# An Experimental Study of Self-enforcing Coalitions*

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**Abstract**

We study a model where agents endowed with power compete for a divisible resource by forming coalitions with other agents. The coalition with the greatest power wins the resource and divides it among its members via proportional sharing. We conduct an economic experiment using this model to investigate possible behavioral factors that may explain deviations from theoretical predictions. The main findings show that agents display rational behavior when forming coalitions, especially when they know that a large proportion of their opponents play myopic strategies in the beginning. Over time, however, agents learn to behave more strategically and even more rationally, and thus enables agents to display more of the behavior predicted by our coalition formation model.

**Keywords:** Coalition Formation, Power Accumulation, Self-enforcement, Experiment.

**JEL Classification** C70 · C91 · D71

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# 1 Introduction

The main economic rationale why agents strategically cooperate and form groups is that they can appropriate certain advantages unavailable to them if they acted on their own. In this framework, rational agents endogenously form coalitions depending on the incentive structure or the environment they face. Recent literature has been very active in modelling how agents form coalitions in the face of very diverse environments.[1]

One such recent advance is introducing heterogeneous *power* for the agents and examining how its configuration in the society affects the manner in which coalitions endogenously form. Power is the ability to influence the behavior of other agents in the society and could emanate from different sources, for instance, political, military or monetary. As an extreme example, dictatorships (a singleton coalition) may occur more frequently in environments when there is one agent who has a disproportionate share of power. For instance, Tullock [30] argues that juntas (a small group that wields power) always degenerates into a dictatorship since whenever formal institutions on distribution and sharing of power, succession of leaders, and generating consensus are weak or absent, there is a tendency for one person to dominate the society. One key question is under what conditions Tullock's conjecture that a ruling coalition always degenerates into a dictatorship forms will hold. One plausible reason is that agents are myopic in choosing their strategies, that is, agents may not take into account the long-run consequences of the coalitions that they form.

An important paper by Acemoglu, Egorov, and Sonin [1] (hereafter AES) tackles this question heads-on and shows, under a very specific bargaining context, how Tullock's conjecture will not hold when agents are farsighted. In their paper, agents with different powers make proposals and respond to such proposals to try to form coalitions with sufficient power to win throughout time. At each point in time, agents outside this winning coalition are "killed", that is, they are unable to participate in future time periods. The "ultimate ruling coalition" that emerges, which is the coalition that will be stable forever starting from a particular point in time, will win the prize and its members will divide this prize among themselves in proportion to their relative power inside the ultimate ruling coalition.[2] AES then show that the unique subgame perfect equilibrium of their bargaining process involves strategies that allow for an ultimate ruling coalition–not necessarily a dictator–to form after one transition, that is, there

[1] An excellent introduction to the concepts in this literature is Ray [26].

[2] AES main stability concept, *self-enforcement*, requires that there will be no subcoalition of the winning coalition that will be powerful enough to encourage further deviations. Self-enforcement is a robustness property that ensures that the coalition that forms never disintegrates afterwards. Another appealing axiom they use is *rationality* that requires agents to pick the coalition that gives them their highest payoff among self-enforcing coalitions. Rationality is is related to immunity to group manipulations in models discussed by Bogomolnaia and Jackson [6], Ehlers [9], Juarez [18].

will be no intermediate coalitions forming.[3]

As a concrete example, imagine three agents in the society where agent 1 has power 20, agent 2 has power 35 and agent 3 has power 45. Notice that no single agent has sufficient power to win, and so he must propose to at least one other agent to form a "winning" coalition, that is, the coalition must have at least 50% of the power in the society (a majority). Suppose 35 was randomly selected to be a proposer and he proposed coalition $\{20, 35\}$ to agent 20. This coalition is winning since the sum of their powers (55) is more than the remaining agent 45 (that is, they have more than 50% of society's total power). Now 20 can either accept or reject this proposal. If he accepts, $\{20, 35\}$ forms and agent 45 is killed. In the next period another proposer is selected but this time only from agents 20 or 35. Agent 20 can only propose $\{20, 35\}$ since he is not winning by himself. Agent 35, however, can propose himself to be a dictator. If that happens, $\{35\}$ will be the ultimate ruling coalition from this period onwards. Since 20 is fully rational and farsighted, agent 20 will never agree to form $\{20, 35\}$ and thus rejects this proposal when faced with it. Following this argument, no 2-person coalition will ever form in this example. On the other hand, proposing the grand coalition $\{20, 35, 45\}$ is feasible since this coalition will never deviate into a 2-person coalition following the same logical process outlined. Hence, this coalition is said to be "self-enforcing" or stable. In this simplified version of the AES model, farsighted agents know that if they propose a 2-person coalition with a higher-powered agent, they will be killed in the future. Higher-powered agents, on the other hand, know they will be rejected by farsighted, lower-powered agents if a 2-person coalition is proposed. Hence, the unique subgame perfect equilibrium strategies requires that the proposer propose only the only self-enforcing coalition $\{20, 35, 45\}$ and nothing else, while the responders would accept the self-enforcing coalition $\{20, 35, 45\}$, a 2-person coalition if proposed by a lower-powered agent, and reject anything else. Playing these SPNE strategies would allow the grand coalition $\{20, 35, 45\}$ to form at once. In this particular example, we can clearly see that if agents are farsighted, then an ultimate ruling coalition that is not a dictator will form.

Hence we have two competing theories on how agents form coalitions over time. On one extreme is the Tullock position, where ruling coalitions always end up in a dictatorship because of the incentives and possibly because of the agents' bounded rationality. At the other extreme is the AES position where a non-dictatorship ruling coalition can form if agents are farsighted.

In this paper, we let actual subjects participate in a laboratory experiment to investigate which theory adheres more closely to agents' actual behavior. In this experiment we play a version of the AES coalition formation model corresponding to the setting we described in the example above. Employing an experimental approach is useful in this setting for two

[3]Jandoc and Juarez [16] extends the analysis of Acemoglu et al [1] to the case where power accumulates, as well as to the case when the prize is shared equally among the agents.

reasons. First, adopting a highly simplified version of AES coalition formation model enables us to examine the extent to which agents' behavior deviates from the predictions of this model. While the AES coalition formation process (see Section 3) provides clear cut predictions on what coalition will emerge starting from a society of agents with specific powers, it rests on the assumption that agents are farsighted and only care about their payoff from self-enforcing coalitions. If agents are myopic, then it is possible that dictatorships will be more likely to form since by trying to maximize immediate payoffs agents may fail to foresee that deviation into a non-self-enforcing coalition would lead to further deviations that may exclude them in the future. If the deviation is substantial, we can examine the agents' strategies in order to determine whether myopia has hindered the agents' from attaining the model's prediction. Second, we can determine whether agents are able to behave more rationally by increasing the incentives for them to do so or by gaining experience through time. The AES game is set up in such a way that the size of the resource does not have any bearing on the ultimate coalition that will form since only the agent's relative payoffs matter. In real-world settings, however, stake size may affect behavior because it could induce agents to behave more "cooperatively" since losing the pot entails a higher potential loss. Moreover, the AES model provides no scope for learning despite the dynamic nature of their game. In reality, however, boundedly rational agents may behave myopically at first but may learn to be strategic if given enough experience playing the game. In summary, we used a laboratory experiment to address the questions: Do agents form coalitions as the model predicts? If not, why does behavior deviate from prediction? Does myopia, learning and stake size affect the agents' decisions?

Our experiment shows that the coalition formation model is not a perfect predictor of the actual coalitions that form. In our setting, the proportion of the grand coalitions that form almost never exceeds half of the total coalitions that form in every game. Over time, however, the proportion of grand coalitions forming tends to rise. Stake size slightly helps in increasing the proportion of grand coalitions forming. Examining the actual strategies of the agents, we find a fairly regular pattern for proposals and responses. First, the proposed coalitions are conditional on a particular agent's power. For instance, agents who have low power (20) tend to propose the grand coalition while agents assigned with higher power (35 or 45) tend to propose a 2-person coalition, especially to the lower-powered agent (20) where they can obtain a higher share of the prize. Second, most of the decision to accept or reject a proposed coalition is also contingent upon both an agent's drawn power and the coalition proposed. For example, almost everyone with power 45 accepts a proposed 2-person coalition, while only about half of agents with power 20 accepts a proposed 2-person coalition. Moreover, almost all agents with power 20 accept a proposed grand coalition.

Put in a larger perspective, our results suggest that many agents exhibit behavior deviating from pure farsightedness and full rationality but learn to behave more strategically with enough experience of playing the coalition formation game. This suggests that elements of both the Tullock and the AES theories may be at work in the real-world. Hence, examining these behavioral factors in a strategic context may prove useful to develop future coalition formation models that will help us understand better how agents form groups in reality.

To our knowledge this is the first and the only paper so far that investigates the implications of adding heterogeneous power and investigating the stability of coalitions that form. Hence our unique contributions are the following. First, we fill in the gap on empirical studies in coalitions formation by using tools of experimental economics. Second, we establish a framework on how to conduct coalition formation experiments with power. Finally, we identify plausible reasons why actual behaviour may deviate from the theoretical predictions, specifically the importance of myopic strategies, learning and stake size. We then point out the need to refine theory to take into account these factors.

# 2 Literature

## 2.1 Experiments on coalition formation

The literature on coalition formation experiments is sparse. The earliest experiments were designed to test and compare solution concepts such as the core (Horowitz [14]) and the individually rational bargaining set (Rapport and Kahan [25]) using a package of software programs called *Coalitions* (Kahan and Helwig [20]).

Along with the rise in the popularity of the bargaining approach to coalition formation (e.g. Baron and Ferejohn [3]) came experiments to test the theoretical predictions of these models. For instance, several papers attempted to implement the procedures in the Baron and Ferejohn model to test its predictions (McKelvey [21], Frechette et al [10], Battaglini and Palfrey [4]).

More recently, Nash et al. [24] conduct an experiment to test a bargaining coalition formation game where players form coalitions by transfering bargaining rights to another player (the "agent") which is then tasked to distribute payoffs to the coalition. While this paper highlights the tension between the incentive of players to keep a larger share of the resource and maintaining cooperation inside the coalition, it does not address the issue of dynamic stability of coalitions and the tension between myopic and farsighted payoffs.

We believe our paper is the first and the only one so far to investigate the implications of heterogeneous power to the dynamic stability of coalitions. In this paper, we implement the procedural rules from the bargaining game of the AES model, and thus examine the failure of some behavioral assumptions in the event that the outcome deviates from the theoretical prediction.[4]

## 2.2 Learning and experience

Fudenberg and Levine [11] assert that a dynamic and adaptive process of learning and evolution can be an alternative to the "common knowledge of rationality" assumption underpinning most game theory models (Aumann [2]). More forcefully, Ken Binmore [5] observes that "most theorist nowadays agree that people get to equilibrium...by an interactive process of trial-and-error learning". The interesting question in the nexus between theory and experiments is not whether the theory is debunked or not but whether the participants learn how to arrive at the equilibrium in repeated trials. More often than not, participants' behavior in each trial is dependent on the results of previous trials. According to Binmore, testing economic theories in a laboratory setting must satisfy three criteria:

- The problem must be framed to be "reasonably" simple;
- The incentives must be "adequate";
- The time allowed for trial-and-error adjustment is "sufficient"

Models of learning were developed that takes into account the possibility that agents adapt their beliefs to past experience instead of reasoning strategically. These models show that agents have a high degree of myopia. However, Hyndman, et al [15] shows through an experiment that economic agents actually rely on both adaptation and forward-looking behavior. Mengel [22] provides a learning model that ties the two features of adaptability and forward-looking behavior together. The model is able to provide explanations for the possibility of cooperation in finitely repeated games.

Even though the environment of our coalition formation game is simple enough, we would expect that agents will undergo a trial-and-error process as they play our game. While there are several ways to model the dynamic and adaptive process of learning, we take a straightforward approach by simply enumerating the strategies employed over the progress of the games as well as the types of coalitions that will form in early and late games.

## 2.3 Stake size

Harrison and List [13] provide an excellent review of varying stakes in economic experiments. The question is whether stakes in economic experiments are non-trivial enough to induce agents to reveal their true behavior. To make the stakes appear more substantial, several experiments were conducted in developing countries where participants are poor enough to

[4] Tremewan and Vanberg [29] point out that if the outcome from these experiments deviate from theoretical predictions, the failure will emanate from behavioral rather than procedural assumptions.

make the stakes more salient. For instance, Slonim and Roth [28] ran their experiments in the Slovak Republic, Kachelmeier and Shehata [19] in China, Cameron [8] in Indonesia, among others. The stakes in these experiments roughly equalled 62.5 hours of work in Slovak or three times the monthly expenditure of the average participant in Indonesia. The effect is somewhat mixed, in some cases high stakes, like the Slovak Republic study, induced a different behavior than that obtained with lower stakes while in the Indonesian study it did not.

Overall, it is still an open question how representative (small) experimental stakes translate into behavior that reflect situations in the real world. In this paper we increase the stake size in some games and examine the coalitions that will form as a result. In some games we increase the stake tenfold (from \$5 to \$50) while in some games we increase only from \$5 to \$20.

The rest of this paper is organized as follows: Section 3 describes the important elements of the theory of the coalition formation game we will conduct in the laboratory. Section 4 describes the design of the experiment. Section 5 discusses the result of the experiment and Section 6 concludes.

# 3 Theoretical considerations

Following AES, there is a set $N = \{1, \ldots, n\}$ of initial agents endowed with powers $\pi = [\pi_1, \ldots, \pi_n]$, respectively. A coalition $S$ is a subset of $N$, that is, $S \subseteq N$. The set of coalitions are all possible subsets of $N$, denoted by $2^N$. A coalition formation game is a pair $(S, \pi)$ where $S \subseteq N$ and $\pi \in \mathbb{R}^S_+$. We assume that power is additive, that is, the power of coalition $S$ is the sum of all powers of the agents inside the coalition, $\pi(S) = \sum_{i \in S} \pi_i$. The set of winning coalitions is given by $W_{(T,\pi)} = \{S \subset T | \pi(S) > \pi(T \setminus S)\}$.

We assume a sharing rule that divides the prize of the agents. This sharing rule is fixed throughout the game and we assume that if the agent is part of the final (limit) coalition $S$, then his share is proportional to his power in the coalition, that is, $\xi_i(S, \pi) = \frac{\pi_i}{\pi(S)}$ if $i \in S$. If the agent is not part of the limit coalition, his payoff is $\xi_i(S, \pi) = 0$.

We have the following extensive form of the game $(N, \pi)$: Stage $j$ of the game starts with coalition $N_j$ and then the stage game proceeds as follows:

1. Nature picks proposer $a_{j,q} \in N_j$ for $q = 1$.
2. Agent $a_{j,q}$ proposes $P_{j,q} \in C_{N_j}, C_{N_j} \subseteq N_j$ such that $a_{j,q} \in P_{j,q}$
3. Agents in $P_{j,q}$ vote sequentially over the proposal. A random agent is selected to be the first voter $v_{j,q,1}$ who votes $\tilde{v}(v_{j,q,1}) \in \{yes, no\}$, then another voter is selected $v_{j,q,2} \neq v_{j,q,1}$ and the voting process continues. If those who voted yes have sufficient power such that $P_{j,q}$ is winning, that is, $P_{j,q} \in W_{(N_j, \pi_{N_j})}$ then proceed to step 4. If not, proceed to step 5.

4. If $P_{j,q} = N_j$, proceed to Step 6. If not, players from $N_j \setminus P_{j,q}$ are eliminated and the game reverts back to step 1 with $N_{j+1} = P_{j,q}$ (and $j$ increases by 1).
5. If $q < |N_j|$, the next agenda setter $a_{j,q+1} \in N_j$ is randomly picked among those in $N_j$ who have not yet proposed at this stage and the game proceeds to step 2 with $q$ increased by 1. If $q = |N_j|$, the game proceeds to step 6.
6. $N_j$ becomes the ruling coalition where each agent $i \in N_j$ receives payoff $\xi_i(N_j, \pi_{N_j})$.

The major result of AES can now be stated and the proofs can be found in Acemoglu, Egorov and Sonin [1].

**Proposition 1** *For the bargaining procedure just described, there exists a pure strategy profile that constitutes a unique subgame perfect equilibrium and leads to an ultimate ruling coalition in at most one transition.*

The intuition is quite clear with the help of the example in Section 1. To reiterate, a farsighted, lower-powered agent knows that if they propose a 2-person coalition to a higher-powered agent they will be killed. Higher-powered agents know that if they propose a 2-person coalition to a farsighted, lower-powered agent they will be rejected. Hence, on the equilibrium path only the self-enforcing grand coalition $\{20, 35, 45\}$ will be the only one proposed and the same coalition will be the only one accepted. Off the equilibrium path, however, higher-powered agents will accept a 2-person coalition from a lower-powered agent. Playing these strategies would allow a self-enforcing coalition to be the ultimate ruling coalition in one transition, without forming any intermediate coalitions.

# 4 Experimental Design

We consider a very simple implementation of the procedures of the game described in the previous section. In this experiment our society is composed of three agents who are endowed with powers either 20, 35 or 45 as in the example in Section 1. Similar to the stages of the game in the previous section, we follow the steps below:

1. An agent is randomly chosen to be the proposer and he proposes to form a winning coalition.
2. Agents in this proposed coalition vote whether or not to join.
3. A coalition passes if the majority of the agents vote to join this coalition.
4. If a coalition passes, the game is repeated ONLY with the agents inside this passed coalition.
5. If the coalition fails, a new proposer is randomly chosen and the game begins again.
6. The game ends if a dictator is left or the same coalition gets to be passed after everyone has been given their chance to propose.

Under the theory, if all agents are farsighted no coalition of size two will be proposed nor accepted on the equilibrium path. Off the equilibrium path, however, a higher-powered agent will accept a 2-person coalition if proposed by a lower-powered agent. Hence, in this game the unique Subgame Perfect Nash Equilibrium (SPNE) strategy is to only propose the grand coalition, accept the grand coalition $\{20, 35, 45\}$ if proposed, accept a 2-person-coalition with a lower-powered agent if proposed, and reject anything else. The unique outcome under the SPNE is the grand coalition $\{20, 35, 45\}$ forming.

We developed our own internet-based software to implement the games. Figure 1 is a screenshot of the proposal stage. In this screen, available information includes the agent's power, other agents' power and their order of proposal, the current turn, the proposed coalition, the pot, the coalitions available for proposal (i.e. those with sufficient power to win) and the corresponding payoffs of each agent in any potentially proposed coalition (if the proposed coalition becomes the ultimate ruling coalition). The randomly chosen agent will then have to propose one coalition (with sufficient power) to the other agents in the game.

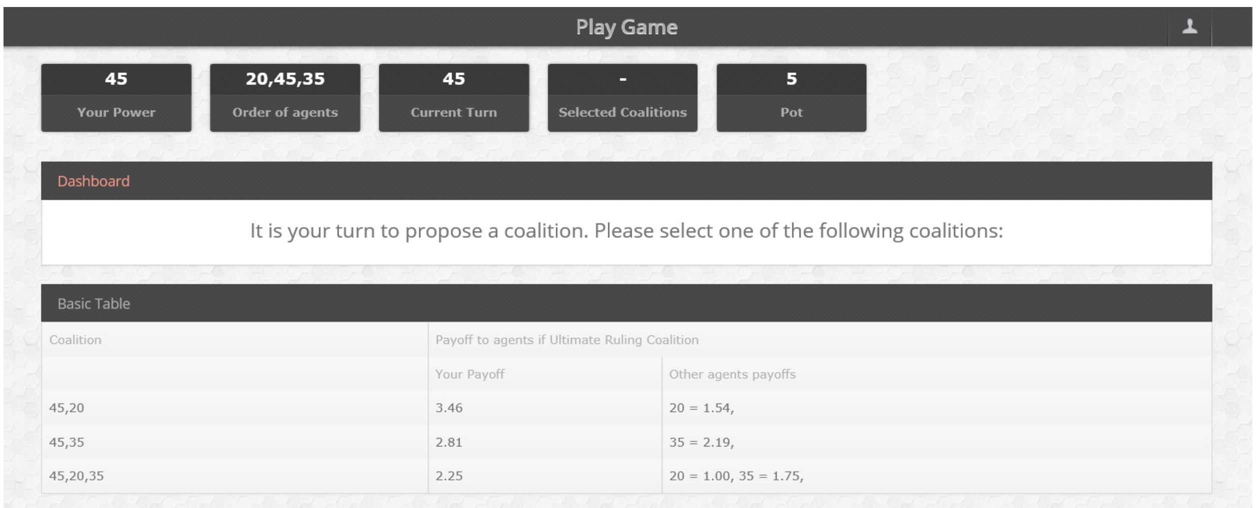


Figure 1: A screenshot of the proposal stage

Once a proposer has made his proposed coalitions, the other agents who are part of this proposed coalition will move to the response stage and will be shown a screen similar to Figure 2. In this screen, available information includes the agent's power, other agents' power, the pot (in dollar terms), the selected proposed coalition, the voting screen, other winning coalitions that were not chosen for proposal, and the corresponding payoffs of each agent.[5]

[5]Note that this screen is only viewed by the agents included in the proposed coalition. If they are not part of the proposed coalition, their vote is an automatic ”No” and they will have to wait whether the proposed coalition passes or fails. If the proposed coalition passes, then they will have to wait until the game ends.

The agent then votes “yes” or “no” to the proposed coalition. The subsequent stages will follow the same procedures until a final coalition passes.

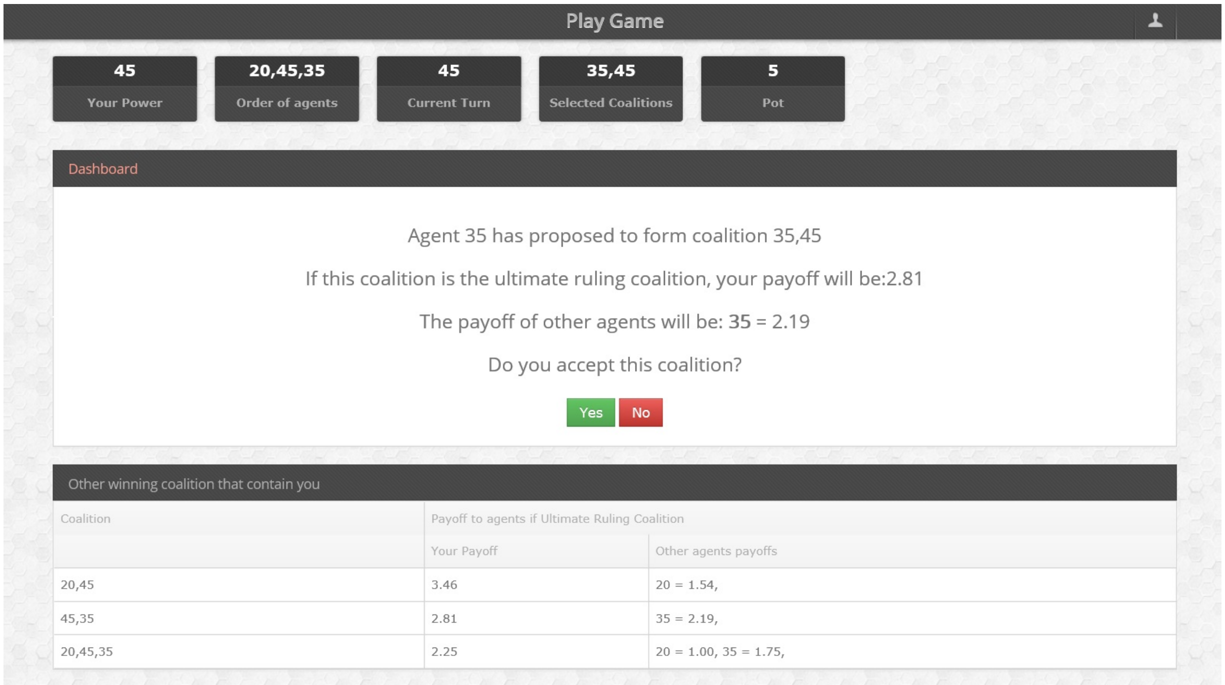


Figure 2: A screenshot of the response stage

In this experiment the participants are undergraduate students from the University of Hawai‘i and recruited via ORSEE (Greiner [12]). Subjects were allowed to participate in only one session in this experiment but they may have some prior experience with other non-related experiments. Subjects were shown a video of the instructions and were administered an online quiz to test how they understood the instructions.[6]

To allow for learning in each session, the participants played up to 15 games with random rematching. We designate the first two games as “practice” games where the subjects will not be paid. After these practice games, the subjects will split a $5 pot in each of the “paid” games played. We pay the subjects the actual amount that they win for all of the paid games. In order to investigate the effect of increasing stakes, in some sessions we offered $20 or $50 in the last game. [7] In total we have five sessions with $50 final games, three sessions with $20 final games and three sessions with $5 final games.

[6]The instructions can be viewed here: `https://www.youtube.com/watch?v=FKc0lPAQN_0`. Appendix A provides screenshots of the instructions and the quiz.

[7]We announced the stake prior to the start for each of these final games regardless whether it is a high stake (i.e., $20 or $50) or low stake (i.e., $5).

Table 1 describes the summary of the experimental sessions. We held 11 sessions where in each session we conducted up to 15 games. Subjects are grouped into 3 for each game, and are randomly selected into one of these groups. The first two games of each session are designated as practice games where the participants receive no money. After these two practice games, we pay the subject's share of the $5 pot for each game. As just mentioned, there are several sessions where we increase the stake size to either $20 or $50. We pay out an average of (not including the $12 show-up fee) $ 20 for the low-stakes sessions, $25 for the $20-stake sessions, and $35 for the $50-stake sessions.

Table 1: Summary of experimental sessions

| Session Date | Number of games per session | Number of subjects | Last game stake |
|---|---|---|---|
| *Low stake sessions* | | | |
| May 6, 2014 | 14 | 15 | $5 |
| February 4, 2015 | 14 | 15 | $5 |
| February 5, 2015 | 14 | 12 | $5 |
| *Medium stake sessions* | | | |
| May 6, 2014 | 14 | 12 | $20 |
| May 7, 2014 | 14 | 12 | $20 |
| June 6, 2014 | 14 | 12 | $20 |
| *High stake sessions* | | | |
| June 5, 2014 | 15 | 9 | $50 |
| June 23, 2014 | 15 | 9 | $50 |
| June 24, 2014 | 15 | 6 | $50 |
| February 4, 2015 | 14 | 15 | $50 |
| February 5, 2015 | 14 | 15 | $50 |

Note: Total number of sessions is 11. Total number of group games is 624 (column 2 times one-third of column 3 and getting the sum). The first two games per session are designated as practice games. There are 132 total participants.

# 5 Results

There is a total of 132 participants and 624 group games in our experiment. Out of 624 group games, 536 games are paid while 88 are practice games.[8] Our analysis only covers the paid games in all sessions, that is, we do not include the first two practice games. In this section, we present our key results for the type of coalitions that form and Section 5.1 will present an analysis of the strategies employed by the agents.

**Observation 1** *Very few grand coalitions form compared to the proportion of singletons (dictator) during the early games of the experiment. However, the proportion of grand coalitions forming significantly increases in later games.*

Considering all games, Figure 3 suggests that very few grand coalitions form which does not seem to accord with the model's prediction where the grand coalition $\{20, 35, 45\}$ should always form. Taking all sessions together, there is no game in which the proportion of grand coalitions forming exceed 50%. In contrast, during the first few games the proportion of dictators never goes below $50\%$. This indicates that the model is a weak predictor of the coalitions that will form. In the following we examine some factors that may induce behavior that will bring the results closer to the model's predictions.

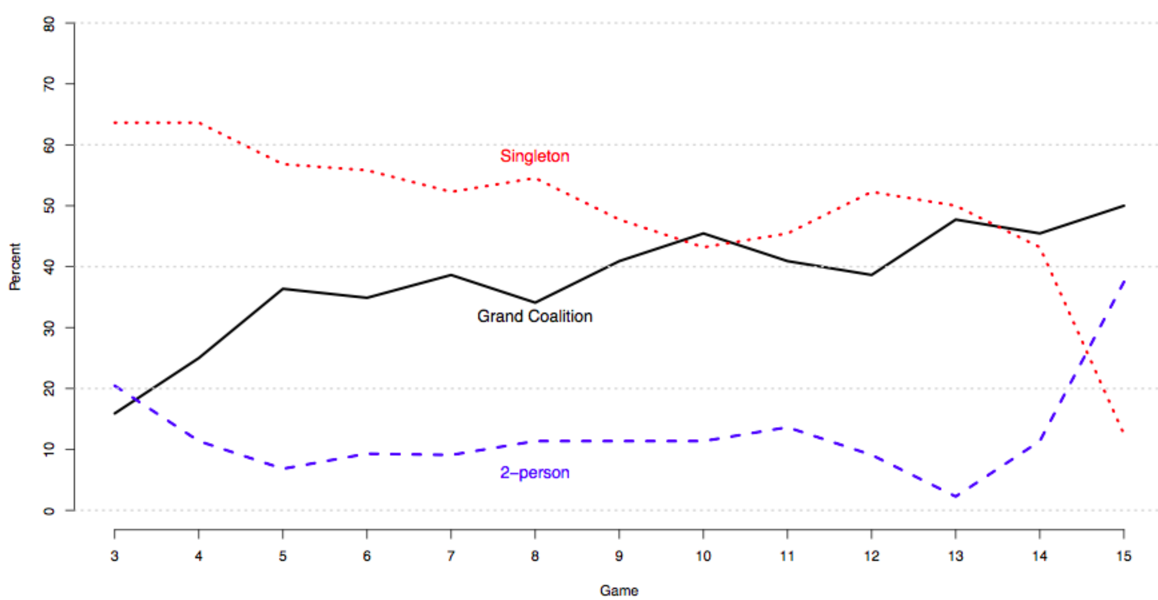


Figure 3: Percentage of final coalition through games, by type

[8]We dropped one paid game in the May 6, 2014 PM session in our analysis due to a software glitch.

In Figure 3 we notice that the proportion of grand coalitions steadily increases while that of singletons decreases. At the very end of the sessions, about half of formed coalitions are grand coalitions. This suggests that as agents learn how the game works, the more they tend to implement the grand coalition. The proportion of 2-person coalitions forming remain relatively steady throughout the games, except for the final game where the proportion increased to 40%.

In this paper we designated games 9 onwards as games in "late" time periods where we suppose that the subjects have gained some knowledge of the experiment. The first set of bars in Figure 4 shows the mean proportion of grand coalitions forming in early games (games 3-8) and late games (games 9 onwards) of the different sessions. The mean proportion of grand coalition in late games is around 40% while the mean proportion for early games is only 30%. This difference is statistically significant using sessions as the unit of observation (p-value= .013, Wilcoxon signed rank test).

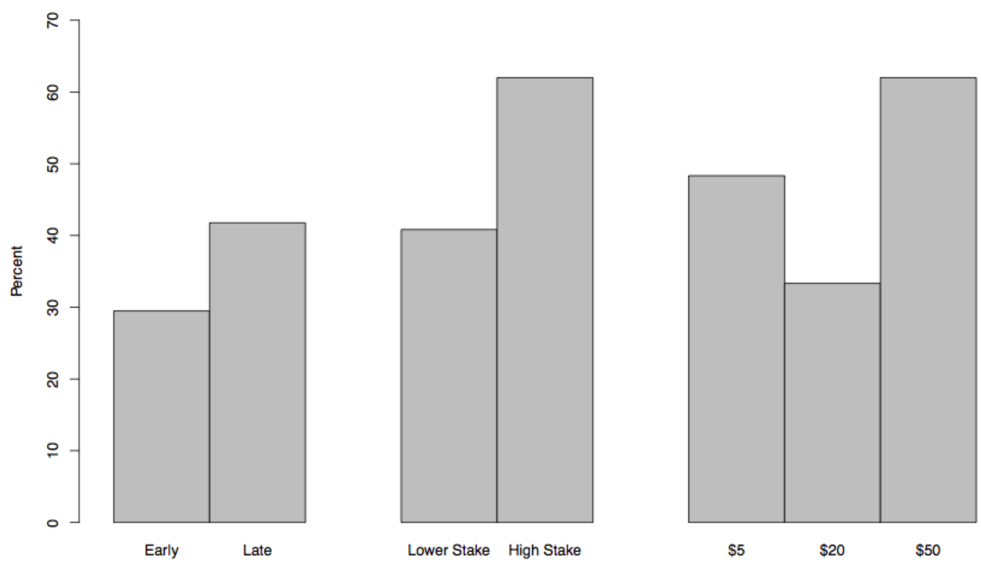


Figure 4: Percentage of grand coalitions forming, by time period and last game stake

The next set of results shows the effect of higher stakes.

**Observation 2** *The difference in the proportion of grand coalitions in high stakes versus low and medium stakes is substantial and significant.*

The middle and rightmost set of bars in Figure 4 shows the percentage of grand coalition formation in the last game of the sessions by stake. In the rightmost set of bars, we see that when agents are offered a pot of $50, close to 70% of coalitions that formed were grand coalitions. However, when the pot was only $20, about 30% of the coalitions were grand, which is lower than the proportion of grand coalitions in the low stake games. In the middle set of bars in Figure 4, we lumped together the \$20 and \$5 into the lower-stakes treatment and calculated the proportion of grand coalitions to total formed coalitions in the last game of the sessions. Using the sessions as the unit of observations, we see that the difference between the proportion of grand coalitions forming in the low and high stakes is substantial (40% vs 62%, respectively) but not statistically significant (p-value$=0.26$, Mann-Whitney test). We also tested the differences in mean proportions of grand coalitions forming for the last game vs the late games (except the last) for both the lower stakes and the higher stakes. The differences in the proportion of grand coalitions forming in the last game vs late games for lower stakes is statistically insignificant using sessions as the unit of observation (p-value$>0.10$, Wilcoxon signed rank test). For the high stake games, this difference is statistically significant (p-value$=0.10$, Wilcoxon signed rank test).

To provide an alternative (higher-powered) test to determine the effect of stakes on the formation of grand coalitions, we used a logit model (Table 2) with specifications that include late games as the sole control, stakes as the sole control, late games and stakes together, and a specification with session fixed effects. We find that the coefficients of the \$50-stake games are robustly positive and statistically significant, showing that increasing the stake size substantially will have a positive effect on the propensity of agents to form grand coalitions.

## 5.1 Analysis of strategies

With such low proportions of grand coalitions forming, it would be instructive to examine the strategies employed by the players. As a first cut, we examine whether subjects are playing myopic strategies and how they affect the proportion of grand coalitions forming. We regard myopic strategies as proposing a two-person coalition to an agent who has a higher power than him or accepting a two-person coalition with someone who has a higher power than him. In the context of our experiment, we tag a strategy as myopic, for instance, if the agent who has power 20 proposes $\{20, 35\}$ or $\{20, 45\}$ or if the agent with power 35 proposes $\{35, 45\}$. In addition, a strategy is deemed myopic if the agent with power 20 accepts to form either $\{20, 35\}$ or $\{20, 45\}$ or if agent with power 35 accepts to form $\{35, 45\}$. We consider alternative definitions of myopic agents:

- Agents that played myopic strategies in half their games (Myopia 1)
- Agents that played myopic strategies in $\frac{1}{3}$ of their games (Myopia 2)
- Agents that played myopic strategies in half of their latter games (Myopia 3)
- Agents that played myopic strategies at least once in their latter games (Myopia 4)

The presence of myopic agents drastically reduces the proportion of grand coalitions. Figure 5 shows this with our various definitions of myopic players. Without the presence of myopic players, the proportion of grand coalition can be as high as around 47% if we define

Table 2: Probability of grand coalition forming

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Grand coalition formed = 1 | | | |
| | (1) | (2) | (3) | (4) |
| Late Games | $0.543^{***}$ | | $0.473^{***}$ | $0.537^{***}$ |
| | (0.149) | | (0.151) | (0.155) |
| Last game, \$5 stake | | 0.582 | 0.336 | 0.160 |
| | | (0.555) | (0.547) | (0.461) |
| Last game, \$20 stake | | −0.111 | −0.357 | −0.458 |
| | | (0.332) | (0.387) | (0.394) |
| Last game, \$50 stake | | $1.275^{**}$ | $1.030^{*}$ | $1.481^{***}$ |
| | | (0.557) | (0.536) | (0.457) |
| Constant | $-0.810^{***}$ | $-0.582^{***}$ | $-0.810^{***}$ | $-0.418^{***}$ |
| | (0.144) | (0.163) | (0.144) | (0.094) |
| Observations | 535 | 535 | 535 | 535 |
| Log Likelihood | −348.544 | −349.188 | −346.052 | −322.198 |
| Akaike Inf. Crit. | 701.087 | 706.376 | 702.105 | 674.395 |
| Session FE | No | No | No | Yes |

*Note:* $^{*}$p<0.1; $^{**}$p<0.05; $^{***}$p<0.01
Standard errors in parentheses are clustered at the session level (11 session-clusters).
Base category for stakes are the games before the last game of the sessions.

myopic players as those who employed myopic strategies at least once in latter games (Myopia 4). Using sessions as unit of observation, except for Myopia 1 the differences in proportions are statistically significant (Wilcoxon signed rank test, p-value$= 0.19$ [Myopia 1], p-value$< .01$ [Myopia 2], p-value$< .01$ [Myopia 3], p-value$< .01$ [Myopia 4]).

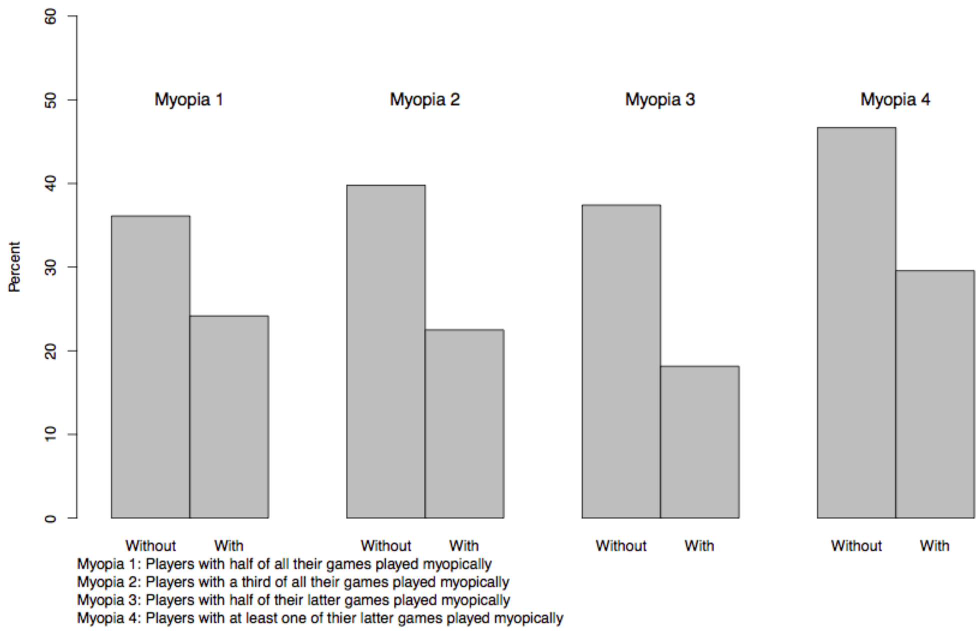


Figure 5: Percentage of grand coalitions forming with and without myopic players

In order to flesh out the actual strategies that our subjects employ, we now look at both the proposal and response stages *at the first round of every game*, that is, we look at the proposals and the responses of each agent every time a new game starts.

**Observation 3** *The proposed coalition is dependent on an agent's power draw. The lower-powered agent (20) proposes the grand coalition more frequently whereas the higher-powered agents (35 and 45) propose a 2-person coalition with the agent with the lowest power (20) more frequently. This is consistent with agents playing their empirical best response which maximizes their expected payoff given the presence of myopic players.*

Table 3 shows the percentage of proposed coalitions by power. While the model predicts that the grand coalition $\{20, 35, 45\}$ forms regardless of the drawn power of the agent proposing, it seems that agents propose coalitions that benefits them in the short run. For instance, for agents that have drawn powers 35 and 45, a large proportion propose a coalition with the agent with the lowest power, that is, agent 20. About 73% of proposals for players who draw power 35 is the coalition $\{20, 35\}$ and 40% of proposals of agents who have drawn power 45 is $\{20, 45\}$. On the other hand, we see that if an agent draws power 20, he proposes the grand coalition $\{20, 35, 45\}$ 60% of the time. About 34% of the time the power-20 agent proposes a 2-person coalition with agent 35.

Table 3: Percentage of proposed coalition at the start of every game, by agent's power

| | $\{20, 35, 45\}$ | $\{20, 35\}$ | $\{20, 45\}$ | $\{35, 45\}$ |
|---|---|---|---|---|
| Power = 20 | 60 | 34 | 6 | - |
| Power = 35 | 20 | 73 | - | 7 |
| Power = 45 | 33 | - | 40 | 27 |

Note: Rows sum to 100%

Table 4 shows the results of these proposals in detail. Line (1) of the Table shows the possible coalitions that can be proposed. For instance, for the agent who has drawn power 20 the possible coalitions he can propose are $\{20, 35, 45\}$, $\{20, 35\}$ or $\{20, 45\}$. Line (2) shows the percentage of the proposed coalition to the total number of proposals made by the agent drawing a particular power. Hence, coalition $\{20, 35, 45\}$ comprise 60% of the total proposals made by agent 20. Line (3) indicates whether the proposed coalition passed (i.e., a majority of agents voted "yes" for this proposed coalition) or failed (i.e., the proposer failed to muster enough "yes" votes), and line (4) shows the percentage of "pass" or "fail" for such coalition proposals.[9] After determining whether a proposed coalition passed or failed, Line (5) lists the possible final coalitions that can form. For instance, if coalition $\{20, 35\}$ passes for agent 20, the possible final coalitions can either be $\{20, 35\}$ (B) or the singleton $\{35\}$ (E). On the other hand, if $\{20, 35\}$ fails, then the possible final coalitions will be the whole gamut of coalitions that can form, that is, $\{20, 35, 45\}$, $\{20, 35\}$, $\{20, 45\}$, $\{35, 45\}$, $\{35\}$ or $\{45\}$ (See the footnote of the table for the labels of coalitions A-F). Conditional on the coalition passing or failing, Line (6) then shows the percentage of each of the possible final coalitions. For example, if $\{20, 35\}$ passes for agent 20, 79% of the time it degenerates into the dictator coalition $\{35\}$. Line (7) shows the final payoff if the specified coalition forms. So for agent 20, coalition $B = \{20, 35\}$ gives the agent $\frac{20}{20+35} \cdot 5 = \$1.82$. Finally, Line (8) shows the expected payoffs of each of the proposal strategies by weighting each final payoff with the appropriate proportions. Tables 5 and 6 present the same information for early and late games, respectively.

We can see in Table 4 that proposing to a lower-powered agent 20 may be consistent with the possibility of the strategies being an empirical best response given that agent 20 has a positive probability of behaving myopically (that is, accepting a 2-person coalition when he

[9]Note that if the grand coalition is proposed, the coalition always passes since it is the default starting coalition when a majority of responders voted "no" for it.

has the lower power). To investigate whether this strategy is indeed an empirical best response, we computed the expected payoffs of the agents given the empirical probabilities obtained in our dataset. In Table 4 we see that for agents who draw power 35 or 45, the strategy that maximizes expected payoff is to propose to the agent with the lowest power (i.e., agent 20). By proposing this coalition, agent 35 for instance will get \$2.84 in expected payoff, which is higher than the expected payoff obtained when he proposes something else. Similarly, agent 45 obtains his maximum expected payoff by proposing $\{20, 45\}$ given the possibility that the proposal will lead to him being a dictator. Playing this strategy yields a higher expected payoff during early games, when agents are still learning the experiment. In early games, proposing a 2-person coalition to the agent with the least power and becoming a dictator is even more lucrative, where the expected payoff is higher than the rest of the possible scenarios the proposer may face. For instance, a 35-powered agent will get \$3.11 in expected payoffs by proposing $\{20, 35\}$. As agents learn more about how to play the experiment in late games, the expected payoff of proposing to the lowest-powered agent diminishes in late games (Table 6). On the other hand, agent 20 maximizes expected payoff by proposing the grand coalition.

Figure 6 shows the evolution of these proposals throughout the games. We can see that for agents with power 20 the proportion of the grand coalition being proposed is gradually rising. This may be an indication that learning is occurring, such that these agents comprehend that proposing the grand coalition will likely not exclude them from the final coalition. The trend of increasing proportion of grand coalition proposals is also true for agent with 35 and 45, although statistical test shows that the the increase is milder for agent 35 (see the logit model in Table 8). This is consistent with the results in Tables 5 and 6. There we can see that for agent 35, proposing the 2-person coalition with the lower-powered agent remains to be an empirical best response which provides him with the highest expected payoff among all his proposal strategies. On the other hand, for agent 45 we can see that in late games the gap in expected payoff from proposing the 2-person coalition with agent 20 and proposing the grand coalition becomes narrower. For agent 45, the expected payoffs of proposing $\{20, 45\}$ vs. $\{20, 35, 45\}$ is \$2.81 vs \$1.05 in early games and \$2.28 vs \$1.65 in late games. For agent 20, the expected payoff from proposing the grand coalition increases from \$0.59 in early games to \$0.66 in late games.

*Proposer = 20*

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Proposed Coalition | $\{20, 35, 45\}$ | | | | | | $\{20, 35\}$ | | | | | | | | $\{20, 45\}$ | | | | | | | |
| (2) Percent of Total Proposals | 60 | | | | | | 34 | | | | | | | | 6 | | | | | | | |
| (3) Outcome of Response | Pass | | | | | | Pass | | Fail | | | | | | Pass | | Fail | | | | | |
| (4) Outcome by Percent | 100 | | | | | | 92 | | 8 | | | | | | 100 | | 0 | | | | | |
| (5) Final Coalition (see Note) | A | B | C | D | E | F | B | E | A | B | C | D | E | F | C | F | A | B | C | D | E | F |
| (6) Frequency (Percent) | 57 | 4 | 0 | 1 | 25 | 13 | 21 | 79 | 40 | 20 | 0 | 20 | 0 | 20 | 8 | 92 | 0 | 0 | 0 | 0 | 0 | 0 |
| (7) Final Payoff ($) | 1 | 1.82 | 1.54 | 0 | 0 | 0 | 1.82 | 0 | 1 | 1.82 | 1.54 | 0 | 0 | 0 | 1.54 | 0 | 1 | 1.82 | 1.54 | 0 | 0 | 0 |
| (8) Expected payoff ($) | 0.64 | | | | | | 0.42 | | | | | | | | 0.12 | | | | | | | |

*Proposer = 35*

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Proposed Coalition | $\{20, 35, 45\}$ | | | | | | $\{20, 35\}$ | | | | | | | | $\{35, 45\}$ | | | | | | | |
| (2) Percent of Total Proposals | 20 | | | | | | 73 | | | | | | | | 7 | | | | | | | |
| (3) Outcome of Response | Pass | | | | | | Pass | | Fail | | | | | | Pass | | Fail | | | | | |
| (4) Outcome by Percent | 100 | | | | | | 39 | | 61 | | | | | | 92 | | 8 | | | | | |
| (5) Final Coalition (see Note) | A | B | C | D | E | F | B | E | A | B | C | D | E | F | D | F | A | B | C | D | E | F |
| (6) Frequency (Percent) | 55 | 0 | 3 | 0 | 17 | 25 | 30 | 70 | 70 | 4 | 0 | 3 | 8 | 15 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 100 |
| (7) Final Payoff ($) | 1.75 | 3.18 | 0 | 2.19 | 5 | 0 | 3.18 | 5 | 1.75 | 3.18 | 0 | 2.19 | 5 | 0 | 2.19 | 0 | 1.75 | 3.18 | 0 | 2.19 | 5 | 0 |
| (8) Expected payoff ($) | 1.80 | | | | | | 2.84 | | | | | | | | 0 | | | | | | | |

*Proposer = 45*

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Proposed Coalition | $\{20, 35, 45\}$ | | | | | | $\{20, 45\}$ | | | | | | | | $\{35, 45\}$ | | | | | | | |
| (2) Percent of Total Proposals | 33 | | | | | | 40 | | | | | | | | 27 | | | | | | | |
| (3) Outcome of Response | Pass | | | | | | Pass | | Fail | | | | | | Pass | | Fail | | | | | |
| (4) Outcome by Percent | 100 | | | | | | 39 | | 61 | | | | | | 35 | | 65 | | | | | |
| (5) Final Coalition (see Note) | A | B | C | D | E | F | C | F | A | B | C | D | E | F | D | F | A | B | C | D | E | F |
| (6) Frequency (Percent) | 47 | 0 | 0 | 0 | 46 | 7 | 25 | 75 | 45 | 14 | 0 | 0 | 34 | 7 | 12 | 88 | 0 | 0 | 0 | 0 | 0 | 0 |
| (7) Final Payoff ($) | 2.25 | 0 | 3.46 | 2.81 | 0 | 5 | 3.46 | 5 | 2.25 | 0 | 3.46 | 2.81 | 0 | 5 | 2.81 | 5 | 2.25 | 0 | 3.46 | 2.81 | 0 | 5 |
| (8) Expected payoff ($) | 1.40 | | | | | | 2.62 | | | | | | | | 2.49 | | | | | | | |

Note: Final Coalitions labels are $A = \{20, 35, 45\}$, $B = \{20, 35\}$, $C = \{20, 45\}$, $D = \{35, 45\}$, $E = \{35\}$, $F = \{45\}$. See the text for the explanation of each of the rows.

Table 4: Expected payoffs by proposal strategy for each power draw, all games

*Proposer = 20*

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Proposed Coalition | $\{20, 35, 45\}$ | | | | | | $\{20, 35\}$ | | | | | | | | $\{20, 45\}$ | | | | | | | |
| (2) Percent of Total Proposals | 41 | | | | | | 48 | | | | | | | | 11 | | | | | | | |
| (3) Outcome of Response | Pass | | | | | | Pass | | Fail | | | | | | Pass | | Fail | | | | | |
| (4) Outcome by Percent | 100 | | | | | | 95 | | 5 | | | | | | 100 | | 0 | | | | | |
| (5) Final Coalition (see Note) | A | B | C | D | E | F | B | E | A | B | C | D | E | F | C | F | A | B | C | D | E | F |
| (6) Frequency (Percent) | 54 | 3 | 0 | 0 | 17 | 26 | 23 | 77 | 50 | 50 | 0 | 0 | 0 | 0 | 11 | 89 | 0 | 0 | 0 | 0 | 0 | 0 |
| (7) Final Payoff ($) | 1 | 1.82 | 1.54 | 0 | 0 | 0 | 1.82 | 0 | 1 | 1.82 | 1.54 | 0 | 0 | 0 | 1.54 | 0 | 1 | 1.82 | 1.54 | 0 | 0 | 0 |
| (8) Expected payoff ($) | 0.59 | | | | | | 0.46 | | | | | | | | 0.17 | | | | | | | |

*Proposer = 35*

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Proposed Coalition | $\{20, 35, 45\}$ | | | | | | $\{20, 35\}$ | | | | | | | | $\{35, 45\}$ | | | | | | | |
| (2) Percent of Total Proposals | 17 | | | | | | 73 | | | | | | | | 10 | | | | | | | |
| (3) Outcome of Response | Pass | | | | | | Pass | | Fail | | | | | | Pass | | Fail | | | | | |
| (4) Outcome by Percent | 100 | | | | | | 47 | | 53 | | | | | | 100 | | 0 | | | | | |
| (5) Final Coalition (see Note) | A | B | C | D | E | F | B | E | A | B | C | D | E | F | D | F | A | B | C | D | E | F |
| (6) Frequency (Percent) | 58 | 0 | 3 | 0 | 21 | 21 | 22 | 78 | 67 | 10 | 0 | 0 | 6 | 17 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| (7) Final Payoff ($) | 1.75 | 3.18 | 0 | 2.19 | 5 | 0 | 3.18 | 5 | 1.75 | 3.18 | 0 | 2.19 | 5 | 0 | 2.19 | 0 | 1.75 | 3.18 | 0 | 2.19 | 5 | 0 |
| (8) Expected payoff ($) | 2.07 | | | | | | 3.11 | | | | | | | | 0 | | | | | | | |

*Proposer = 45*

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Proposed Coalition | $\{20, 35, 45\}$ | | | | | | $\{20, 45\}$ | | | | | | | | $\{35, 45\}$ | | | | | | | |
| (2) Percent of Total Proposals | 24 | | | | | | 48 | | | | | | | | 28 | | | | | | | |
| (3) Outcome of Response | Pass | | | | | | Pass | | Fail | | | | | | Pass | | Fail | | | | | |
| (4) Outcome by Percent | 100 | | | | | | 38 | | 62 | | | | | | 41 | | 59 | | | | | |
| (5) Final Coalition (see Note) | A | B | C | D | E | F | C | F | A | B | C | D | E | F | D | F | A | B | C | D | E | F |
| (6) Frequency (Percent) | 38 | 0 | 0 | 0 | 58 | 4 | 6 | 94 | 52 | 17 | 0 | 0 | 24 | 7 | 18 | 82 | 50 | 6 | 0 | 0 | 44 | 0 |
| (7) Final Payoff ($) | 2.25 | 0 | 3.46 | 2.81 | 0 | 5 | 3.46 | 5 | 2.25 | 0 | 3.46 | 2.81 | 0 | 5 | 2.81 | 5 | 2.25 | 0 | 3.46 | 2.81 | 0 | 5 |
| (8) Expected payoff ($) | 1.05 | | | | | | 2.81 | | | | | | | | 2.54 | | | | | | | |

Note: Final Coalitions labels are $A = \{20, 35, 45\}$, $B = \{20, 35\}$, $C = \{20, 45\}$, $D = \{35, 45\}$, $E = \{35\}$, $F = \{45\}$. See the text for the explanation of each of the rows.

Table 5: Expected payoffs by proposal strategy for each power draw, early games

*Proposer = 20*

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Proposed Coalition | $\{20, 35, 45\}$ | | | | | | $\{20, 35\}$ | | | | | | | | $\{20, 45\}$ | | | | | | | |
| (2) Percent of Total Proposals | 76 | | | | | | 21 | | | | | | | | 3 | | | | | | | |
| (3) Outcome of Response | Pass | | | | | | Pass | | Fail | | | | | | Pass | | Fail | | | | | |
| (4) Outcome by Percent | 100 | | | | | | 85 | | 15 | | | | | | 100 | | 0 | | | | | |
| (5) Final Coalition (see Note) | A | B | C | D | E | F | B | E | A | B | C | D | E | F | C | F | A | B | C | D | E | F |
| (6) Frequency (Percent) | 59 | 4 | 0 | 1 | 29 | 7 | 18 | 82 | 33 | 0 | 0 | 33 | 0 | 34 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| (7) Final Payoff ($) | 1 | 1.82 | 1.54 | 0 | 0 | 0 | 1.82 | 0 | 1 | 1.82 | 1.54 | 0 | 0 | 0 | 1.54 | 0 | 1 | 1.82 | 1.54 | 0 | 0 | 0 |
| (8) Expected payoff ($) | 0.66 | | | | | | 0.32 | | | | | | | | 0 | | | | | | | |

*Proposer = 35*

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Proposed Coalition | $\{20, 35, 45\}$ | | | | | | $\{20, 35\}$ | | | | | | | | $\{35, 45\}$ | | | | | | | |
| (2) Percent of Total Proposals | 23 | | | | | | 73 | | | | | | | | 4 | | | | | | | |
| (3) Outcome of Response | Pass | | | | | | Pass | | Fail | | | | | | Pass | | Fail | | | | | |
| (4) Outcome by Percent | 100 | | | | | | 33 | | 67 | | | | | | 75 | | 25 | | | | | |
| (5) Final Coalition (see Note) | A | B | C | D | E | F | B | E | A | B | C | D | E | F | D | F | A | B | C | D | E | F |
| (6) Frequency (Percent) | 55 | 0 | 5 | 0 | 13 | 27 | 39 | 61 | 72 | 0 | 0 | 4 | 9 | 15 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 100 |
| (7) Final Payoff ($) | 1.75 | 3.18 | 0 | 2.19 | 5 | 0 | 3.18 | 5 | 1.75 | 3.18 | 0 | 2.19 | 5 | 0 | 2.19 | 0 | 1.75 | 3.18 | 0 | 2.19 | 5 | 0 |
| (8) Expected payoff ($) | 1.63 | | | | | | 2.61 | | | | | | | | 0 | | | | | | | |

*Proposer = 45*

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Proposed Coalition | $\{20, 35, 45\}$ | | | | | | $\{20, 45\}$ | | | | | | | | $\{35, 45\}$ | | | | | | | |
| (2) Percent of Total Proposals | 43 | | | | | | 31 | | | | | | | | 26 | | | | | | | |
| (3) Outcome of Response | Pass | | | | | | Pass | | Fail | | | | | | Pass | | Fail | | | | | |
| (4) Outcome by Percent | 100 | | | | | | 40 | | 60 | | | | | | 29 | | 71 | | | | | |
| (5) Final Coalition (see Note) | A | B | C | D | E | F | C | F | A | B | C | D | E | F | D | F | A | B | C | D | E | F |
| (6) Frequency (Percent) | 54 | 0 | 0 | 0 | 37 | 9 | 60 | 40 | 33 | 7 | 0 | 0 | 53 | 7 | 0 | 100 | 34 | 13 | 0 | 0 | 40 | 13 |
| (7) Final Payoff ($) | 2.25 | 0 | 3.46 | 2.81 | 0 | 5 | 3.46 | 5 | 2.25 | 0 | 3.46 | 2.81 | 0 | 5 | 2.81 | 5 | 2.25 | 0 | 3.46 | 2.81 | 0 | 5 |
| (8) Expected payoff ($) | 1.65 | | | | | | 2.28 | | | | | | | | 2.44 | | | | | | | |

Note: Final Coalitions labels are $A = \{20, 35, 45\}$, $B = \{20, 35\}$, $C = \{20, 45\}$, $D = \{35, 45\}$, $E = \{35\}$, $F = \{45\}$. See the text for the explanation of each of the rows.

Table 6: Expected payoffs by proposal strategy for each power draw, late games

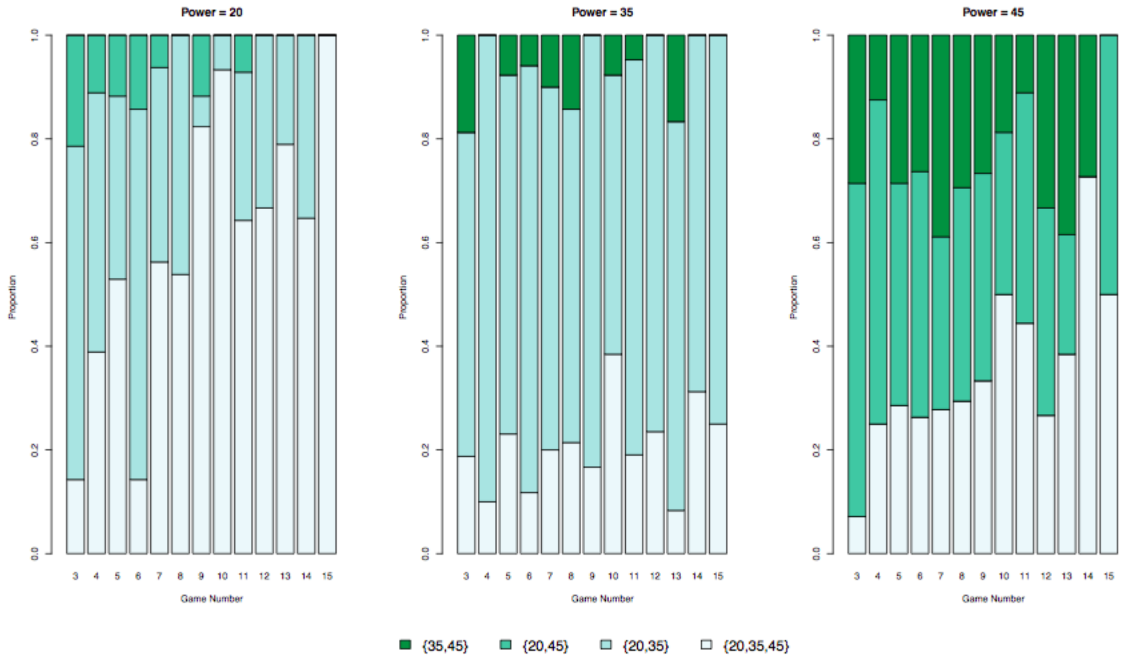


Figure 6: Percentage of proposed coalition at the start of every game, by game and agent's power

**Observation 4** *Responses are dependent on an agent's drawn power. Higher-powered agents tend to accept 2-person coalitions with an agent with a lower power. A substantial proportion of responses accept the grand coalition when offered.*

Table 7: Percentage of responses at the start of every game, by agent's power and proposed coalition

| | $\{20,35,45\}$ | | $\{20,35\}$ | | $\{20,45\}$ | | $\{35,45\}$ | |
|---|---|---|---|---|---|---|---|---|
| | Accept | Reject | Accept | Reject | Accept | Reject | Accept | Reject |
| Power = 20 | 31 | 1 | 17 | 26 | 10 | 15 | - | - |
| Power = 35 | 51 | 10 | 20 | 2 | - | - | 6 | 11 |
| Power = 45 | 81 | 5 | - | - | 7 | 0 | 7 | 0 |

Note: Rows sum to 100%

Table 7 shows some interesting patterns regarding the responses of the agents. First, higher power agents tend to overwhelmingly accept a 2-person coalition with an agent with a lower power. For instance, agent 35 tend to almost always accept $\{20, 35\}$ and agent 45 always accepts $\{20, 45\}$ and $\{35, 45\}$. This strategy may be consistent with both subgame perfect equilibrium strategy (off the equilibrium path) and also exhibiting other-regarding behavior

(Bolton and Ockenfels [7]), in the sense that they care for the lower-powered agent to get a higher share than staying at the grand coalition. However, the latter may not be true since as Figure 3 shows, the proportion of 2-person final coalition forming seem to be relatively low. Hence, the 2-person coalition will more likely to deviate into a singleton rather than stay at the 2-person coalition. In Table 4, for instance, if agent 20 proposed $\{20, 35\}$ and it passes, 79% of the time it degenerates into a singleton coalition where 35 is the dictator.

Another interesting pattern is that agent who draw power 45 face a proposed grand coalition 86% of the time but the agent with power 35 only face the grand coalition around 61% of every first round proposals. This is indicative of a reluctance by the lower powered agents to include 45 in a 2-person coalition, since they know that it could lead to two things: first, they could get a relatively lower payoff compared to a 2-person coalition with a lower-powered agent and second, they know that agent 45 can kill them. This behavior may be consistent with both empirical expected payoff maximization and farsighted behavior.

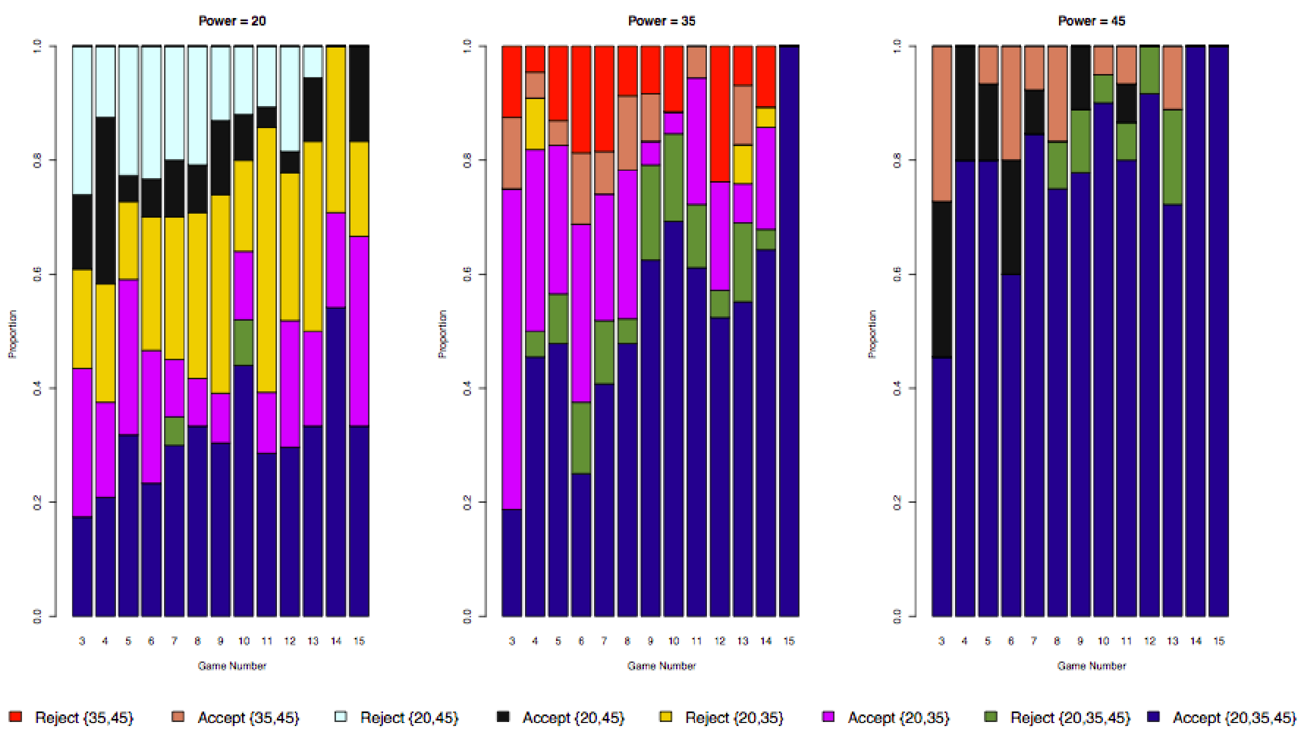


Figure 7: Percentage of responses at the start of every game, by game and agent's power

Figure 7 shows how these responses evolve throughout the games. For agent with drawn power 20, the proportion of rejecting 2-person coalitions increases throughout games and at the same time the proportion of accepting the grand coalition is also increasing (see Table 10). For both agents drawing power 35 and 45, the proportion of accepted grand coalitions increases over time. Agent 45 almost always face a proposed grand coalition, and most of them are accepted.

In order to assess the probability of proposing the grand coalition, we employ a logit analysis that takes into account an agents power as well as several possible scenarios of immediate past experience. These experience variables are (1) agents have no prior experience in proposing a coalition when currently chosen to be a proposer; (2) proposed a 2-person coalition in the last time the agent was chosen to be a proposer and being in the final coalition that formed during that time; (3) proposed a 2-person coalition in the last time the agent was chosen to be a proposer but being out of the final coalition that formed during that time; (4) proposed the grand coalition in the last time the agent was chosen to be a proposer and being in final coalition that formed during that time; and (5) proposed the grand coalition in the last time the agent was chosen to be a proposer but being out of the final coalition that formed during that time.

We ran five specifications: (1) with just the agents' power as controls; (2) with an interaction of power and late games; (3) with just prior experience as controls; (4) both power and experience as controls; and (5) power, experience, stakes, and late game interactions as controls.

Table 8 provides corroborating evidence to the analysis we have presented earlier. First, agents with relatively higher power (i.e., agents 35 and 45) have a lower probability of proposing the grand coalition, and this result is robust throughout all specifications. Another robust finding is that when agents propose the grand coalition when he was last a proposer, he will more likely propose the grand coalition if chosen as a proposer again. This is shown by the positive and statistically significant coefficients on the "Proposed grand" variable throughout all specifications. The interaction with late games shows up positive and significant, echoing our prior result that more grand coalitions are proposed during late games.

We likewise performed a similar analysis with response strategies. We first examined the probability of accepting the grand coalition conditional on being proposed a grand coalition. In these runs we also account for immediate past experience in responding to a proposed coalition. These possible scenarios are: (1) agents have no prior experience in responding when currently chosen to be a responder; (2) accepting a 2-person coalition in the last time that an agent was chosen to be a responder and being in the final coalition that formed during that time; (3) accepting a 2-person coalition in the last time that an agent was chosen to be a responder but being out of the final coalition that formed during that time; (4) rejecting a 2-person coalition

Table 8: Probability of proposing the grand coalition

| | *Dependent variable:* | | | | |
|---|---|---|---|---|---|
| | Grand coalition proposed = 1 | | | | |
| | (1) | (2) | (3) | (4) | (5) |
| Power = 35 | $-1.743^{***}$ | $-1.194^{***}$ | | $-1.961^{***}$ | $-1.259^{***}$ |
| | (0.249) | (0.200) | | (0.239) | (0.194) |
| Power = 45 | $-1.102^{***}$ | $-0.769^{***}$ | | $-1.272^{***}$ | $-0.800^{***}$ |
| | (0.281) | (0.236) | | (0.256) | (0.219) |
| Late games | | $1.512^{***}$ | | | $1.973^{***}$ |
| | | (0.377) | | | (0.431) |
| Power = 35 x Late games | | $-1.160^{***}$ | | | $-1.482^{***}$ |
| | | (0.438) | | | (0.567) |
| Power = 45 x Late games | | $-0.659$ | | | $-0.943^{**}$ |
| | | (0.487) | | | (0.382) |
| Proposed 2-person, in final | | | 0.236 | 0.362 | 0.120 |
| | | | (0.308) | (0.344) | (0.417) |
| Proposed 2-person, out of final | | | 0.277 | 0.271 | 0.268 |
| | | | (0.256) | (0.309) | (0.513) |
| Proposed grand, in final | | | $1.517^{***}$ | $1.865^{***}$ | $1.667^{***}$ |
| | | | (0.184) | (0.196) | (0.494) |
| Proposed grand, out of final | | | $1.327^{***}$ | $1.483^{***}$ | 0.830 |
| | | | (0.297) | (0.346) | (0.514) |
| $5 stake | | | | | 0.044 |
| | | | | | (0.427) |
| $20 stake | | | | | 0.744 |
| | | | | | (0.475) |
| $50 stake | | | | | $1.215^{**}$ |
| | | | | | (0.489) |
| Constant | $0.392^{**}$ | $-0.357^{*}$ | $-1.019^{***}$ | $-0.134$ | $-0.606^{**}$ |
| | (0.179) | (0.198) | (0.222) | (0.277) | (0.290) |
| Experience/Late Game Interaction | No | No | No | No | Yes |
| Observations | 535 | 535 | 535 | 535 | 535 |
| Log Likelihood | −324.462 | −308.903 | −334.516 | −299.883 | −287.569 |
| Akaike Inf. Crit. | 654.923 | 629.806 | 679.032 | 613.766 | 609.137 |

*Note:* $^{*}$p<0.1; $^{**}$p<0.05; $^{***}$p<0.01
Standard errors in parentheses are clustered at the session level (11 session-clusters).
Base category for stakes are the games before the last game of the sessions.

in the last time that an agent was chosen to be a responder and being in the final coalition that formed during that time; (5) rejecting a 2-person coalition in the last time that an agent was chosen to be a responder but being out of the final coalition that formed during that time; (6) accepting the grand coalition in the last time that an agent was chosen to be a responder and being in the final coalition that formed during that time; (7) accepting the grand coalition in the last time that an agent was chosen to be a responder but being out of the final coalition that formed during that time; (8) rejecting the grand coalition in the last time that an agent was chosen to be a responder and being in the final coalition that formed during that time; and (9) rejecting the grand coalition in the last time that an agent was chosen to be a responder but being out of the final coalition that formed during that time.

The first specification in Table 9 show that while the coefficient is negative for agents 35 (significant) and 45 (not significant), the intercept is still sufficiently large such that there is still a positive probability in accepting a grand coalition. This is consistent with the findings in Table 7 where agents, when faced with a proposed grand coalition, tend to accept it. The experience variables do not seem to be robust, but some results are worth mentioning. First, the "Accept 2 person-out" may signify that agent may be willing to take risk with being in a 2-person coalition for the chance at a higher payoff. Second, the "Reject grand, in" decreases the probability of accepting the grand coalition, suggesting a form of hysteresis in the response strategies.

Finally, we examine the probability that the agents will accept a 2-person coalition conditional on being proposed a 2-person coalition. We likewise control for the same experience variable as in the case where we analyzed the probability of accepting the grand coalition. The difference is here we split the agent with power 35 into two scenarios, one when offered the coalition $\{20, 35\}$ and the other when offered the coalition $\{20, 45\}$ to account for the possible differences in strategies when faced with these different coalitions. In Table 10 we see that drawing a higher power robustly increases the probability that agents will accept a two person coalition. This effect is particularly strong for agent 45, since he can always propose to be a dictator once a two person coalition that includes him forms. The other robust variable shows that rejecting the grand coalition in the last time he was a responder makes an agent increase his probability that a 2-person coalition will be accepted. This also suggests some consistency and hysteresis in the behavior of these agents.

Table 9: Probability of accepting a grand coalition

| | Dep. variable: Accepting the grand coalition=1 | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Power = 35 | −1.686** | −1.896* | | −1.609** | −2.459** |
| | (0.745) | (0.998) | | (0.801) | (1.124) |
| Power = 45 | −0.715 | 0.260 | | −0.585 | 0.179 |
| | (0.768) | (0.161) | | (0.863) | (0.280) |
| Late games | | −0.297 | | | 15.787*** |
| | | (0.784) | | | (1.386) |
| Power = 35 x Late games | | 0.331 | | | 1.164 |
| | | (0.838) | | | (1.073) |
| Power = 45 x Late games | | −1.188 | | | −0.653 |
| | | (0.896) | | | (0.899) |
| Accept 2-person, in final | | | −1.386 | −1.259 | −1.559 |
| | | | (0.959) | (1.036) | (1.233) |
| Accept 2-person, out of final | | | −2.079** | −1.906** | −0.831 |
| | | | (0.821) | (0.931) | (1.217) |
| Reject 2-person, in final | | | −1.144 | −1.107 | −1.827 |
| | | | (0.912) | (0.934) | (1.221) |
| Reject 2-person, out of final | | | −1.553 | −1.653 | 16.662*** |
| | | | (1.048) | (1.025) | (0.712) |
| Accept grand, in final | | | 1.602 | 1.684 | 16.603*** |
| | | | (1.250) | (1.321) | (0.871) |
| Accept grand, out of final | | | −0.907 | −0.763 | 16.574*** |
| | | | (0.658) | (0.705) | (1.134) |
| Reject grand, in final | | | −3.104*** | −3.080*** | −2.953 |
| | | | (0.938) | (0.964) | (2.775) |
| Reject grand, out of final | | | −1.649 | −1.480 | 17.440*** |
| | | | (1.377) | (1.323) | (2.022) |
| $5 stake | | | | | 17.569*** |
| | | | | | (1.150) |
| $20 stake | | | | | 18.185*** |
| | | | | | (1.222) |
| $50 stake | | | | | 0.804 |
| | | | | | (1.351) |
| Constant | 3.423*** | 3.611*** | 3.258*** | 4.220*** | 4.584*** |
| | (0.675) | (0.945) | (0.666) | (0.846) | (1.179) |
| Experience/Late Game Interaction | No | No | No | No | Yes |
| Observations | 406 | 406 | 406 | 406 | 406 |
| Log Likelihood | −117.490 | −116.122 | −103.694 | −98.239 | −87.699 |
| Akaike Inf. Crit. | 240.979 | 244.243 | 225.387 | 218.477 | 225.398 |

*Note:* *p<0.1; **p<0.05; ***p<0.01. Standard errors in parentheses are clustered at the session level (11 session-clusters).
Base category for stakes are the games before the last game of the sessions.

Table 10: Probability of accepting a two person coalition

| | Dep. variable: Accepting two-person coalition =1 | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Power = 35, $\{20, 35\}$ | 2.876*** | 3.297*** | | 2.963*** | 3.341*** |
| | (0.727) | (0.860) | | (0.794) | (0.934) |
| Power = 35, $\{35, 45\}$ | −0.141 | −0.048 | | −0.178 | −0.041 |
| | (0.290) | (0.505) | | (0.282) | (0.576) |
| Power = 45 | 18.026*** | 17.893*** | | 18.044*** | 18.004*** |
| | (0.463) | (0.479) | | (0.473) | (0.467) |
| Late games | | −0.288 | | | 0.451 |
| | | (0.360) | | | (1.255) |
| Power = 35, $\{20, 35\}$ x Late games | | −0.948 | | | −0.596 |
| | | (0.982) | | | (1.159) |
| Power = 35, $\{35, 45\}$ x Late games | | −0.254 | | | −0.470 |
| | | (0.928) | | | (0.956) |
| Power = 45 x Late games | | 0.288 | | | −0.261 |
| | | (0.773) | | | (0.663) |
| Accept 2-person, in final | | | −0.285 | −0.311 | −0.319 |
| | | | (0.311) | (0.328) | (0.467) |
| Accept 2-person, out of final | | | −0.144 | 0.165 | −0.057 |
| | | | (0.271) | (0.334) | (0.401) |
| Reject 2-person, in final | | | −1.534*** | −1.724*** | −1.185 |
| | | | (0.379) | (0.455) | (0.745) |
| Reject 2-person, out of final | | | −0.818* | −0.755* | −0.838 |
| | | | (0.457) | (0.446) | (1.018) |
| Accept grand, in final | | | −0.814*** | −0.660*** | −0.558 |
| | | | (0.258) | (0.200) | (0.403) |
| Accept grand, out of final | | | −0.859** | −0.534** | −0.376 |
| | | | (0.338) | (0.239) | (0.574) |
| Reject grand, in final | | | −0.076 | −0.056 | 0.141 |
| | | | (0.715) | (0.773) | (1.410) |
| Reject grand, out of final | | | 13.930*** | 17.575*** | 17.173*** |
| | | | (0.688) | (0.718) | (1.337) |
| $5 stake | | | | | −1.488*** |
| | | | | | (0.529) |
| $20 stake | | | | | −0.781 |
| | | | | | (1.680) |
| $50 stake | | | | | 0.691 |
| | | | | | (0.643) |
| Constant | −0.460** | −0.327* | 0.636*** | −0.009 | −0.058 |
| | (0.203) | (0.184) | (0.195) | (0.190) | (0.196) |
| Experience/Late Game Interaction | No | No | No | No | Yes |
| Observations | 332 | 332 | 332 | 332 | 332 |
| Log Likelihood | −181.300 | −179.578 | −218.975 | −171.540 | −170.199 |
| Akaike Inf. Crit. | 370.600 | 375.157 | 455.949 | 367.080 | 384.398 |

*Note:* *p<0.1; **p<0.05; ***p<0.01. Standard errors in parentheses are clustered at the session level (11 session-clusters).
Base category for stakes are the games before the last game of the sessions.

## 5.2 Typology of agents

In the previous subsection we looked at the type of strategies that were played in the experiment. Here we will attempt to categorize subjects into several types depending on the strategies they play. Note that the subjects may play different types of strategies throughout the games, and in this exercise we will attempt to assign subjects based on a scoring method called quadratic deviation measure (QDM) (see Nagel and Fang [23] as well as Selten [27] for an axiomatic analysis of the method). This measure takes the quadratic difference between the actual choice vector of a subject in a potential move and the choice vector predicted by the model. Let $c_{i,\alpha(m)}(t) = [c_{i,\alpha(m)}(1), \ldots, c_{i,\alpha(m)}(T)]$ be the strategy choices that an agents make in round $t$ given a model $m$, whether he's a proposer or a responder. Note that the choice can be any coalition if he's a proposer, or whether to accept or reject the coalition if he's a responder. Specifically, each element in this choice vector takes on the value

$$c_{i,\alpha(m)}(t) = \begin{cases} 1 & \text{if strategy } \alpha \text{ prescribed by model } m \text{ is chosen in round t} \\ 0 & \text{otherwise} \end{cases}$$

Here, we choose three types of models. First, the **equilibrium model** where agents play the subgame perfect equilibrium strategies. In our setting, this corresponds to subjects proposing $\{20, 35, 45\}$ and nothing else, and accepting $\{20, 35, 45\}$. Also part of the SPNE strategy is to accept a 2-person coalition whenever an agent has the higher power. Hence, the choice vector $c_{i,\alpha(eq)}(t)$ will get 1 in the $t^{th}$ index if he is a proposer and he proposes $\{20, 35, 45\}$ or if he is a responder and he accepts $\{20, 35, 45\}$ or accepts a 2-person coalition if he has the higher power. Otherwise, the vector registers a zero in the $t^{th}$ index. The second type of model is the **myopic model**. In this model, agents play myopic strategies where lower-powered agents propose a 2-person coalition with a higher-powered agent when it's his turn to propose, or accept a 2-person coalition with a higher-powered agent when it is time to respond. Here, the choice vector $c_{i,\alpha(myo)}(t)$ will get 1 in the $t^{th}$ index if, for instance, a subject has power 20 and he proposes $\{20, 35\}$ or $\{20, 45\}$. If agent 20 is a responder and he accepts $\{20, 35\}$ or $\{20, 45\}$ then he also gets a 1 on the $t^{th}$ index. The third type of model is where subjects play their **empirical best response**. Here, if an agent is a proposer the he will propose to a lower-powered agent or propose himself if a 2-person coalition has formed. If he is a responder, he will accept a 2-person coalition from a lower-powered agent or reject a 2-person coalition if he has a lower power. Here, the choice vector $c_{i,\alpha(br)}(t)$ will get 1 in the $t^{th}$ index if, for instance, a subject has power 45 and he proposes $\{20, 45\}$ or $\{35, 45\}$. If agent 45 is a responder and he accepts $\{20, 45\}$ or $\{35, 45\}$ then he also gets a 1 on the $t^{th}$ index. We have shown that this strategy is consistent to maximizing the expected payoffs given the empirical probabilities given in Tables 4.4 to 4.6.

Let $p_{i,\alpha(m)}(t) = [p_{i,\alpha(m)}(1), \ldots, p_{i,\alpha(m)}(T)]$ be the vector of predicted choices given a model. This vector will register a 1 on the $t^{th}$ index if there is an opportunity to play a strategy prescribed by a model. For instance, in the best response model if you have power 35 or 45 and chosen to be a proposer in round 1, then you have the opportunity to play a best response strategy (i.e., propose to a lower-powered agent) and thus a 1 registered in the first index if you are a proposer. Hence,

$$p_{i,\alpha(m)}(t) = \begin{cases} 1 & \text{if strategy } \alpha \text{ can be played in round t} \\ 0 & \text{otherwise} \end{cases}$$

The quadratic deviation measure for a particular agent $i$ in model $m$ is thus given by:

$$QDM_{i,m} = \frac{\sum_t^T (c_{i,\alpha(m)}(t) - p_{i,\alpha(m)}(t))^2}{T} \tag{1}$$

Clearly, a $QDM_{i,m}$ closer to zero indicates a high proportion of strategies employed by the agents coinciding with those prescribed by model $m$. We then categorize the subjects into equilibrium players, myopic players, or empirical best response players by simply taking the minimum of QDMs for the three models for each subject $i$, that is,

$$type_i = \begin{cases} \text{Equilibrium} \quad \text{if } QDM_{i,eq} = \arg\min(QDM_{i,eq}, QDM_{i,myo}, QDM_{i,ebr}) \\ \text{Myopic} \quad \text{if } QDM_{i,myo} = \arg\min(QDM_{i,eq}, QDM_{i,myo}, QDM_{i,ebr}) \\ \text{Empirical Best Response} \quad \text{if } QDM_{i,br} = \arg\min(QDM_{i,eq}, QDM_{i,myo}, QDM_{i,ebr}) \end{cases}$$

Table 11 summarizes the subject types across sessions for all games, early games and late games. It is clear that there are very diverse types of agents in the experiment. About 44% of the agents can be classified as "equilibrium players", 23% of the agents can be classified as "myopic" while 33% of the agents can be classified as mainly playing "equilibrium best response" strategies. There is also a substantial heterogeneity within sessions as some sessions are dominated by "equilibrium" players, such as the February 4, 2015, AM session and some sessions are dominated by myopic players, such as the June 23, 2014 session.

An interesting pattern is the decrease in number of myopic agents, as well as the increase in the number of "equilibrium" agents, when we move to late games. For instance, in early games 29% of the agents are classified as myopic but this percentage declines to 19% in late games. The proportion of "equilibrium" agents increases from 41% in early games to 55% in late games. This echoes the recurring finding that agents seem to learn the more they play our coalition formation game. This increase in the number of equilibrium subjects and the decrease of myopic subjects are probably the reasons why the proportion of grand coalitions forming in the late rounds is increasing.

# 6 Conclusion

The debate between AES and Tullock highlights how nuances in assumptions of human behavior affect how coalitions form and evolve. Dictatorships will be more common if agents behave myopically–that is, if agents do not take into account further possible ramifications of joining a particular group. If agents are farsighted, as in the AES case, the higher the chance that groups do not degenerate into a dictatorship. Our results in this paper suggest that agents' behavior is more complicated than what the dichotomy of the debate alleges. Indeed, we actually observe a lot of rational behavior, with some agents taking advantage of myopic agents especially in early games when agents do not have much experience playing. This behavior naturally leads to a proliferation of dictatorships. However, given sufficient time the agents learn how to behave more strategically and rationally, therefore avoiding being part of a coalition where they could be sidelined in the future.

The evidence in this paper has yielded some important insights. First, the agents' strategies are contingent on the power that they have drawn. In particular, many agents seem to be playing their empirical best response to the possibility that the other agents behave myopically. For instance, higher powered agents seem to propose the coalition with agent 20 in it. This is consistent with the behavior that agents maximize their expected payoff by taking advantage of the probability that the agent 20 may play myopically and accept the coalition which could then lead the higher-powered agent to form a dictatorship. Second, there is some hysteresis in the way agents are playing their strategies. For instance, agents who tend to accept a 2-person coalition or reject the grand coalition in the last time they were a responder increases the probability that they would accept a 2-person coalition when he is tasked to respond to such a coalition. This is an indication of the consistency of behavioral types. In addition, there is some evidence of an positive incentive effect of substantial stakes.

| Sessions | Number of Subjects | All games | | | Early games | | | Late games | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Equilibrium | Myopic | Empirical Best Response | Equilibrium | Myopic | Empirical Best Response | Equlibrium | Myopic | Empirical Best Response |
| May 6, 2014, AM | 12 | 5 | 2 | 5 | 6 | 2 | 4 | 7 | 2 | 3 |
| May 6, 2014, PM | 15 | 9 | 2 | 4 | 8 | 2 | 5 | 7 | 4 | 4 |
| May 7, 2014 | 12 | 7 | 3 | 2 | 5 | 4 | 3 | 8 | 2 | 2 |
| June 5, 2014 | 9 | 1 | 4 | 4 | 3 | 4 | 2 | 4 | 3 | 2 |
| June 6, 2014 | 12 | 3 | 4 | 5 | 1 | 4 | 5 | 5 | 2 | 5 |
| June 23, 2014 | 9 | 0 | 7 | 2 | 3 | 5 | 1 | 0 | 6 | 3 |
| June 24, 2014 | 6 | 2 | 1 | 3 | 1 | 2 | 3 | 4 | 1 | 1 |
| February 4, 2015, AM | 15 | 10 | 1 | 4 | 8 | 5 | 2 | 11 | 1 | 3 |
| February 4, 2015, PM | 15 | 9 | 1 | 5 | 8 | 4 | 3 | 11 | 1 | 3 |
| February 5, 2015, AM | 12 | 5 | 4 | 3 | 4 | 4 | 4 | 6 | 2 | 4 |
| February 5, 2015, PM | 15 | 7 | 2 | 6 | 8 | 2 | 5 | 10 | 1 | 4 |
| Overall (Number) | 132 | 58 | 31 | 43 | 55 | 38 | 39 | 73 | 25 | 34 |
| Overall (Percent) | 100 | 44 | 23 | 33 | 41 | 29 | 30 | 55 | 19 | 26 |
| Min QDM | | 0 | 0.12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Max QDM | | 7.31 | 11.6 | 7.68 | 3.26 | 10.56 | 3.27 | 4.76 | 10.56 | 5.33 |
| Mean QDM | | 1.39 | 3.17 | 1.40 | 0.83 | 1.51 | 0.65 | 0.74 | 1.88 | 0.89 |

Table 11: Subject type by session for all games, early games and late games

Given our experimental setup it is hard to disentangle strategies that exhibit some of the common behavioral phenomena such as other-regarding behavior. After all, proposing the grand coalition in this experiment is also consistent with having pro-social preferences. However, in the majority of cases there is evidence to suggest that this behavior can be ruled out. For instance, when faced with a 2-person coalition with a lower-powered agent, an overwhelming proportion of these agents will propose himself to be a dictator.[10]

All these results taken together suggest that elements of both Tullock and AES are important to understand the richness and complexity of how people form groups. From this experiment we see that people are rational, albeit through a trial-and-error learning process. Thus, the Tullock effect dominates until learning the game kicks in. The presence of a small number of myopic players is enough to drive rational agents to propose a 2-person coalition. This points out the importance of heterogeneity of behavioral types in the coalition formation process.

## 6.1 Extensions

There are several ways to extend our coalition formation experiment. First, the experiment can investigate how the sharing rules affect how coalitions are formed. In our particular coalition formation game, the theoretical prediction will not change if we change our sharing rule to equal sharing.[11] It is an open question whether the proportion of grand coalitions forming will be different under the two sharing rules.

Another interesting extension is the issue of endogenizing the sharing rule. Apart from the coalition that can form, agents can bargain over the split of the prize as well. This issue is still a loose end for both theory and experiment.

In the case of proportional sharing, it may be rational for a high-powered agent to "decrease" his power in order to incentivize other agents to include him in a self-enforcing coalition. Whether high-powered agents actually accumulate or decrease power when given the option is an interesting study for both theory and experiment.

[10]The only case where it does not happen is in the late games when agent 45 proposes $\{20, 45\}$ and if passed, about 60% of the time this 2-person coalition still forms.

[11]Equal sharing or proportional sharing satisfy a property where agents have the same ordinal ranking over coalitions in which they belong. See Jandoc and Juarez [17] for a more detailed discussion of this property they call "consistent ranking".

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