiper order of play, the Nash equilibrium of the stage game results in highest possible payoff (see Table 1) of $a alternating between Player 1 and Player 3. The average overall payoff is $(a +2b)/3, with each of the first movers averaging $(a + b)/2, which is greater than Player 2's average payoff of $b. The above reciprocal equilibrium has no first-mover advantage and the players equally share the maximum possible spoils. Presumably, this sharing outcome evolves from Player 2 credibly signalling her willingness to "punish" the unkindness of other players by not always playing Red.[6] A first move of Blue is considered unfair by Player 2 not because it leaves Player 2 with a relatively smaller payoff, but because the first mover, by choosing Red, could have provided an opportunity for Player 2 to realize a higher payoff (Falk and Fischbacher 2006).

With finite repetition, the unique subgame-perfect equilibrium is precisely the backward induction solution to the stage game—the first-mover choses Blue and the other two plays choose Red. However, there is plenty of evidence (Monet and Serra 2003) that inexperienced players of finite repetitions of a one-shot game frequently

[6] The reciprocal equilibrium presented is just one of many with no first-mover advantage that extracts the maximum possible payout from the experimenter. Three Reds each round and 3 Blues each round also have no first-mover advantage, but each of these is payout dominated by 1 Blue and 2 Reds.

deviate from the predicted play.[7] If players focus little or no attention on the end-game until it is imminent, a reciprocal equilibrium might arise out of a behavioral sense of fairness.

This raises intriguing questions about experimental results across the SIM, SEQ and HYBRID protocols in a repeated-interaction game:

- Are there behavioral similarities between SIM and HYBRID?
- With SEQ, do behaviors under the windshield wiper order of play differ from behaviors with a randomly determined order of play?
- Does the first-mover advantage vanish?
- Are the average payoffs for SIM and SEQ the same?

3 Experimental Design

Players (subjects) were university sophomores with no game playing experience. No reference was made to actual voting games by public bodies so as not to bias the players by evoking beliefs of civic responsibility.[8] Fifteen sessions were conducted, each of which began with one experimenter going over the instruction sheet (found in the Appendix). Each session consisted of 3 different players playing multiple rounds of different protocols. Players sat along a single table. To prevent communication among the players, each player occupied a separate, portable carrel. Each player was given Blue and Red cards. In each round, a player indicated her choice by sliding a Red or Blue card under the front of the carrel, out of sight from the other players. Once all players moved, their choices were posted and the next round began. Under SIM protocol, players were told: (i) to make their choice by sliding a card under the front of their carrel, (ii) that once all players did so, cards would be randomly collected, and (iii) that choices made in the current round would be publicly displayed. Under HYBRID protocol, players were told the order in which they would choose. A player knew it was her turn to play when the experimenter appeared in front of her carrel, at which time the experimenter requested that the player submit a card while unaware of the choices of all previous players. The SEQ protocol was the

[7] The finding goes back to the 1950 experiment on the prisoners' dilemma conducted by Melvin. Dresher and Merrill Flood. Only 14 of the 100 rounds produced the Nash equilibrium of the stage game, 10 of which occurred no later than round 30. John Nash commented (Flood 1958, p. 16): "The flaw in this experiment as a test of equilibrium point theory is that the experiment really amounts to having the players play one multimove game. One cannot just as well think of the thing as a sequence of independent games…There is much too much interaction."

[8] Similarly, in Rapoport's (1979, 124) public goods experiment "no reference was made to contribution or defection in order not to bias the subjects by evoking social norms or altruism."

same as HYBRID except that, at the time the experimenter retrieved a player's card, he announced publicly the choice of that player. Thus players knew the choices of all previous players.

Suppose a particular session involved the 3 players sitting on the dais in seats A, B, and C:

Seat A	Seat B	Seat C
SMITH	JONES	ADAMS.

The order of play under HYBRID and SEQ utilized either the windshield wiper (WW) procedure or a random determination of the first player (RD). With WW, in a sequence of independent games, the unique subgame-perfect equilibrium rotates the first-mover advantage between Smith and Adams. Poor Jones is stuck in the middle.

With RD, each player has a 1/3 probability of choosing first. The player sitting to the left of the first mover plays second; when Adams moves first, Smith moves second and so on. The predicted expected payoff over an entire sequence of RD play is the same for each player even though, in any given round, theoretically one player always has a strategic first-mover advantage.

The combinations of protocols, treatments and procedures are summarized in Table 5, where the treatment identifiers 1 and 2 are taken from Table 3.

Table 5 Protocols, Treatments and Procedures

Protocol	SIM	HYBRID	SEQ
Treatment	1 = No & 2 = No	1 = Yes & 2 = No	1 = Yes & 2 =Yes
Procedure		WW or RD	WW or RD

Table 6 summarizes the experiments by protocol and procedure.[9] At the beginning of each session, players were *not* informed that play would involve different protocols, nor did they know when the last round of any protocol would be played. For example, at the start of sessions 2-4, players were informed only of the SIM protocol. At the start of round 9, an experimenter explained the HYBRID protocol and publicly announced that the order of play would now resemble

[9] Session 1 had a total of 25 rounds, while each of sessions 2-15 had 30 rounds. In sessions 1-13, SIM was played in rounds 1-8. HYBRID was played in rounds 9-18 and 9-22 of sessions 1 and 2-13, respectively. SEQ-RD occurred in rounds 1-18 of sessions 14 and 15.

Table 6 Session Summaries

Session Number	Number of Rounds by Protocol, Procedure, and Session				
	SIM	HYBRID		SEQ	
		WW	RD	WW	RD
1	8	10		7	
2-4	24	42		24	
5-8	32		56		32
9-13	40	70		40	
14, 15				24	36
Total Rounds	104	122	56	95	68

a windshield wiper with Smith moving first and Adams last. In the next round, Adams would move first and Smith last and so on. At the start of round 23, an experimenter explained the SEQ protocol and publicly announced that the order of play would continue to resemble a windshield wiper. Sessions 2-4 involved 24 rounds of SIM, 42 rounds of HYBRID and 24 rounds of SEQ. At the start of round 9 in sessions 5-8, the HYBRID was explained and players were told that the order of play in each round would now be randomly determine by tossing a 6-sided die.[10] Summing across the bottom row of Table 6 reveals that the fifteen sessions had a total of 445 rounds of play.

4 Results

Table 7 reports patterns of play by protocol and procedure. The values are percentages derived from the totals found in the last row of Table 6. For example, 34% of the 122 rounds under the HYBRID protocol having a WW order of play had exactly one Blue. Row 3 of Table 7 shows the proportion of rounds under the HYBRID and SEQ protocols that produced a first-mover advantage (the unique subgame-perfect equilibrium). The proportion of rounds with exactly one Blue (Row 1) was greater than the proportion of rounds with a first-mover advantage (Row 3) under all protocols. Rows 3-5 clearly indicate that the free-rider payoff of $2 was not reserved to the first mover. The last 2 entries in the last row show the percentage of rounds in which the second mover (knowingly?) blocked the first mover from the possibility of receiving a $2 payoff. This occurrence was almost as likely under WW (19%) as RD (21%).

[10] If the face of the die revealed dots totaling: 1 or 2, Smith moved first, 3 or 4 Jones moved first, and 5 or 6 Adams moved first.

Table 7 Patterns of Play by Protocol and Procedure

Percentage of rounds with the indicated pattern of play	Protocol and Procedure				
	SIM	HYBRID		SEQ	
		WW	RD	WW	RD
Exactly one Blue is played	36%	34%	32%	65%	59%
First mover plays Blue		43%	38%	43%	41%
Exactly one Blue is played and it is played by first mover		12%	7%	32%	32%
Exactly one Blue is played and it is played by second mover		11%	7%	19%	12%
Exactly one Blue is played and it is played by third mover		12%	18%	14%	15%
First mover played Blue and the second mover played Red		30%	27%	38%	38%
First mover played Blue and the second mover played Blue		28%	36%	19%	21%

If the SIM and HYBRID protocols were different, then one would expect their payoffs to be different.[11] Therefore, the payoffs for each player were calculated and SIM and HYBRID were compared using the average payoffs as the dependent variable and the protocol (SIM versus HYBRID) and the session (the subjects) as the factors.[12] Results are found in Table 8.

Table 8 ANOVA Using Protocol (SIM & HYBRID) and Session as Factors

Source of variation	Sum of squares	df	Mean square	F	Significance
Session	19.088	12	1.591	3.038	0.001
Protocol (SIM vs. HYBRID)	0.560	1	0.560	1.071	0.302
Error	140.308	268	0.524		
Total	159.887	281			

Dependent variable: Average payoffs.

The difference in the payoffs between the protocols was not significant. However, the difference in payoffs across sessions was significant.

While there was not a significant difference in average payoffs between SIM and HYBRID, there might have been a significant difference in payoffs based on the order of play for the HYBRID protocol. When we examined this possibility, we found that there were no significant differences in payoffs based on the order of play. The

[11] Because there is no order of play in the SIM protocol, the average payoff for players was calculated for both the SIM and HYBRID protocols for each round of play and used as the dependent variable in the ANOVA analysis.

[12] In Table 8 and subsequent ANOVA analyses, an interaction term was not included because the interactions were not statistically significant.

average payoffs in the HYBRID protocol for the first, second, and third mover are shown in Table 9. Although there was a higher payoff for the first player in comparison to the second player, as would be expected if the HYBRID protocol were similar to the SEQ protocol, this difference was not statistically significant.[13] Therefore, in subsequent analysis, the SIM and HYBRID protocols will be treated as the same protocol, designated as SIM. Table 5 then compresses to Table 10.

Table 9 Average Payoffs by Mover for the HYBRID Protocol

	n	Mean
Payoff to first mover	178	0.4326
Payoff to second mover	178	0.3427
Payoff to third mover	178	0.4270

Table 10 Protocols, Treatments and Procedures

Protocol	SIM	SEQ
Treatment	1 = No & 2 = No	1 = Yes & 2 =Yes
Procedure		WW or RD

As shown in Table 10, the sequential protocol (SEQ) has two procedures, windshield (WW) and random (RD). For WW, if there is a first player advantage, then we would expect to see a flip-flopping of the probability of playing Blue on the first play for the players in seat A and seat C. Tables 11 and 12 show that, while this flip-flopping does tend to happen, it is not a strong relationship. The χ^2 and Fisher exact probability test results are barely significant at the 5% level (Table 12).

Table 11 Flip-Flopping with SEQ and WW

	Number of Blues played by player in seat A	Number of Blues played by player in seat C	Total
Count % of Blues when player in seat A played first	28 57.1%	21 42.9%	49 100.0%
Count % of Blues when player in seat C played first	15 36.6%	26 63.4%	41 100.0%
Total	43 47.8%	47 52.2%	90 100.0%

[13] Using a paired sample t-test to compare the difference in the payoffs for the first and second player, the p-value is 0.084. The p-value for comparing the payoffs between the second and third players is 0.120

Table 12 Chi-Square Test for Table 11

	Value	df	Asymptotic Significance (2-sided)	Exact Significance (2-sided)	Exact Significance (1-sided)
Pearson chi-square	3.781	1	0.052		
Fisher's exact test				0.060	0.041

Number of valid cases equals 90.

In the RD procedure, each player had an equal opportunity of realizing the first-mover advantage, which might have resulted in greater cooperation and higher payoffs. Independent sample t-tests were used to see if there was a significant difference in payoffs by order of play between the WW and RD procedures. As can be seen in Table 13, the payoffs for players were, on average, higher for the WW procedure than the RD procedure, which was exactly opposite to what was conjectured above. However, these differences were not statistically significant (Table 14).

Table 13 Payoffs by Mover and Procedure in SEQ

	Procedure	n	Mean
Payoff to first mover	WW	95	1.042
	RD	68	0.7941
Payoff to second mover	WW	95	0.873
	RD	68	0.661
Payoff to third mover	WW	95	0.852
	RD	68	0.735

Table 14 t-tests for Equality of Means in Table 13

	df	Significance (2-tailed)
Payoff to the first mover	161	0.090
Payoff to the second mover	161	0.085
Payoff to the third mover	161	0.288

Since the RD and WW procedures for the SEQ protocol were not conducted in the same sessions, it might be that there were significant variations among sessions (i.e., the people in a session make a difference). By backing out this variability, the observed differences in the procedures might become significant. To investigate this possibility, two sessions were conducted with each using both the RD and WW procedures. The results are shown in Table 15. The mean payoff for the WW procedure was higher than for the RD procedure, but this difference was not significant as shown in the two-way ANOVA table presented as Table 16.

Table 15 Average Payoffs for RD and WW for Session 14 and 15

Procedure	Mean
RD	0.731
WW	0.986

Table 16 ANOVA Using Procedure (RD & WW) and Session (14 & 15) as Factors

Source of variation	Sum of squares	df	Mean square	F	Significance
Session	2.963E-02	1	2.963E-02	0.059	0.809
Procedure (RD vs. WW)	0.934	1	0.934	1.854	0.179
Error	28.703	57	0.504		
Total	29.667	59			

Dependent variable: Average payoffs.

When the payoff for each mover was examined for these two sessions (Table 17), the payoff for the first mover was statistically significantly higher for WW than RD.[14]

Table 17 Payoffs by Mover and Procedure in SEQ for Sessions 14 and 15

	Procedure	n	Mean
Payoff to first mover	WW	24	1.167
	RD	36	0.611
Payoff to second mover	WW	24	1.000
	RD	36	0.778
Payoff to third mover	WW	24	0.792
	RD	36	0.806

On average, possibly players did as well or better under WW because it became clear that the player stuck in the middle would block payoffs for everybody by playing Blue unless the other players cooperated. The communication of information may be more uncertain because of the changing roles under RD compared

[14] Using related sample t-tests, the payoffs for the second and third movers were not significantly different under the two procedures.

to the rhythmic nature of WW.[15] In spite of these interesting differences in outcomes in some circumstances, the RD and WW procedures are combined within the SEQ protocol in the subsequent analysis.

For the SEQ protocol, was there a first-mover advantage? To investigate this possibility, the payoffs were used as the dependent variable with order of play and session as the factors. The results of the two-way ANOVA (Table 18) showed no significant advantage in the order of play, but a significant difference in the payoffs based on the session.

Table 18 ANOVA for SEQ Using Order of Play and Session as Factors

Source of variation	Sum of squares	df	Mean square	F	Significance
Session	26.696	14	1.907	3.148	0.000
Order of play	2.286	2	1.143	1.887	0.153
Error	285.893	472	0.606		
Total	314.875	488			

Dependent variable: Payoffs.

The average payoffs were in the expected order, with the highest average payoff going to the first mover, the next highest to the third mover and the lowest to players stuck in the middle, as shown in Table 19.

Table 19 Mean Payoffs by Mover in SEQ

Playing Position	Mean
First mover	0.944
Second mover	0.791
Third mover	0.809

The final question addressed was: are the average payoffs for the SIM and SEQ protocols the same? [16] Using average payoffs as the dependent variable and Protocol and Session as factors, the two-way ANOVA shows that both factors are significant with Protocol having a p-value of 6.44×10^{-7} (Table 20).

[15] In these two sessions, the RD procedure was run first, followed by the WW procedure. It may be that learning occurred during the RD procedure which was transferred to the WW procedure. Therefore, subsequent experiments should reverse this sequence.

[16] This analysis excludes sessions 14 and 15, because neither of these sessions included a SIM, protocol. If these sessions are included, the results are not substantively different.

Table 20 ANOVA Using Protocol (SEQ & SIM) and Session as Factors

Source of variation	Sum of squares	df	Mean square	F	Significance
Session	18.825	14	1.345	2.643	0.001
Protocol (SEQ vs. SIM)	13.044	1	13.044	25.640	0.000
Error	218.242	429	0.509		
Total	254.423	444			

Dependent variable: Average payoffs.

The SEQ protocol resulted in significantly higher payoffs than the SIM protocol (Table 21), presumably because of the greater communication of information that was possible in the SEQ protocol.

Table 21 Average Payoffs of the SIM and SEQ Protocols

Protocol	Mean
SIM	0.429
SEQ	0.845

Moreover, there were also statistically significant differences among sessions. Table 22 shows the average payoff by session.

Table 22 Average Payoffs by Session

Session	Mean	Session	Mean	Session	Mean
1	0.518	6	0.408	11	1.208
2	0.697	7	0.441	12	0.653
3	0.486	8	0.508	13	0.386
4	0.730	9	0.664	14	0.603
5	0.919	10	0.686	15	0.648

There are statistically significant differences among the means in Table 22, especially for the outliers.[17] Session 11, for example, was an outlier. Apparently the participants in this session learned to cooperate and share the wealth. Similarly, session 13 was an outlier where there was little cooperation.[18] Since the average

[17] Based on a Bonferroni post hoc test and $\alpha = 5\%$

[18] For session 11, 97% of the rounds had a positive average payoff, whereas in session 13, only 30% of the rounds had a positive average payoff.

payoff varied from a low of $0.386 per player per round to a high of $1.208, clearly people matter, as well as the games they play.

5 Conclusions

Under the sequential protocol, a first-mover advantage requires that the other players "cooperate." Results from the WW procedure were consistent with players stuck in the middle trying to get the other players to allow them to be the only player who chooses Blue in future rounds by blocking (playing Blue) in the current round. Perhaps some players stuck in the middle believed that WW was biased against them and thus they were being treated unkindly if the "jokers and clowns" alongside them never afforded them the opportunity to realize the highest possible payoff.

Interestingly, we found that the percentage of rounds in which the first mover and the second mover played Blue were just about the same under the WW and RD procedures. This finding differs from ultimatum games showing responders being more likely to accept low offers generated by a random device—while the responder may not like the inequality, at least the process was fair. Perhaps the RD procedure would display relatively more cooperation if the experiments were replicated with more rounds of play.

How choices change based on the number of players and relative payoffs are areas for future research. If the $2 payoff were $10, the subgame-perfect equilibrium payoff list would change from [2, 1, 1] to [10, 1, 1]. Our conjecture is that the latter payoff structure would yield more sharing of the strategic advantage due to an increase in the likelihood that the player stuck in the middle will signal discontent by blocking the first mover from receiving $10. Kreps (1990, p. 101) makes a similar conjecture. Finally, members of elected bodies are often confronted with the issue of switching from sequential to simultaneous order of play. Some advocates of switching say the benefits from doing so include:

- There is no stigma associated with the First or Last to Vote.
- There is no identification of "The Tie Breaker."
- The individual's decision is privately initiated and has no inference of influence.[19]

Perhaps elected officials should also be informed of our finding that average payoffs were significantly higher with sequential play compared to simultaneous play.

[19] http://www.electrovote.com/ElectroVote/general.htm (last accessed 03/26/08).

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:

Number of Players choosing RED	$Payoff to those choosing **RED**	$Payoff to those choosing **BLUE**
3	1	
2	1	2
1	-1	0
0		0

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** these 5 rounds.

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