How individual preferences are aggregated in groups: An experimental study*

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Abstract

This paper experimentally investigates how individual preferences, through unrestricted deliberation, are aggregated into a group decision in two contexts: reciprocating gifts and choosing between lotteries. In both contexts, we find that median group members have a significant impact on the group decision, but the median is not the only influential group member. Non-median members closer to the median tend to have more influence than other members. By investigating the same individual's influence in different groups, we find evidence for relative position in the group having a direct effect on influence. These results are consistent with predictions from spatial models of dynamic bargaining, for members with intermediate levels of patience. We also find that group deliberation involves bargaining and compromise as well as persuasion: preferences tend to shift towards the choice of the individual's previous group, especially for those with extreme individual preferences.

Keywords: group decision-making, role of deliberation, social influence

JEL Classification: C72, C92, H41

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1 Introduction

Many important decisions, in various contexts, are made by groups, such as committees, governing bodies, juries, business partners, teams, and families. Group decisions are typically preceded by deliberation among members, who enter the process with varying opinions and preferences. The expansion of democratic institutions and rapid progress in communication technology further highlight the prevalence of group decisions - in politics and business, among other facets of society - and the importance of investigating the process of such decisions (see the related discussion in Charness and Sutter, 2012).

This paper presents an experimental investigation of group decision-making in two settings that are stylized versions of important real-world decision problems: (i) choosing how much to reciprocate as the second mover in a sequential gift-exchange game (Brandts and Charness, 2004; Fehr, Kirchsteiger and Riedl, 1993), and (ii) choosing between (comparatively) safe and risky lotteries, using a version of the risk-preference elicitation questionnaire of Holt and Laury (2002). Gift-exchange games are often used as a stylized framework for employment relationships with incomplete labor contracts, in which the employee performance is not always enforceable (for example, see Brown, Falk and Fehr, 2004; Charness, 2004; Charness, Cobo-Reyes, Jiménez, Lacomba and Lagos, 2012; Fehr and Gächter, 1998; Fehr et al., 1993), while the lottery choice can be considered a simplified version of financial portfolio or investment decisions. For both of the tasks above, there is no clear normative criterion for evaluating the quality of decisions.[1] In the gift-exchange game, a group's chosen reciprocation level (conditional on the first-mover's gift) should depend on members' social preferences, while lottery choices should depend on members' risk preferences. Hence, in our experiments the main focus is how different preferences shape the group decision, through bargaining and/or persuasion.

Experimental investigation of group decisions has long been a central research area in social psychology, and has recently attracted more attention in experimental economics.[2] A novel feature of our design is that before deliberation, we solicited each member's opinion on what she thought the group's choice should be. It was randomly determined whether the eventual group choice or one of the initial individual opinions were implemented, making the solicited initial opinions payoff-relevant. In either case, the implemented outcome applied to all members with respect to payoffs. Hence, the solicited opinions can be interpreted as the outcome for the group that the individual would have chosen before

[1]Such tasks are dubbed "non-intellective" by Laughlin (1980) and Laughlin and Ellis (1986). For recent experimental investigations of group decision-making with intellective tasks, see Blinder and Morgan (2005) and Cooper and Kagel (2005) and Kocher and Sutter (2005). Glaeser and Sunstein (2009) provide a related theoretical analysis.

[2]The investigation of risk attitudes of groups versus individuals started with Stoner (1961). See also Teger and Pruitt (1967), Burnstein, Vinokur and Trope (1973), and Brown (1974). Recent papers in economics include Shupp and Williams (2008), Baker, Laury and Williams (2008) and Masclet, Colombier, Denant-Boemont and Loheac (2009). Groups' attitudes towards cooperation and reciprocity were first examined in the context of prisoner's dilemma games: see Pylyshyn, Agnew and Illingworth (1966), Wolosin, Sherman and Maynatt (1975), Lindskold, McElwain and Wayner (1977), Rabbie (1982), Insko, Schopler, Hoyle, Dardis and Graetz (1990), and Schopler and Insko (1992). Wildschut, Pinter, Vevea, Insko and Schopler (2003) provide a meta-analysis of the subject, while Charness, Rigotti and Rustichini (2007) is a more recent contribution in economics. Other treatments investigate centipede games (Bornstein, Kugler and Ziegelmeyer, 2004), ultimatum games (Bornstein and Yaniv, 1998; Robert and Carnevale, 1997) and dictator games (Cason and Mui, 1997; Luhan, Kocher and Sutter, 2009). Closest to our work is Kocher and Sutter (2007), who investigate gift exchange games similar to ours.

deliberation, as a dictator. Another distinguishing aspect of our experiment is that groups consist of five individuals, unlike most existing studies, which investigate three-person groups.[3] Five-person groups allow us to compare the influence of the extreme group members to the non-median members who are not at the extremes.[4]

Our central empirical investigation regresses the group decision on the ordered individual decisions by the group members.[5] This regression provides a detailed picture of how a member's influence on the group decision depends on her relative position within the group. In contrast, most of the existing literature focuses on comparing aggregate statistics of group and individual decisions.[6]

Conceptually, our empirical methodology is motivated by the influential work of Davis (1973), who defines social decision schemes as mappings between individual preferences and the group decision.[7]

To provide a more formal conceptual framework, we consider two types of dynamic spatial bargaining models considered in the literature. Both approaches feature multi-period games, such that in each period members consider and vote on a proposed action. The first approach, by Banks and Duggan (2000), assumes that a proposal is endogenously selected by a proposer, the identity of whom is determined randomly and independently across periods. We show that the model generates similar predictions both for the case of simple majority rule and unanimity rule. In particular, the expected group decision is a convex combination of individual opinions, and depending on the level of patience, it can span the range between the mean individual opinion (in the case of low levels of patience) and the median individual opinion (in the case of high levels of patience). In general, the model predicts that relative position within the group matters in how much influence the individual has on the group decision, and in particular members closer to the median member have more influence than extreme group members. An alternative modeling approach for group decision making over spatial policy out-

[3]Among the papers closest to our experimental design, Cason and Mui (1997) use two-person groups, while Luhan et al. (2009) use three-person groups.

[4]Besedes, Deck, Quintanar, Sarangi and Shor (2014) also feature a design (in the context of an intellective task) in which individual opinions for what the group decision should be are solicited, and afterwards it is randomly determined which individual decision applies to all group members. However, in this treatment team members do not deliberate and make a group decision. In our experiment we observe both what the individuals would choose for the group before deliberation, and the group decision that the same individuals agree upon after deliberation.

[5]In the gift-exchange games, ordering is based on the extent of reciprocation of the first mover's gift. In the lottery choice problem, ordering is based on the frequency of choosing the safer (low-spread) lottery over the high-spread lottery in a list of lotteries with increasing odds of the higher outcome. In the main text we report results from OLS specifications, as the interpretation of regression coefficients is clearer in this case. In the Supplementary Appendix we also provide Tobit specifications and show that all our results qualitatively remain the same.

[6]For example, Teger and Pruitt (1967) and Myers and Arenson (1972) focus solely on comparing mean individual and mean group decisions. We are aware of five papers that examine the relationship between individual preferences and the group decision: Fiorina and Plott (1978), Corfman and Harlam (1998), Arora and Allenby (1999), Zhang and Casari (2012), and Casari, Zhang and Jackson (2012). In the first three of the above papers preferences are exogenously imposed by the experimenter, essentially constructing pure bargaining situations. Zhang and Casari report on experiments in a lottery choice context, conducted in parallel to ours, in which subjects offer proposals to each other until an agreement is reached, where members' initial proposals are interpreted as their individual preferences. Casari et al. consider a very similar design in the context of an intellective task, bidding for a company takeover. However, the proposals in these experiments are suggestions to other group members, and might reflect strategic considerations to influence the subsequent group discussion, and hence cannot be interpreted as bids members would choose if they were dictators for the group. In contrast, the opinions solicited in our experiment before group discussions are not revealed to other members.

[7]For a detailed discussion on how various social decision schemes affect the ways in which the distributions of group and individual choices might differ, see Kerr, MacCoun and Kramer (1996).

comes is proposed by Compte and Jehiel (2010). They assume that proposals to be voted on emerge according to an exogenous process.[8] The main prediction from this model is that if some player can influence the expected group choice (which is when members are not too impatient) then it is either only the median member (in case the group adopts a simple majority voting rule) or exactly two members. In case of the group adopting a unanimity rule, the latter two members are the ones with extreme ideal points. For supermajority voting rules other than unanimity, the influential members can be closer to the median.

Our empirical findings are as follows. First, we find that the coefficient of the constant is insignificant, and we cannot reject the hypothesis that the sum of the coefficients of members' individual decisions is one. This is consistent with the group decision being a convex combination of the members' decisions. A constant significantly different from zero would indicate a level shift in group decisions, suggesting that the group decision situation itself sways members' preferences in a particular direction, independently of initial opinions. Second, the median group member always has a significant effect on the group choice. However, some (but not all) of the other group members also have an impact on the group choice. In the gift-exchange context, the members immediately above and below the median have a significant impact, but the members at the extremes do not. In the lottery choice context, besides the median, the second least risk-averse and the most risk-averse group members seem to be influential. Overall, while there is a tendency for groups to ignore extreme individual opinions, the most risk-averse member has some influence on the group decision, possibly because the arguments that can be brought up to support risk-averse choices are particularly persuasive.[9] In both settings we can reject the "mean hypothesis" that all members' opinions matter equally, and the "median hypothesis" that only the median member's opinion matters,[10] even though our results confirm that the median member has a significant influence.

The empirical results are broadly consistent with the predictions of the spatial bargaining models summarized above, for cases when members patience is from an intermediate range. In the Banks and Duggan (2000) model this is the case when the acceptance set is likely to include the ideal points of members next to the median, but less likely to include the ideal points of extreme members. The Compte and Jehiel (2010) model can also explain the observed outcomes if members are not too impatient and groups tend to adopt a supermajority rule but not unanimity rule. In this case the theoretical prediction is that there are exactly two influential members, but their identities depend on the exact locations of ideal points (besides the voting rule adopted). Another possibility generating similar predictions in this context is when some groups adopt a simple majority rule, while others a supermajority rule.

The above empirical analysis does not distinguish between the direct effect of relative positions

[8] They also examine cases when members can exert costly effort to influence the proposal process.

[9] The persuasive argument theory (Brown, 1974; Burnstein et al., 1973), which originated in social psychology, posits that deliberation drives group decisions in a particular direction because arguments in that direction are more persuasive. A related explanation is that people with certain preferences tend to be more persuasive than others (for example, more selfish individuals are also more aggressive in deliberation).

[10] The latter would hold theoretically under a simple majority voting rule provided preferences are single-peaked (see Moulin, 1980).

within a group on the group choice and the effect of unobserved characteristics of individuals which may be correlated with their relative positions. We investigate this issue utilizing the experimental design feature that each subject participates in multiple groups and decisions. We compare three econometric models explaining the absolute difference between an individual's decision and the group decision. In the first one, the independent variables indicate the relative position of the individual in the group. In the second model we only allow subject-specific fixed effects to explain the difference between group and individual. Finally, in the third model we allow for both types of explanatory variables. We find that the first model has better explanatory power than the second one, and the combined third model improves explanatory power only by a modest amount relative to the first model. Controlling for individual fixed effects does not change significance and magnitude of the coefficients of relative position. A robust finding from these specifications is that being at either of the extreme relative positions significantly increases the difference between the group decision and the individual's decision, relative to the median member's difference to the group. At the same time, being at a non-median position next to the median does not increase the above difference significantly, relative to the median.

The above findings are also useful for interpreting aggregate level differences between individual and group choices. Consistent with earlier papers, we observe that groups on average reciprocate less than individuals in the gift-exchange setting - standardly referred to as the "selfish shift." Our data suggests that this shift is not attributable to subjects behaving differently in groups,[11] or to arguments to be selfish being especially persuasive, as in the persuasive argument theory. The influences of the group members immediately next to the median roughly cancel each other out, and on average the group choice is very close to the median member's choice. The selfish shift arises mainly because the distribution of individual preferences is skewed: in particular the median member's preferred reciprocation level is below that of the mean.[12] For lottery choices, groups are on average more risk-averse than individuals. Although the most risk-averse member influences the group choice, she is not the main driver of this "cautious shift", as her influence is roughly cancelled out by that of the second least risk-averse member, and again on average the group choice is very close to the median. The cautious shift arises primarily because the median individual choice is more risk-averse than the mean one. This observation also suggests an explanation for why earlier experiments sometimes found cautious shifts, while others found risky shifts: namely, that for some types of lottery choice problems

[11] An influential explanation in social psychology, the social comparison theory, argues that people behave fundamentally differently in group settings than individually (Levinger and Schneider, 1969). It posits that people are motivated both to perceive and to present themselves in a socially desirable way. To accomplish this, a person might react in a way that is closer to what he regards as the social norm than how he would act in isolation.

There are several other explanations of why people make decisions differently in groups, that apply to particular types of choices. The identifiability explanation (Wallach, Kogan and Bem, 1962, 1964) claims that people in group decisions act more selfishly because the other side's ability to assign personal responsibility is more limited. In the context of lottery choices, Eliaz, Ray and Razin (2005) point out that subjects who are not expected utility maximizers exhibit a group shift, because the decision problem associated with the possibility of being pivotal in a group's lottery choice decision differs from individually deciding on the lottery choice if the probability of being pivotal is less than 1.

[12] The observation that the distribution of attitudes towards reciprocity is skewed towards the selfish direction is made, for example, in Ledyard (1995), Palfrey and Prisbey (1997), Brandts and Schram (2001), Fischbacher, Gächter and Fehr (2001), and Ambrus and Pathak (2012).

the median individual tends to be more risk-averse than the mean, while in other types the opposite holds.[13]

In both of our settings, the variance of group choices is smaller than that of individual decisions, mainly because extreme member preferences tend to be curbed by groups. This suggests that, in the types of decision contexts we examine, delegating the decision to a committee can reduce the variability of outcomes, and reduce the likelihood of extreme outcomes.[14]

We also find evidence of social influence in our experiments, in that group choices affect the subsequent individual choices of subjects. In particular, individuals tend to adjust their individual choices in the direction of prior group decisions. Our participants have no incentives to misstate individual preferences due to social pressure, since other group members only receive information about this choice at the very end of the experiment, and in a non-identifiable manner. This suggests that the group decision process does not just involve bargaining and compromise, but also persuasion, i.e. members trying to change each others' opinions.[15] We also find that the members who tend to change their opinions (in the direction of the previous group decision) are the extreme ones, hence deliberation leads to depolarization of opinions in the settings we examine. This finding suggests that social decision making, as in a deliberative democracy, could have an important role in preference formation, besides preference elicitation and aggregation.

An important feature of our experimental design is that group members can freely deliberate (face-to-face communication in a private room, with no experimenter present) and can select their own way to arrive at a group decision. This is motivated by the observation that for many real-world group decision problems, there is no externally-imposed decision mechanism (such as a voting rule), and there are no hard constraints on the amount of deliberation before the decision. This aspect is an important difference between our work and Goeree and Yariv (2011)'s recent experimental investigation of collective deliberation, in which different voting mechanisms (simple majority, two-thirds majority, and unanimity) are imposed.[16] In general, as there are some settings in which a decision rule is externally imposed and others in which there is no such constraint, we believe the investigation of both cases is warranted.

As shown recently by several papers (Charness and Jackson, 2009; Charness et al., 2007; Chen and Li, 2009; Sutter, 2009), individuals' decisions depend on whether their consequences only apply to them or to the entire group to which they belong.[17] Our main focus is not directly related to this

[13] As Hong (1978) demonstrates, the cultural setting can also influence the direction of the shift.

[14] In different contexts, particularly those in which groups are asked to form a political opinion, deliberation can lead to extremization of opinions (Manin, 2005; Sunstein, 2000, 2002), although it can also lead to depolarization of opinions (Burnstein, 1982; Ferguson and Vidmar, 1971).

[15] We use the term *persuasion* in a broad sense: group decision-making changing a participant's privately stated individual choice in subsequent rounds; our design does not allow us to distinguish between different (psychological) channels of persuasion.

[16] The experiments of Goeree and Yariv also differ from ours with regards to the decision tasks, as well as many aspects of experimental design (including the nature of communication, which is impersonal in their experiments, via a computer network). Hence, our results are not directly comparable to theirs. For an earlier experimental investigation of group decision making with externally imposed voting rules, see Bower (1965). For a recent paper featuring both deliberation and externally imposed voting rule, see Elbittar and Gomberg (2012).

[17] This is related to the in-group versus out-group sentiments theory in social psychology (Kramer, 1991; Tajfel, Billig, Bundy and Flament, 1971), which posits that subjects develop more other-regarding preferences toward their group

effect, as we are interested in comparing initial individual opinions on what the group should choose to the group choice itself. Nevertheless, to compare this effect to the effects of preference aggregation, in one of our sessions we also solicited group members' choices before deliberation in a scenario in which the choice was only payoff-relevant for themselves (and all other group members received a constant payment independent of the choice). In this session it was randomly selected whether the group choice, or one of the individual-for-group choices, or one of the individual-for-individual choices got implemented.[18] Consistent with the existing literature, we find that individuals reciprocate less when deciding for the group than for only themselves, and are less risk-averse. In both of the examined settings, the magnitudes of these differences are similar to the differences between average individual-for-group choices and average group choices resulting from preference aggregation.

2 Experimental design and procedures

To explore how individual opinions are aggregated in groups, our experiment utilizes non-intellective decision-making situations from the two main domains of economic experiments: strategic social interaction and non-strategic, individual decision making. We confront subjects with the choice of a second mover in a gift-exchange game, and with a list of binary lottery choice situations. As we elicit both individual and group choices from the same individuals over the same decision task for the group, our design allows us to observe the aggregation of individual choices to group decisions.

The first game featured in our experiments is structurally the same as the one in Brandts and Charness (2004), and following their terminology we refer to it as a gift-exchange game.[19] In our version of the game, a first mover and a second mover are each endowed with 10 tokens, which have monetary value. First, the first mover may send a gift of 0 to 10 tokens to the second mover. The amount is deducted from the first mover's account, but is tripled on the way before being awarded to the second mover. Then the second mover decides whether to send a gift of 0 to 10 tokens to the first mover under the same conditions: for each token sent, one token is deducted from the second mover's account, and triple the amount is added to the first mover's account. While the socially optimal behavior is to exchange maximal gifts, in the unique Nash equilibrium outcome neither player contributes any gift.

The typical experimental data on this game shows first movers extend trust and there is a significant likelihood of reciprocation among second movers, yielding outcomes that are closer to the socially efficient one. Individuals differ both in their degrees of trust as well as in their pattern of reciprocation. In our experiment we concentrate on the latter, studying how individual reciprocal patterns to a diverse set of stimuli are aggregated to group behavior.

For the risk choice situation, we used a version of the risk preference elicitation questionnaire of Holt

members than towards subjects outside the group.

[18] Cason and Mui (1997) and Luhan et al. (2009) also solicit individual-for-individual decisions, besides group decisions, but they did not solicit individual-for-group decisions, which is the central component of our analysis. Furthermore, in these studies, individuals interact with individuals, and groups interact with groups, while the first-mover in our gift-exchange game is always an individual.

[19] The term gift-exchange game was introduced by Fehr et al. (1993). Gift-exchange games are similar in structure to trust games, and can be more generally classified as sequential social dilemma games.

and Laury (2002). Subjects made ten choices between two lotteries, namely $p[\$11.50] \oplus (1-p)[\$0.30]$ vs. $p[\$6.00] \oplus (1-p)[\$4.80]$ with $p \in \{0, 0.1, 0.2, ..., 0.9\}$. Of this choice list, one lottery was randomly selected, the decision implemented and the corresponding lottery played out. Most lottery-choice experiments of this kind observe heterogeneous individual risk attitudes, with a majority of people being slightly to strongly risk averse.[20] Our experiment studies how these individual risk preferences are aggregated to a group risk attitude when the group has to make a decision that applies to all members.

In each session, we had n groups of five participants (with n varying between 3, 4, and 6, depending on session enrollment numbers), plus "individual decision-makmers" (see below). Assignment to these roles was random by letting participants draw a numbered card.

For *group members*, each session consisted of three phases. In the first phase, the group made three decisions: two choices as as second movers in the gift-exchange game (with two different first movers), and one choice in the lottery task. For each of the three choice situations, group members first made individual decisions (i.e. their choice if they can dictate the group decision), and submitted their decisions secretly to a research assistant. Then the research assistant left the room, and the group members freely discussed and made a group decision. After the three decisions, the initial random assignment to the n groups g was reshuffled by assigning each group member i to her new group $g + i \pmod{n}$. The newly formed groups made again two gift-exchange and one lottery decision, following the same procedures as in Phase 1. After that, group participants were reshuffled again according to the same procedure, and made another two gift-exchange and one lottery decision in Phase 3.

The additional six *individual decision-makers* in each session were only used to generate first-mover choices for the six group gift-exchange decisions. Specifically, they made n first-mover decisions in a row at the beginning of the experiment, without any feedback, with n equal to the number of groups in the session.[21] Afterwards they had to stay in the lab until the end of the session.

The experimental sessions took place in 2008 and 2010 in the Computer Laboratory for Experimental Research at Harvard Business School. We conducted seven sessions with a total of 172 student subjects, each session comprising either 21, 26, or 36 participants, and lasting approximately one hour and thirty minutes. The experiment was computerized using the z-Tree software (Fischbacher, 2007). After subjects arrived instructions were distributed.[22] An experimenter (the same in all sessions) led subjects through the instructions and answered open questions. Then, subjects were randomly assigned to be group or individual participants, and group participants were led to small group rooms to make their decisions, while individual participants stayed in the main lab. After all decisions in all three phases had been made, group members filled in a post-experimental questionnaire asking for

[20] A typical result observed in Holt and Laury (2002) lottery tasks is that some participants make non-monotonic/inconsistent choices, i.e. make more than one switch between the safe and risky lotteries when going down the ordered list of choices. As Holt and Laury (2002), we consider the total number of safe choices per lottery task as our outcome measure. Overall, we observe relatively little inconsistency. While 3.1% of individual lottery tasks exhibit non-monotonic choices (5.4% of the very first tasks in a session), none of the observed group decisions was inconsistent.

[21] About half of first movers in our sessions did vary their offers, despite receiving no feedback between offers, while the other half didn't. Each decision of a single first mover was played against a different group.

[22] Instructions are included in the Supplementary Appendix.

demographic data and containing open questions for motivations of subjects' decisions.[23]

At the end of the experiment all participants were paid in cash. Tokens for the gift-exchange game were converted to real money at a fixed exchange rate, plus subjects received an additional fixed show-up fee of $10.[24] Group members earned the income from each gift-exchange game and from one randomly chosen of the three lottery questionnaire choices they were involved in. Subjects were told that for each of those choices with 50% probability one of the individual decisions would become the effective group choice, with equal probability allocated to every member's decision, and that in this case it would not be revealed which individual's decision was implemented. With the remaining 50% probability, the group's joint decision became the effective group choice.

In the last session, in addition to individuals' choices on behalf of the group, we also elicited individuals' choices on behalf of themselves. That is, if an individual-for-individual decision was randomly selected at the end of the experiment, then the corresponding choice would only be implemented for that individual, while the other four group members received a fixed payment of 15 tokens/$5.50 for that choice. This allows us to test in a small sample whether individual-for-group choices differ substantially from individual-for-individual choices in our two settings. In this session, the 50% probability of individual choices to matter for payoff was split equally between individual-for-group and individual-for-individual choices.

Overall, we collected five individual choices and one group choice for each of the 156 gift-exchange games and 78 ten-decision lottery tasks. In the last session, we collected an additional 90 individual-for-individual decisions for the gift-exchange game and 45 individual-for-individual decisions for lottery tasks.

3 Theoretical Background

The question of group members negotiating over outcomes in a non-transferrable utilities setting (no side payments among group members) has been analyzed theoretically. One approach is provided in the spatial bargaining model of Banks and Duggan (2000), which is an adaptation of the multilateral bargaining model of Baron and Ferejohn (1989), popular in modeling legislative bargaining in political science, to settings with non-transferrable utilities.[25] An alternative approach is provided in Compte and Jehiel (2010), who also propose a generalization that encompasses both model frameworks. The common features of the two approaches are the following:

1. They assume members' utilities over outcomes in a policy space as a negative function of the distance between the group's choice and the exogenously specified ideal point of the member.

2. They both consider a multi-stage game in which at every stage a proposal is being considered and group members vote whether the proposal is accepted or not. The proposal passes if the

[23] We did not find any systematic effects of specific demographic characteristics (gender, age, field of studies) moderating influence on group decisions. Also see below our results from regressions with individual-specific effects that may absorb any effects of demographics.

[24] The exchange rate for gift-exchange games of $0.10 per token was verbally announced at the beginning of sessions.

[25] The origins of random proposal bargaining, which is at the heart of these models, go back to Binmore (1987).

proposal is supported by a winning coalition. In the most natural specifications of the models, when group members are ex ante symmetric and the voting rule satisfies a monotonicity property, this corresponds to at least k members supporting the proposal, where k can range between the smallest integer larger than half of the group members (simple majority rule) and the total number of group members (unanimity rule).

3. Group members discount payoffs from policy outcomes and prefer to get to an agreement earlier rather than later.

The difference between the two approaches is in the way proposals come about. Banks and Duggan (2000) follow a more conventional approach, going back to Rubinstein (1982), in that the proposal at any stage is chosen by a group member. In particular, the proposer is chosen randomly and independently across time, according to the same probability distribution, at every stage. In contrast, in the basic model of Compte and Jehiel (2010), proposals arise according to an exogeneous process. Below we summarize some predictions from both of these modeling approaches. There is also a possibility that besides pure bargaining, members try to persuade and change the ideal points of each other, during group discussion. This is discussed at the end of the section.

First we consider a 1-dimensional version of the spatial bargaining model in Banks and Duggan (2000). In the simplest version of the model, players' ideal points are commonly known, and acceptance of a proposal requires a simple majority. Later we show that the predictions generated from this model extend, in weaker forms, to versions of the model in which ideal points are private information, and when accepting a proposal requires unanimity.

Formally, consider a 5-player dynamic bargaining game, in which in each period ($t = 0, 1, 2, \ldots$) the proposer is chosen i.i.d., with each of the five players chosen with probability 1/5. A proposer must propose an action on $[0, 1]$. Player i's type, or ideal point, is $x_i \in [0, 1]$, and her payoff when an agreement y is reached at period t is $\delta^t(1 - (x_i - y)^2)$, where $\delta \in (0, 1)$ is a common discount factor. Without loss of generality, assume $0 \leq x_1 \leq x_2 \leq x_3 \leq x_4 \leq x_5 \leq 1$. After an offer is made, players announce sequentially, in a random order, whether they accept or reject the offer. The proposal is accepted if and only if at least 3 group members accept.

The assumption of a 1-dimensional state space corresponds to the existence of a natural ordering of choices in both types of decision problems featured in our experiments (amount to be reciprocated in the gift-exchange game, and the switching point from safe to risky lotteries in lottery choices). We assume a continuum of choices for analytical convenience only: the qualitative predictions of the model remain the same if the set of possible action choices is a finite subset of the unit interval. We focus on stationary subgame-perfect equillibria (SSPE) of the game, that is, subgame-perfect equilibria (SPE) in which players' proposal strategies and acceptance rules do not change over time.[26]

In this game, for any specification of ideal points and the discount factor, SSPE is unique, and it is characterized by a compact set of acceptable proposals $A \subseteq [0, 1]$, of which x_3 is an interior

[26] There are several recent papers that provide micro-foundations for selecting Markov perfect equilibria (equivalent to SSPE in our context) in sequential-move games. See Bhaskar and Vega-Redondo (2002) and Bhaskar, Mailath and Morris (2013) for general classes of asynchronous-move games, and Ambrus and Lu (forthcoming) in the context of dynamic bargaining.

point (relative to $[0, 1]$). When given the opportunity, each player proposes the point of A closest to her ideal point. This implies that the median player always proposes her ideal point. Other players either propose their ideal points (if included in A) or the closest boundary point of A. The size of A decreases with δ, shrinking to the median member's ideal point as members get very patient. The theorem below formalizes these statements. The proof is in the Appendix, and it explicitly solves for the unique SSPE in every region of parameter values.[27]

Theorem 1: In a bargaining game with publicly known ideal points and plurality decision rule, SSPE is unique. For any set of ideal points, the set of acceptable proposals A monotonically decreases in δ, it converges to the whole choice set as $\delta \to 0$, and it converges to the median ideal point as $\delta \to 1$.

The proof in the Appendix also reveals that for generic specifications of ideal points - when the median is not an extreme point of the choice set - for low enough δ in fact $A = [0, 1]$ and hence all players can propose their ideal points. Conversely, for high enough δ only players with an ideal point equal to the median can propose their ideal points. This means that if players are impatient enough, then the expected action chosen by the group is equal to the mean of the ideal points, while if players are very patient then the expected group choice is very close to the median ideal point. In general, the equilibrium prediction of the model for the expected group decision, for different levels of patience, spans the range between the mean and median ideal point. For intermediate levels of patience only players closer to the median can propose their ideal points, and player 2 (the less extreme member to the left of the median) is more likely to influence the expected group decision than player 1 (the left extreme member). Similarly, player 4 is more likely to influence the group decision than player 5. In short, the prediction is that if players are not very patient then non-median members' ideal points can also affect the expected group decision, but extreme members' ideal points are less likely to be influential than the ideal points of non-median members next to the median.[28]

The above analysis assumes that the ideal points of group members are known at the beginning of the bargaining game. In the experiments, we kept the individual decisions preceding the group discussion private information. Therefore, taken literally, the above model implicitly assumes that members truthfully reveal their ideal points to each other before they start bargaining. This can be the case for example when there are costs associated with lying or misrepresenting one's true preferences. If, however, subjects are strategic, then the bargaining game is one of multi-sided asymmetric information. Such games are notoriously difficult to analyze, and they tend to have a severe multiplicity of equilibria.[29] Nevertheless, below we show that some of the qualitative features carry over to situations

[27]The result on convergence to the median when players become patient also follows from Theorem 5 of Banks and Duggan (2000).

[28]When applying the model directly to the groups we observe in our experiment and predicting group choices from elicited individual preferences, and then regressing those predictions on the individual choices using an OLS model (as we do in our main empirical analysis reported below), we find exactly the discussed pyramid shape in coefficients on ordered individual opinions, the steepness of which is moderated by δ. In addition, all linear regressions have $R^2 > 0.99$, indicating that a linear approximation is able to capture the model's predictions almost perfectly (non-linear components of the model only play a minor role).

[29]See for example Fudenberg and Tirole (1983) and Cramton (1984, 1992).

in which ideal points are privately known, and players are strategic in reporting their ideal points.

To formally analyze the situation with incomplete information, we modify the previous model in two ways (besides assuming that ideal points are private information). First, we augment the game with one round of cheap talk before bargaining, in which members simultaneously and publicly announce ideal points. Second, here we assume that the set of possible action choices, and hence the set of possible types of players, is a finite subset of $(0, 1)$. Assume that the distribution of types are iid across members, with distribution function F allocating positive probability to each possible type. The next result shows that for both very impatient, and for very patient players, there exist sequential equilibria in which players truthfully announce their types at the beginning of the game, and then bargain the same way as in the game with publicly known ideal points. In particular, this results in all members proposing their ideal points when the discount factor is low enough (hence the expected group decision is the mean ideal point), and all members proposing the median ideal point when the discount factor is high enough. The proof of Theorem 2 can be found in the Appendix.

Theorem 2: In a bargaining game with private ideal points and simple majority rule, preceded by a round of cheap talk, for low enough discount factors there is a sequential equilibrium in which members announce their types truthfully, and then all members propose their ideal points in the bargaining phase. Moreover, all sequential equilibria are outcome-equivalent to the equilibrium above. Conversely, for high enough discount factors there is a sequential equilibrium in which members announce their types truthfully, and then all members propose the median announced ideal point in the bargaining phase.

In both versions of the model above, it is assumed that groups use simple majority rule to get to an agreement. However, similar results hold, with some caveats in the case of very patient players, when the group adopts some supermajority rule or unanimity as decision criterion. In a Supplementary Appendix we report a full analysis of the unanimity rule case. Similar to the case of simple majority, the acceptance set in an SSPE converges to the set of all possible choices as $\delta \to 0$ (and hence when members are very impatient, all of them can propose their ideal points), it monotonically decreases with δ, and converges to a single action choice as $\delta \to 1$. The difference is that in general the latter limit point is between the mean and the median ideal point under unanimity, although when the median is equidistant to the two extreme ideal points, then the limit point is exactly the median.[30]

Summarizing the predictions of various versions of the Banks and Duggan (2000) type spatial bargaining model:

(i) the expected group decision is a convex combination of individual decisions;

(ii) if players are very impatient then the expected group decision is close to the mean individual decision;

[30] Note that this condition does not restrict x_2 and x_3 to be the same distance from the median, and therefore for specifications satisfying this condition the median typically differs from the mean.

(iii) if players are very patient then the expected group decision tend to be close to the median individual decision (requires extra assumptions if the group decision rule is not simple majority);

(iv) for intermediate levels of patience, the further a member is from the median, the less effect she has in expectation on the group decision (same caveat as for the previous prediction).

The bargaining model analyzed in Compte and Jehiel (2010) has the same basic structure as the complete information version of the Banks and Duggan (2000) model described above. The difference is that the proposal to be voted on, x, at every period $t = 1, ...,$ is independently drawn from a set of possible proposals X, from the same distribution $F(x)$ with density $f(x) \in \triangle(X)$. The latter distribution is assumed to satisfy certain technical requirements. In our context, a sufficient condition for the latter is that the support is the whole interval $[0, 1]$ and $f(x)$ is continuously differentiable and bounded away from 0.

In this model, just like in Banks and Duggan (2000), there is a unique SSPE, characterized by a set of acceptable proposals A. If $F(x)$ has full support then A is an interval contained in $[0, 1]$. A further similarity is that as $\delta \to 0$, A becomes X (any proposal is accepted). In this model this does not imply though that the expected group decision is the mean ideal point of group members. Instead, it is the expectation of $F(x)$, an exogenous parameter of the model (and hence unaffected by members' preferences). As δ increases, A shrinks, and in a 1-dimensional setting as in ours, it converges to a single point as $\delta \to 1$. Compte and Jehiel (2010) show that for general δ, set A is influenced by at most two group members in a 1-dimensional setting. In case of an odd number of members and simple majority rule, only the median member has an impact on A. For stricter majority rules, there are two key members, and their identities depend on the parameters of the model. Under unanimity rule the two key members are those with extreme ideal points.

To summarize, the model of Compte and Jehiel (2010) implies that members' preferences only influence the expected group decision if members are patient enough. If members are patient, the identity of the influential member(s) depends crucially on the voting rule: in case of simple majority only the median member has an influence, in case of unanimity, the two extreme members, while for in-between voting rules there are exactly two influential members, whose identities depend on various parameters of the model. Compte and Jehiel (2010) also show that these basic predictions extend to a generalization of the model in which members have some imperfect influence on the emerging proposals, subject to a technical condition.

Lastly, the models above can be extended to incorporate the possibility of persuasion, in particular others in the group persuading a member to change her ideal point (as opposed to just agreeing upon a compromise). Note that since the tasks in our experiments are not intellective, persuasion in our context does not involve transmission of hard information as in standard economic models of persuasion (for example Kamenica and Gentzkow, 2011), and hence has to include a psychological component, as in Cialdini and Goldstein (2004) and Cooper and Rege (2011). There are two straightforward ways to incorporate this into the theoretical framework. One possibility is that it is the group decision itself that persuades members to change their ideal points, presumably towards the group decision. Formally, the shifted ideal point is: $\widehat{x}_i = g^i(x_i, y - x_i)$, where x_i is the member's ideal point before the group decision, and $y - x_i$ is the difference between the group decision and the original ideal point, with $g_1^i, g_2^i \geq 0$. The function determining the shifted ideal point is indexed by the member's position in the group, allowing for relative position within the group influencing the magnitude of the shift. In this case persuasion does not directly affect the analysis of the current group decision process, instead the outcome of the decision process changes the ideal points subjects start out with in the next group decision problem. Another possibility is that persuasion happens during communication among group members, before the bargaining stage. This leaves the formal analysis unchanged, with the caveat that the relevant ideal points in the bargaining stage are not the originals, but the ideal points after persuasion. In this case, the effect of an individual's original ideal point on the eventual group decision measures both the individual's capacity to affect others' ideal points through persuasion as well as the individual's leverage to influence the expected outcome of the resulting bargaining game.

4 Competing Hypotheses

Our stylized theoretical considerations motivate a number of competing hypotheses for the experiment. We investigate situations in which five individuals first make an individual choice, and then jointly decide on a group choice, for the same decision problem. Our main empirical model can be generally written as:

$$y_{gt} = f(x_{i_1gt}, x_{i_2gt}, x_{i_3gt}, x_{i_4gt}, x_{i_5gt}, X_{gt})$$

where t stands for a time period (at which every group is associated with one particular decision problem), y_{gt} is group g's observed decision in period t, x_{igt} is the observed decision of individual i in the same period, and X_{gt} is a vector of characteristics of the decision situation. We will use $x_{gt}^{(j)}$ to refer to the jth lowest decision among the individuals in group g (in particular $x_{gt}^{(1)}$ referring to the lowest, and $x_{gt}^{(5)}$ referring to the highest decision).

For gift-exchange games, variable x_{igt} corresponds to member i's individual reciprocation decision to the first mover, relative to the first mover's offer.[31] Thus, $x_{gt}^{(1)}$ represents the reciprocation of the most selfish member, minus the first mover's offer, while $x_{gt}^{(5)}$ represents the reciprocation of the most generous member, minus the first mover's offer. In the lottery tasks, choices might be inconsistent in that individuals might switch more than once from the safe to the risky lottery (about 3% of our subjects do so), such that their "cutoff" is not well-defined. We follow Holt and Laury (2002) and use the total number of safe choices per lottery task as a measure of risk aversion. (Our results presented below would not be qualitatively different when we used the position of the first switch to the risky lottery instead.) So for lottery choices, $x_{gt}^{(1)}$ equals the lowest number of safe choices in a group and corresponds to the most risk-loving group member, while $x_{gt}^{(5)}$ equals the number of safe choices of the most risk-averse group member.

[31] In the Supplementary Appendix we also present an alternative specification for gift-exchange games in which we do not normalize the reciprocation decisions by the first offer, and instead add the first offer as an additional control variable in the regressions. The results from this alternative specification are qualitatively the same.

We focus on models in which the group decision is a linear function of $(x_{igt})_{i=1,..,5}$:

$$y_{gt} = \alpha + \beta_1 x_{gt}^{(1)} + \beta_2 x_{gt}^{(2)} + \beta_3 x_{gt}^{(3)} + \beta_4 x_{gt}^{(4)} + \beta_5 x_{gt}^{(5)} + \epsilon_{gt}. \tag{1}$$

First we investigate whether there is a systematic shift between the group's decision and the individual decision. In particular, we test the hypothesis that $\alpha = 0$. Note that $\alpha \neq 0$ would imply that there is a difference between individual and group decisions that is independent of members' preferences.

Next, we investigate the hypothesis that the coefficients of individual decisions sum up to one:

$$\sum_{i=1}^{5} \beta_i = 1.$$

Note that $\alpha = 0$ and $\sum_{i=1}^{5} \beta_i = 1$ imply that the group decision is a convex combination of individual decisions; hence, the coefficients of the latter can be interpreted as the weights of different members in shaping the group decision.

Next we examine the *mean hypothesis*, which implies that the group's decision is simply a function of the mean individual decision:

$$y_{gt} = \alpha + \beta \left(\frac{1}{5} \sum_{i=1}^{5} x_{gt}^{(i)} \right).$$

That is, the mean is a sufficient statistic for the group's decision. If $\beta = 1$, then the mean exactly predicts the component of the group decision that varies with individual preferences. In our econometric tests, we test whether we can reject the hypothesis that $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5$. The version of the mean hypothesis which further requires the mean to exactly predict the group decision, what we call the *strong mean hypothesis*, involves tests of the hypothesis that $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \frac{1}{5}$.

A competing hypothesis, the *median hypothesis*, implies that the group's decision is a function of the median individual decision only, so that

$$y_{gt} = \alpha + \beta x_{gt}^{(3)}.$$

In our econometric tests, we estimate equation (1), and test whether we can reject the hypothesis that $\beta_1 = \beta_2 = \beta_4 = \beta_5 = 0$. The version of the hypothesis which further requires the median to exactly predict the group decision, what we call the *strong median hypothesis*, involves testing whether we can reject both $\beta_1 = \beta_2 = \beta_4 = \beta_5 = 0$ and $\beta_3 = 1$.

The last hypothesis, the *extreme-irrelevance hypothesis*, implies that extreme opinions are ignored in the group decision: $\beta_1 = \beta_5 = 0$.

5 Results

5.a Summary Statistics

The upper part of Table 1 lists averages of gift-exchange and lottery decisions at the individual and group level. We observe that on average, both individuals and groups reciprocate less as second movers than what they received from the first mover (the returned gifts, normalized by the received gifts, are negative), and are generally risk-averse. Compared to the mean individual decision, the median decision is less altruistic and more risk-averse. On average, group decisions are between the mean and median individual decisions, but closer to the median.

We use Datta and Satten (2008)'s signed-rank test for clustered data to compare our matched data on group means/medians and group decisions, with clustering at the session level.[32] For gift-exchange decisions, we find that groups reciprocate less than the average member ($p = 0.035$), while there is no difference between group decisions and the median members' decisions ($p = 0.277$). For lottery decisions, we observe a similar pattern: group decisions are significantly more risk averse than the average of members' decisions ($p = 0.037$), but not different to the median member's decision ($p = 0.449$).

TABLE 1
Average choices at individual and group level in gift-exchange games and lottery tasks

	Gift-exchange decisions (Normalized amount returned)			Lottery decisions (Number of safe choices)		
	N	Avg	StdDev	N	Avg	StdDev
Individual	780	-3.86	3.70	390	6.31	1.30
Group Median	156	-4.21	3.34	78	6.44	0.73
Group	156	-4.31	3.29	78	6.41	0.86
Only last session						
Individual for individual	90	-2.29	2.71	45	6.56	1.16
Individual for group	90	-2.44	2.18	45	6.29	1.24

Standard deviations of group and individual choices are reported in columns 3 and 6 of rows 1 and 3 of Table 1, respectively. We find that the variance of group choices is smaller than the variance of individual decisions, for both decision tasks. To provide statistical corroboration for this observation, which controls for the clustering in our data, we calculate the variance of group and individual decisions for each session separately, and use these session data points in non-parametric Wilcoxon signed-ranks tests. The tests yield $p = 0.018$ for gift-exchange decisions and $p = 0.018$ for lottery decisions, allowing us to reject the Null hypothesis of equal variances of group and individual choices.

[32] Due to our group rematching procedure, our data is clustered at the session level. The tests we use are similar to Wilcoxon signed-rank tests or Sign tests, but allow the distribution of pair-wise differences to differ between clusters. Details are given in Datta and Satten (2008). We are grateful to Tom Wilkening for providing us with an Excel macro implementation of the test. We obtain the same qualitative results when using session averages and traditional Wilcoxon signed-ranks tests.

The individual decisions considered above were taken on behalf of the group, such that the object and scope of the group and individual decisions were the same. In the last session, we elicited two types of individual decisions: individual-for-individual and individual-for-group. The lower part of Table 1 contains summary statistics for these two types of decisions in the last session. Individuals in this session give slightly less when deciding for the group rather than themselves (0.15 fewer tokens on average), but are slightly more risk-taking (0.27 fewer safe choices on average) in this case. Testing these differences statistically is difficult, since our independent unit of observation is the session.[33] In general, the magnitude of the difference between individual-for-individual and individual-for-group decisions is similar to the difference between individual-for-group and group decisions caused by preference aggregation.

5.b Main results

Table 2 reports the results of our main econometric specifications, regressing the group decision on the ordered individual decisions in the group. Models (1) and (3) represent the basic linear specifications, while Models (2) and (4) verify robustness with respect to including session-phase fixed effects into the model.[34]

In all models, the coefficient on the median member's choice, β_3, is positive and significant. In gift-exchange decisions, also the second highest and the fourth highest individual choice contribute to explaining the group choice, while the coefficients on the extreme individual choices β_1 and β_5 are insignificant. In lottery choices, on the other hand, the member one position less risk-averse than the median, as well as the most risk-averse member have a significant effect, besides the median member. When controlling for session-phase effects, the coefficient on $x_{gt}^{(5)}$ stays significant, while the coefficient on $x_{gt}^{(2)}$ just misses the 10%-level with a p-value of $p = 0.115$.[35]

Our results do not support the hypothesis of a level shift – in both models (1) and (3) we do not observe a significant constant α. Table 3 reports the results from post-estimation hypothesis tests which directly test the competing hypotheses in Section 4 for the four OLS models reported in Table 2. We reject both the weak and strong versions of the mean and the median hypotheses for all models: neither are all five individual choices equally important, nor is only the median important and none of the other individual decisions. Consistent with our finding that the constant is not significant in models (1) and (3), we cannot reject the complementary hypothesis that the coefficients on individual

[33] Wilcoxon signed-ranks tests, applied to the respective 15 very first (and thereby statistically independent) individual decisions for self and group in this session yield p-values of $p = 0.629$ and $p = 0.103$ for gift-exchange and lottery choices, respectively.

[34] Our hypotheses developed in Section 4 assume a linear structural model of how individual decisions are aggregated to group decisions. Thus, reporting OLS estimates and running post-estimation hypotheses tests on their results (see Table 3) is appropriate here. To test for robustness of our results, we ran the same models as Tobit specifications, and with absolute gifts rather than normalized gifts, including the first mover's offer as a control. The results are reported in the Supplementary Appendix in Tables 7, 8, and 9. In general, all our results and conclusions are robust to the specification.

[35] In Tobit versions of these analyses reported in Table 7 in the Supplementary Appendix, the coefficient of $x_{gt}^{(2)}$ is significant in model (4).

TABLE 2

OLS REGRESSIONS OF GROUP CHOICES ON INDIVIDUAL CHOICES

	Gift-exchange decisions (Normalized amount returned)		Lottery decisions (Number of safe choices)	
Model	(1)	(2)	(3)	(4)
Constant	-0.233	-0.164	-0.224	-0.930
	[0.244]	[0.229]	[0.671]	[1.090]
$x_{gt}^{(1)}$	0.031	0.021	0.062	0.034
	[0.069]	[0.070]	[0.044]	[0.117]
$x_{gt}^{(2)}$	0.347**	0.332**	0.348**	0.313
	[0.101]	[0.120]	[0.101]	[0.170]
$x_{gt}^{(3)}$	0.274*	0.343**	0.318*	0.525***
	[0.118]	[0.095]	[0.151]	[0.141]
$x_{gt}^{(4)}$	0.298**	0.342**	0.101	-0.03
	[0.099]	[0.110]	[0.123]	[0.125]
$x_{gt}^{(5)}$	0.062	0.014	0.206*	0.224**
	[0.042]	[0.093]	[0.089]	[0.067]
Session-Phase FE	N	Y	N	Y
N	156	156	78	78
R^2	0.771	0.811	0.505	0.618

Notes: *, **, *** denote significance at the 10%, 5%, and 1%-level, respectively. Standard errors are clustered at the experiment session level, and shown in brackets.

choices add up to 1 in any of our models. We also cannot reject the hypothesis that extreme choices do not matter, except for model (4) on lottery decisions which includes session-phase fixed effects.

5.c *Order versus subject-specific effects*

The results in the previous section establish that the median member, and certain other members have significant influence on the group decision. However, they do not rule out that there are unobserved individual characteristics, correlated with relative positions in groups, that determine how influential different members are with respect to the group decision. Since each individual participates in 6 gift-exchange and 3 lottery decisions, in three different groups, we can investigate this issue further, at the individual level.

Below we compare three empirical models, in all of which the dependent variable is the absolute difference between the group choice and an individual's choice (Δ_{gi}). In the first model, we regress this variable on a set of independents indicating the relative position of the individual in the given

TABLE 3

Results from post-estimation hypothesis tests, p-values

Hypothesis	Model (1)	(2)	(3)	(4)
Weak mean	0.024**	0.051*	0.068*	0.061*
Strong mean	0.032**	<0.001***	0.075*	<0.001***
Weak median	0.004***	0.003***	0.016**	<0.001***
Strong median	0.005***	0.005***	<0.001***	<0.001***
Extreme-irrelevance	0.339	0.953	0.131	<0.001***
Convex combination	0.741	0.427	0.739	0.688

Note: *, **, *** denote significance at the 10%, 5%, and 1%-level, respectively.

group. In the second model, we aim to explain the same dependent variable purely by subject-specific individual fixed effects. In the third model, we allow both the relative position within the group and individual effects to influence the variable of interest. Formally, the models we investigate are:

$$\Delta_{gi} = \alpha + \beta_1 p_{gi}^{(1)} + \beta_2 p_{gi}^{(2)} + \beta_4 p_{gi}^{(4)} + \beta_5 p_{gi}^{(5)} + \epsilon_{gi}.$$

$$\Delta_{gi} = \alpha + \gamma_i + \epsilon_{gi}.$$

$$\Delta_{gi} = \alpha + \beta_1 p_{gi}^{(1)} + \beta_2 p_{gi}^{(2)} + \beta_4 p_{gi}^{(4)} + \beta_5 p_{gi}^{(5)} + \gamma_i + \epsilon_{gi}.$$

In the above regression equations, γ_i with $i \in \{1, ..., N\}$ represent subject fixed-effects, with the constraint $\sum_{i=1}^{N} \gamma_i = 0$. The variables $p_{gi}^{(k)}$ indicate the (tie-weighted) relative position of individual i in group g. If individual i's position in the group is the unique kth lowest within the group, $p_{gi}^{(k)}$ takes the value of 1, while all $p_{gi}^{(k')}$ for $k' \neq k$ take the value 0. If individuals $i_{l_1}, ..., i_{l_m}$ are tied at positions $k, ..., k+m$ then all $p_{gi}^{(k)}$ for $k \in \{k, ..., k+m\}$ take the value $1/|\{k, ..., k+m\}|$ and all other $p_{gi}^{(k')}$ take the value of 0. Thus, for example, if an individual i is tied with another group member at the lowest value in the group, we would have $p_{gi}^{(1)} = 0.5, p_{gi}^{(2)} = 0.5, p_{gi}^{(3)} = 0, p_{gi}^{(4)} = 0, p_{gi}^{(5)} = 0$.

In our estimations, the indicator variable for the 3rd position (median) is omitted to avoid perfect multicollinearity, in the presence of the constant term. Given this, the constant α represents the average difference of the group choice from the median member. Coefficients β_1, β_2, β_4, β_5 represent how much further away from the group choice the individual decisions of individuals at positions 1, 2, 4, and 5 are. To return to our example of individual i tied with another group member at positions 1 and 2, the post-estimation prediction of the difference between the group and the individual choice of this subject according to the third model above would be the sum of constant, individual effect, and

TABLE 4

OLS regressions of difference between individual and group choice

	Gift-exchange decisions			Lottery decisions		
Model	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.314	1.990***	0.391	0.124	0.923***	0.184
	[0.335]	[0.000]	[0.307]	[0.183]	[0.000]	[0.107]
$p_{gi}^{(1)}$	2.780***		2.615***	1.790***		1.630***
	[0.678]		[0.645]	[0.186]		[0.253]
$p_{gi}^{(2)}$	0.385		0.616	0.516*		0.298
	[0.349]		[0.374]	[0.236]		[0.249]
$p_{gi}^{(4)}$	0.911*		0.952*	0.225		0.266
	[0.426]		[0.431]	[0.245]		[0.247]
$p_{gi}^{(5)}$	4.305***		3.812***	1.465***		1.500***
	[0.477]		[0.464]	[0.137]		[0.172]
Subject FE	N	Y	Y	N	Y	Y
N	780	780	780	390	390	390
Adj. R^2	0.225	0.156	0.291	0.363	0.198	0.472

Notes: *, **, *** denote significance at the 10%, 5%, and 1%-level, respectively. Standard errors are clustered at the experiment session level, and shown in brackets. Subject fixed-effects are constrained in that their sum is equal to zero.

weighted average of position-effects 1 and 2, $\Delta_{gi} = \alpha + 0.5\beta_1 + 0.5\beta_2 + \gamma_i$.

Table 4 summarises the results of our investigation, which are remarkably similar across our two domains of decisions, gift-exchange and lottery choices. Models (1) and (4) show the estimates from the first equation, which only includes order indicators. While being at positions 1 and 5 implies that the group decision is significantly further away from the individual's decision than from the median's decision, for positions 2 and 4 the difference is not significant or depends on the specification. In models (2) and (4), using only subject fixed-effects as explanatory variables of the difference between an individual's choice and the choice of her group (the second equation above), we observe a drop in explanatory power. Adding these subject fixed-effects to the base model with order indicators (the third equation) increases the explanatory power only modestly, and has basically no effect on the size and significance of the order coefficients.

In sum, the relative position of an individual choice within a group seems to be the most important indicator of the individual's impact on the group's choice, and is particularly robust against controlling for possible (unobserved) individual characteristics which might additionally influence an individual's effect on the group choice.

5.d *Social influence*

Our experimental design allows us to study the effect of group decisions on subsequent decisions of the involved individuals. Subjects made two gift-exchange decisions and one lottery decision within the same group, before being rematched to another group in the next of three phases. Thus, for gift-exchange decisions, when looking at the first decision in a phase, the previous decision (in $t-1$) was made in a different group. For the second decision in a phase, however, the previous decision (in $t-1$) was made in the same group. The first two models presented in Table 5 regress the first and second individual choice in a phase, respectively, on the subject's own decisions in $t-1$ as well as the difference between the group's choice and the own choice in $t-1$. We find that the first individual choice in a phase is correlated with the own previous decision, but not with the group choice in the previous, different group. The second choice in a phase, however, is correlated both with the own previous choice and with the difference between group decision and own decision in the same group in $t-1$ (such that when the group decision was more generous than the own decision in $t-1$, the own decision becomes more generous in t).

TABLE 5
OLS REGRESSIONS OF CURRENT INDIVIDUAL CHOICES ON CHOICES MADE BEFORE IN A DIFFERENT GROUP OR THE SAME GROUP

	Gift-exchange (Normalized amount returned)		Lottery (Nb safe choices)
Decision in phase	1st	2nd	
Constant	-1.295***	-1.717***	-0.130
	[0.329]	[0.395]	[0.157]
Own decision in t–1	0.734***	0.659***	1.022***
	[0.064]	[0.046]	[0.027]
Diff to Group in t–1	0.061	0.176***	0.393***
	[0.042]	[0.045]	[0.048]
N	260	390	260
R^2	0.478	0.338	0.679

Notes: For the first gift-exchange decision in a phase, and for all lottery decisions, decisions in t–1 were made in a different group. For the second gift-exchange decision in a phase, decisions in t–1 were made in the same group. *, **, *** denote significance at the 10%, 5%, and 1%-level, respectively. Standard errors are clustered at the experiment session level, and shown in brackets.

A similar analysis for lottery decisions in provided in the third model in Table 5. We find that the current decision of an individual, besides being highly correlated with the own previous decision, is positively correlated with the difference between the previous group choice and previous own individual choice.

These results indicate the existence of social influence. In gift-exchange games, the previous group choice only has a significant effect when the group members stay together (that is, for the second gift-

TABLE 6
OLS regressions of current individual choices on choices made before, conditional on previous position

	Gift-exchange 2nd decision in phase (Normalized amount returned)	Lottery (Nb safe choices)
Constant	-1.939***	0.012
	[0.406]	[0.342]
Own decision in t–1	0.665***	1.003***
	[0.04]	[0.052]
Was (1)	0.296*	0.312**
× Diff to Group in t–1	[0.146]	[0.121]
Was (2)	0.063	0.16
× Diff to Group in t–1	[0.194]	[0.103]
Was (3)	0.189	0.07
× Diff to Group in t–1	[0.115]	[0.102]
Was (4)	0.069	-0.305
× Diff to Group in t–1	[0.056]	[0.185]
Was (5)	0.024	0.566***
× Diff to Group in t–1	[0.102]	[0.111]
N	260	260
R^2	0.338	0.679

Notes: *, **, *** denote significance at the 10%, 5%, and 1%-level, respectively. Standard errors are clustered at the experiment session level, and shown in brackets.

exchange situation within a phase).[36] However, the second individual gift-exchange decisions within a phase already incorporate the influence of the first group choice in the same phase, so this just means that the same group members do not have a further influence on each others' individual choices the second time around. The influence of the first group choice in a phase is permanent, in the sense that we do not observe a correction in the opposite direction when individuals part from their previous group members and get into new groups.

To explore whether group members at different positions are differently affected by the group choice in their subsequent decision, we run extended versions of the models reported in Table 5, with results reported in Table 6. In particular, we interact the difference between an individuals' own choice in $t-1$ and the group choice in $t-1$ with a dummy indicating whether this person's individual choice was at position (1), (2), (3), (4), or (5) in the group in the previous decision situation. In other words, we estimate the effect of the group choice separately by position. For gift-exchange decisions, we find

[36]Tobit versions of these analyses yield the same results, see Table 10 in the Supplementary Appendix.

that for second choices within a phase, there is only a significant effect for the least altruistic member, with this member's individual choice becoming less egoistic. For lottery choices, we find relatively strong significant effects for both the most risk-averse and the most risk-loving person, both of whom adjust their subsequent lottery task decision towards the previous group choice.[37]

These results suggest that deliberation not only suppresses extreme opinions in the current decision, but that it also has a long-lasting effect by changing the opinions of extreme group members, bringing them closer to the median.

5.e Relating the empirical results to predictions of spatial bargaining models

Our experiments were not particularly designed to test the predictions of spatial bargaining models, or to compare the validity of different types of spatial bargaining models. In particular, we do not control the level of patience of group members, or the decision rule the group adopts. Posing no restriction in these dimensions implies that both a Banks and Duggan (2000) and a Compte and Jehiel (2010) type model can explain a wide range of observed behavior, especially if groups are heterogeneous in the decision rule they adopt. Nevertheless, we can identify the range of parameter values for which the models' predictions are broadly consistent with the empirical findings. In the Banks and Duggan (2000) model framework, this simply requires an intermediate level of patience for the members. For too impatient members, the group decision would be the mean individual opinion and all members would be influential, while for too patient members the group decision would be the median individual opinion (subject to an additional condition if the decision rule is not simple majority). It is for intermediate levels of patience that extreme individual opinions are not likely to be included in the acceptance set, but all non-extreme individual opinions are likely enough to influence the expected group decision.

A Compte and Jehiel (2010) type model can also generate predictions that are consistent with the empirical findings. This first of all requires that the level of patience is not too low, because in that case no member would be influential. Second, it cannot be that either all groups adopt simple majority rule or that all groups adopt unanimity rule. In the first case only the median member would be influential, while in the second case only the extreme members. However, if it is either the case that groups tend to adopt a supermajority rule but not unanimity, or that some groups adopt a simple majority rule while other groups a supermajority rule then it can be that exactly the non-extreme members are influential in expectation.[38]

[37]For lottery decisions, within-group variance of individual decisions is statistically significantly lower in phase 2 than in phase 1, and in phase 3 than in phase 2. We do not observe such decrease of within-group variance over time for gift-exchange decisions. The time needed for group deliberation (the time from when the group discussion started until the group decision was entered into the experiment program) is statistically significantly lower for phase 2 than for phase 1 in both decision contexts, but does not decrease further in phase 3. In both gift-exchange and lottery decision environments, we do not observe a significant correlation between within-group variance and group deliberation time.

[38]For supermajority rules other than unanimity, Compte and Jehiel (2010) predicts that in each group exactly two members are influential, but the identity of these two members depend on the specific individual opinions in the group. So it can be the case that for some type of individual opinion compositions the median and another member are influential, while for some other type of compositions two non-median members are influential.

6 Conclusion

This paper investigates how groups come to an agreement through deliberation, and which group members have a significant influence on the group choice. We find that the member with the median opinion has the greatest influence on the choice, but there are members in both direction from the median who can also influence the choice. We observe that extreme opinions tend to be suppressed in group decision making. We also find evidence that persuasion is part of deliberation, as individual opinions tend to move towards previous group decisions the individuals participated in. This particularly holds for individuals with extreme opinions, implying that deliberation has a permanent depolarizing effect in the population. This is consistent with the idea behind deliberative democracy, in that deliberation, not merely voting, provides real authenticity to social choices.

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Appendix

Theorem 1: In a bargaining game with publicly known ideal points and plurality decision rule, SSPE is unique. For any set of ideal points, the set of acceptable proposals A monotonically decreases in δ, it converges to the whole choice set as $\delta \to 0$, and it converges to the median ideal point as $\delta \to 1$.

Proof: Let y_i denote member i's proposal, and define the following:

$$\lambda_1 \equiv \arg \min_{i \in \{1,2,4,5\}} |x_i - x_3|$$

$$\lambda_{k+1} \equiv \arg \min_{i \in \{1,2,4,5\} \setminus \{\lambda_1, \ldots, \lambda_k\}} |x_i - x_3|$$

Thus, $|x_{\lambda_1} - x_3| \leq |x_{\lambda_2} - x_3| \leq |x_{\lambda_3} - x_3| \leq |x_{\lambda_4} - x_3|$, so that player λ_k is the non-median player whose ideal point is the k-th closest (among non-median players) to that of the median player.

First, Theorem 1 of Banks and Duggan (2000) implies that there is no delay in SSPE (along the equilibrium path all proposals are accepted).

Next, note that in any SSPE, the acceptable proposals are exactly those that are acceptable to player 3. This follows because for all players, in any SSPE, the expected continuation value if there is no agreement in the current round depends only on the expectation and the variance of the proposal in the next round. Let the expectation of the proposal in the SSPE be $\overline{y}$. Since the variance affects all players' payoffs the same way, the difference in expected continuation payoffs across players only depends on the distance between ideal points and $\overline{y}$. This means that if a proposal y is preferred by player 3 to no agreement in the current round and $y \leq \overline{y}$ then players 1 and 2 also prefer it. Conversely, if a proposal y is preferred by player 3 to no agreement in the current round and $y > \overline{y}$ then players 4 and 5 also prefer it.

Because payoffs are quasi-concave, in any SSPE, the set of proposals acceptable to player 3 is a convex interval. Moreover, this interval contains x_3, the action that yields the highest possible payoff to player 3. Given this, we need to consider the following cases:

Case (i): the acceptance set contains x_3, but does not contain any other player's ideal point.

The incentive compatibility condition to lure player 3 is

$$v \geq \delta(4v + 1)/5$$

Letting v denote player 3's payoff and setting $y = x_{\lambda_1}$ gives the bound on δ:

$$\delta > \frac{5\big(1 - (x_{\lambda_1} - x_3)^2\big)}{5 - 4(x_{\lambda_1} - x_3)^2}.$$

Then, given the above inequality holds,

$$y_1 = y_2 = x_3 - \sqrt{\frac{5(1-\delta)}{5-4\delta}},\ y_3 = x_3,\ y_4 = y_5 = x_3 + \sqrt{\frac{5(1-\delta)}{5-4\delta}}.$$

This candidate equilibrium cannot exist for $\delta \leq \frac{5\left(1-(x_{\lambda_1}-x_3)^2\right)}{5-4(x_{\lambda_1}-x_3)^2}$. In this case, $|x_3 - x_{\lambda_1}| \leq \sqrt{\frac{5(1-\delta)}{5-4\delta}}$, so that x_{λ_1} is in the acceptance set given above (making it suboptimal for player λ_1 to propose anything other than x_{λ_1}).

Case (ii): the acceptance set contains two consecutive players' ideal points, including x_3.

The incentive compatibility condition to lure player 3 is

$$v \geq \delta(3v + 2 - (x_{\lambda_1} - x_3)^2)/5$$

Setting the payoff of the median voter equal to v and setting $y = x_{\lambda_2}$ gives the next bound on δ:

$$\frac{5\left(1-(x_{\lambda_2}-x_3)^2\right)}{5-(x_{\lambda_1}-x_3)^2-3(x_{\lambda_2}-x_3)^2} < \delta \leq \frac{5\left(1-(x_{\lambda_1}-x_3)^2\right)}{5-4(x_{\lambda_1}-x_3)^2}.$$

Then, given the above inequality holds,

$$y_3 = x_3,\quad y_{\lambda_k} = \begin{cases} x_{\lambda_k} & \text{if } k = 1 \\ x_3 - \sqrt{\dfrac{5(1-\delta)+\delta(x_{\lambda_1}-x_3)^2}{5-3\delta}} & \text{if } k > 1,\ \lambda_k < 3 \\ x_3 + \sqrt{\dfrac{5(1-\delta)+\delta(x_{\lambda_1}-x_3)^2}{5-3\delta}} & \text{if } k > 1,\ \lambda_k > 3 \end{cases}$$

This candidate equilibrium cannot exist for $\delta < \frac{5\left(1-(x_{\lambda_2}-x_3)^2\right)}{5-(x_{\lambda_1}-x_3)^2-3(x_{\lambda_2}-x_3)^2}$. In this case, $|x_3 - x_{\lambda_2}| < \sqrt{\frac{5(1-\delta)+\delta(x_{\lambda_1}-x_3)^2}{5-3\delta}}$, so that x_{λ_2} is strictly between x_3 and the prescribed proposal given above. Consequently, player λ_2's ideal point x_{λ_2} would be accepted if proposed, so it would then be suboptimal for player λ_2 to propose anything other than x_{λ_2}.

This candidate equilibrium cannot exist for $\delta > \frac{5\left(1-(x_{\lambda_1}-x_3)^2\right)}{5-4(x_{\lambda_1}-x_3)^2}$ either. In this case, $1-(x_3-x_{\lambda_1})^2 < \delta\left[5-(x_3-x_{\lambda_1})^2-\sum_{i\neq\lambda_1}(x_3-y_i)^2\right]/5$, where the y_i's are the proposals given above, so that $y_{\lambda_1} = x_{\lambda_1}$ is not incentive compatible with respect to player 3. Consequently, player 3 would reject x_{λ_1} so that it would be suboptimal for player λ_1 to propose x_{λ_1}.

Case (iii): the acceptance set contains three consecutive players' ideal points, including x_3.

The incentive compatibility condition to lure player 3 is

$$v \geq \delta(2v + 3 - (x_{\lambda_1} - x_3)^2 - (x_{\lambda_2} - x_3)^2)/5$$

Setting the payoff of the median voter equal to v and setting $y = x_{\lambda_3}$ gives the next bound on δ:

$$\frac{5\big(1-(x_{\lambda_3}-x_3)^2\big)}{5-(x_{\lambda_1}-x_3)^2-(x_{\lambda_2}-x_3)^2-2(x_{\lambda_3}-x_3)^2} < \delta \leq \frac{5\big(1-(x_{\lambda_2}-x_3)^2\big)}{5-(x_{\lambda_1}-x_3)^2-3(x_{\lambda_2}-x_3)^2}.$$

Then, given the above inequality holds,

$$y_3 = x_3, \quad y_{\lambda_k} = \begin{cases} x_{\lambda_k} & \text{if } k \leq 2 \\ x_3 - \sqrt{\dfrac{5(1-\delta)+\delta[(x_{\lambda_1}-x_3)^2+(x_{\lambda_2}-x_3)^2]}{5-2\delta}} & \text{if } k > 2,\ \lambda_k < 3 \\ x_3 + \sqrt{\dfrac{5(1-\delta)+\delta[(x_{\lambda_1}-x_3)^2+(x_{\lambda_2}-x_3)^2]}{5-2\delta}} & \text{if } k > 2,\ \lambda_k > 3 \end{cases}$$

This candidate equilibrium cannot exist for $\delta < \frac{5\left(1-(x_{\lambda_3}-x_3)^2\right)}{5-(x_{\lambda_1}-x_3)^2-(x_{\lambda_2}-x_3)^2-2(x_{\lambda_3}-x_3)^2}$. In this case, $|x_3 - x_{\lambda_3}| < \sqrt{\frac{5(1-\delta)+\delta[(x_{\lambda_1}-x_3)^2+(x_{\lambda_2}-x_3)^2]}{5-2\delta}}$, so that x_{λ_3} is strictly between x_3 and the prescribed proposal given above. Consequently, player λ_3's ideal point x_{λ_3} would be accepted if proposed, so it would then be suboptimal for player λ_3 to propose anything other than x_{λ_3}.

This candidate equilibrium cannot exist for $\delta > \frac{5\left(1-(x_{\lambda_2}-x_3)^2\right)}{5-(x_{\lambda_1}-x_3)^2-3(x_{\lambda_2}-x_3)^2}$ either. In this case, $1-(x_3-x_{\lambda_2})^2 < \delta\left[5-(x_3-x_{\lambda_2})^2-\sum_{i\neq\lambda_2}(x_3-y_i)^2\right]/5$, where the y_i's are the proposals given above, so that $y_{\lambda_2} = x_{\lambda_2}$ is not incentive compatible with respect to player 3. Consequently, player 3 would reject x_{λ_2} so that it would be suboptimal for player λ_2 to propose x_{λ_2}.

Case (iv): the acceptance set contains four consecutive players' ideal points, including x_3.

The incentive compatibility condition to lure player 3 is

$$v \geq \delta(v + 4 - (x_{\lambda_1}-x_3)^2 - (x_{\lambda_2}-x_3)^2 - (x_{\lambda_3}-x_3)^2)/5$$

Setting the payoff of player 3 equal to v and setting $y = x_{\lambda_4}$ gives the next bound on δ:

$$\frac{5\big(1-(x_{\lambda_4}-x_3)^2\big)}{5-\sum_{i=1}^{5}(x_i-x_3)^2} < \delta \leq \frac{5\big(1-(x_{\lambda_3}-x_3)^2\big)}{5-(x_{\lambda_1}-x_3)^2-(x_{\lambda_2}-x_3)^2-2(x_{\lambda_3}-x_3)^2}.$$

Then, given the above inequality holds,

$$y_3 = x_3, \ y_{\lambda_k} = \begin{cases} x_{\lambda_k} & \text{if } k \leq 3 \\ x_3 - \sqrt{\dfrac{5(1-\delta)+\delta[(x_{\lambda_1}-x_3)^2+(x_{\lambda_2}-x_3)^2+(x_{\lambda_3}-x_3)^2]}{5-\delta}} & \text{if } k=4,\ \lambda_4<3 \\ x_3 + \sqrt{\dfrac{5(1-\delta)+\delta[(x_{\lambda_1}-x_3)^2+(x_{\lambda_2}-x_3)^2+(x_{\lambda_3}-x_3)^2]}{5-\delta}} & \text{if } k=4,\ \lambda_4>3 \end{cases}$$

This candidate equilibrium cannot exist for $\delta < \frac{5\left(1-(x_{\lambda_4}-x_3)^2\right)}{5-\sum_{i=1}^{5}(x_i-x_3)^2}$. In this case, $|x_3 - x_{\lambda_4}| < \sqrt{\frac{5(1-\delta)+\delta[(x_{\lambda_1}-x_3)^2+(x_{\lambda_2}-x_3)^2+(x_{\lambda_3}-x_3)^2]}{5-\delta}}$, so that x_{λ_4} is strictly between x_3 and the prescribed proposal given above. Consequently, player λ_4's ideal point x_{λ_4} would be accepted if proposed, so it would then be suboptimal for player λ_4 to propose anything other than x_{λ_4}.

This candidate equilibrium cannot exist for $\delta > 5\frac{\left(1-(x_{\lambda_3}-x_3)^2\right)}{5-(x_{\lambda_1}-x_3)^2-(x_{\lambda_2}-x_3)^2-2(x_{\lambda_3}-x_3)^2}$ either. In this case, $1-(x_3-x_{\lambda_3})^2 < \delta\left[5-(x_3-x_{\lambda_3})^2-\sum_{i\neq\lambda_3}(x_3-y_i)^2\right]/5$, where the y_i's are the proposals given above, so that $y_{\lambda_3} = x_{\lambda_3}$ is not incentive compatible with respect to player 3. Consequently, player 3 would reject x_{λ_3} so that it would be suboptimal for player λ_3 to propose x_{λ_3}.

Case (v): all members propose their ideal points.

Given

$$\delta \leq \frac{5\left(1-(x_{\lambda_4}-x_3)^2\right)}{5-\sum_{i=1}^{5}(x_i-x_3)^2},$$

we have

$$y_i = x_i \text{ for all } i.$$

This candidate equilibrium cannot exist for $\delta > \frac{5\left(1-(x_{\lambda_4}-x_3)^2\right)}{5-\sum_{i=1}^{5}(x_i-x_3)^2}$. In this case, $1-(x_3-x_{\lambda_4})^2 < \delta\sum\left(1-(x_3-y_i)^2\right)/5$, where the y_i's are the proposals given above, so that $y_4 = x_{\lambda_4}$ is no incentive compatible to player 3. Consequently, it would be suboptimal for player λ_4 to propose x_{λ_4}.

This concludes the analysis of possible cases. Since $\lambda_1, ..., \lambda_4$ are not restricted to be strictly positive, the above analysis also covers parameter values when multiple players' ideal points are at the median position. Relatedly, for some ideal point configurations, only some of the above cases apply. For example, if there are two players with ideal points exactly at the median, then the set of δ for which exactly one player proposes her ideal point is empty: for any $\delta \in (0,1)$ at least the two median players can propose their ideal points in SSPE.

Since the regions of discount factors for which different types of equilibria (cases (i)-(v)) apply partition $(0,1)$ for any $(x_1, .., x_5)$, SSPE is always unique. The above characterization of the unique SSPE also implies all of the other claims in the statement of the theorem. ■

Theorem 2: In a bargaining game with private ideal points and simple majority rule, preceded by a round of cheap talk, for low enough discount factors there is a sequential equilibrium in which members announce their types truthfully, and then all members propose their ideal points in the bargaining phase. Moreover, all sequential equilibria are outcome-equivalent to the equilibrium above. Conversely, for high enough discount factors there is a sequential equilibrium in which members announce their types truthfully, and then all members propose the median announced ideal point in the bargaining phase.

Proof: Let $a_1 < ... < a_N$ be the set of possible actions and player types. Define $\Delta \equiv \min_i(a_{i+1} - a_i)$.

Consider first the continuation game on the equilibrium path following the reporting stage. Note that player 3's continuation payoff at any stage, in case of no agreement, is δ, as according to the candidate equilibrium profile all players propose x_3 subsequently. Therefore $\delta \geq 1 - \Delta^2$ implies that player 3 rejects any proposal other than x_3. Moreover, any proposal $y < x_3$ gets rejected by players 4 and 5, and any proposal $y > x_3$ gets rejected by players 1 and 2. Conversely, a proposal $y = x_3$ gets gets accepted by any player i, since it yields a payoff of $1-(x_i-x_3)^2 > 0$, which is strictly larger than the continuation payoff $\delta(1-(x_i-x_3)^2)$. This also implies that any player i strictly prefers proposing x_3 to any other proposal.

Now we consider the stage in which players report their valuations. Suppose a player with true ideal point x_i reports $x'_i \neq x_i$, and consider each of the possible cases: (a) misreporting leads other players to believe the median ideal point is not x_i, when in fact it is x_i, (b) misreporting leads other players to believe the median ideal point is not x_j, when in fact it is $x_j \neq x_i$, (c) misreporting has no effect on other players' beliefs regarding the median ideal point.

For case (a), misreporting strictly decreases player i's payoff because other players will no longer propose player i's ideal point if recognized in the first period. Therefore no matter how the game proceeds thereafter, player i is strictly worse than if other players were to propose the true median of x_i in the first period.

For case (b), other players' beliefs regarding the median ideal point can only be affected by player i misreporting if x_j is strictly between x_i and x'_i. Therefore, the perceived median, $\tilde{x}_j$ is further from player i's ideal point than the true median: $|\tilde{x}_j - x_i| > |x_j - x_i|$. Consequently, other players (if recognized) propose $\tilde{x}_j$, which gives player i a strictly worse payoff regardless of whether or not the proposal is accepted than the payoff if other players propose (and accept) x_j, as in the truthful equilibrium.

For case (c), player i's payoff is not affected by the deviation.

Therefore, player i cannot profit from misreporting in any of the three cases, and is strictly hurt by misreporting in cases (a) and (b). Moreover, for any x_i, player i's ex-ante expectation of x_i being the true median ideal point is nonzero for a finite type space with independently distributed types. The likelihood of strictly hurting oneself by misreporting is strictly positive for any x_i. Thus, truth-telling is the unique optimal action in the reporting stage. ■

Supplementary Appendix to
Attila Ambrus, Ben Greiner, Parag A. Pathak:
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(not for publication)

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A Theory

In this Supplementary Appendix we assume that ideal points are commonly known to be $0 \leq x_1 \leq ... \leq x_5 \leq 1$, and that the agreement of all five players is required for a proposal to pass.

Convexity of Set of Acceptable Agreements

First we establish that the set of acceptable agreements, denoted by Y, in any SSPE is convex. Given $y_1, \ldots, y_5$, and conditional on all other players accepting, player i's potential payoff from accepting player j's proposal y_j is $1-(y_j-x_i)^2$, while the continuation value in case of no acceptance is $v_i \leq \frac{\delta}{5}$. The difference between the potential payoff from acceptance and the continuation value, i.e. $1-(y_j-x_i)^2-v_i$, is decreasing as $|y_j - x_i|$ increases. Therefore, if $1-(y_j-x_i)^2-v_i \geq 0$ and $|y_{j'} - x_i| < |y_j - x_i|$ both hold, we must have that $1-(y_{j'}-x_i)^2-v_i(y_{j'}) \geq 0$, implying that $y_{j'}$ — like y_j — is in the acceptance region for player i. Thus, the set of proposals that player i is willing to accept, denoted Y_i, is convex. Furthermore, this set is the intersection of the unit interval and a closed interval in R centered at x_i: $Y_i = [0,1] \cap [x_i - z_j, x_i + z_j]$, where $z_j > 0$ is implicitly defined above. Since the intersection of convex sets is convex, the set of mutually acceptable agreements, $Y \equiv Y_1 \cap \ldots Y_5$, is also convex. Consequently, if $x_i \in Y$ and $x_{i+k} \in Y$ for $k \geq 1$, then $x_{i+1} \in [x_i, x_{i+k}] \in Y$. Therefore any player with an ideal point that is between the minimum and the maximum ideal points of players who propose their ideal point in a given SSPE must also propose their ideal point in that SSPE. This feature means we can limit our consideration to the cases covered below.

Case (i): all members propose their ideal points.

For one of the extreme members, $n = \{1, 5\}$, the incentive compatibility condition to lure all other voters is

$$1-(x_1-x_5)^2 \geq \delta[5-\sum_{i=1}^{5}(x_i-x_n)^2]/5,$$

which gives the upper bound on δ:

$$\delta \leq \min_{n\in\{1,5\}} \left\{ \frac{5[1-(x_5-x_1)^2]}{5-\sum_{i=1}^{5}(x_i-x_n)^2} \right\}.$$

Then, given the above inequality holds, $y_i = x_i$ for all i.

This candidate equilibrium cannot exist for $\delta > \min_{n\in\{1,5\}}\left\{\frac{5[1-(x_5-x_1)^2]}{5-\sum_{i=1}^{5}(x_i-x_n)^2}\right\}$. In this case, $1-(x_3-x_m)^2 < \delta\sum(1-(x_3-y_i)^2)/5$, where the y_i's are the proposals given above and $m \equiv \arg\min_{n\in\{1,5\}}\left\{\frac{5[1-(x_5-x_1)^2]}{5-\sum_{i=1}^{5}(x_i-x_n)^2}\right\}$, so that $y_m = x_m$ is not incentive compatible to player $6-m$ (i.e. to the opposite extreme). Consequently, it would be suboptimal for player m to propose x_m.

Case (ii): four consecutive members propose their ideal points.

Now, one – but not both – of the extreme members, $n = \{1,5\}$, is willing to accept the other's ideal point. Thus, the corresponding range for δ is:

$$\min_{n\in\{1,5\}}\left\{\frac{5[1-(x_5-x_1)^2]}{5-\sum_{i=1}^{5}(x_i-x_n)^2}\right\} \leq \delta \leq \max_{n\in\{1,5\}}\left\{\frac{5[1-(x_5-x_1)^2]}{5-\sum_{i=1}^{5}(x_i-x_n)^2}\right\}.$$

The incentive compatibility condition for n to accept the other extreme member's offer is

$$v = \delta[v + 4 - \sum_{i=2}^{4}(x_i - x_n)^2]/5$$

Define

$$\gamma \equiv \arg\max_{n\in\{1,5\}}\left\{\sum_{i=1}^{5}(x_i-x_n)^2\right\}.$$

Provided δ is in the range specified above, letting the payoff function for γ equal to v and solving for the other extreme member's offer gives:

$$y_k = \begin{cases} x_k & \text{if } : k \in \{2,3,4,\gamma\} \\ x_1 + \sqrt{\dfrac{5(1-\delta)+\delta[(x_2-x_1)^2+(x_3-x_1)^2+(x_4-x_1)^2]}{5-\delta}} & \text{if } k=5,\ \gamma=1 \\ x_5 - \sqrt{\dfrac{5(1-\delta)+\delta[(x_2-x_5)^2+(x_3-x_5)^2+(x_4-x_5)^2]}{5-\delta}} & \text{if } k=1,\ \gamma=5 \end{cases}$$

This candidate equilibrium cannot exist for $\delta < \min_{n\in\{1,5\}}\left\{\frac{5[1-(x_5-x_1)^2]}{5-\sum_{i=1}^{5}(x_i-x_n)^2}\right\}$. In this case, $|x_\gamma - x_{6-\gamma}| < \sqrt{\frac{5(1-\delta)+\delta[(x_2-x_1)^2+(x_3-x_1)^2+(x_4-x_1)^2]}{5-\delta}}$, so that $x_{6-\gamma}$ is strictly between x_γ and the prescribed proposal $y_{6-\gamma}$ given above. Consequently, player $6-\gamma$'s ideal point $x_{6-\gamma}$ is in the set of mutually acceptable agreements (in particular, it is acceptable to the opposite extreme, γ), so that it is no longer optimal for player $6-\gamma$ to propose anything other than $x_{6-\gamma}$.

This candidate equilibrium cannot exist for $\delta > \max_{n\in\{1,5\}}\left\{\frac{5[1-(x_5-x_1)^2]}{5-\sum_{i=1}^{5}(x_i-x_n)^2}\right\}$. In this case, $1-(x_{6-\gamma}-x_\gamma)^2 < \delta\left[5-(x_{6-\gamma}-x_\gamma)^2-\sum_{i\neq 6-\gamma}(y_i-x_\gamma)^2\right]/5$, where the y_i's are the proposals given above, so that $y_\gamma = x_\gamma$ is not incentive compatible to player $6-\gamma$ (i.e. to the opposite extreme). Consequently, it would be suboptimal for player γ to propose x_γ.

Case (iii): three consecutive members propose their ideal points.

In this case, neither extreme accepts the other's ideal point, but accepts all other members' ideal points. The indifference conditions that determine the extreme members' proposals are:

$$1-(y_5-x_1)^2=\delta[5-(y_1-x_1)^2-(y_5-x_1)^2-\sum_{i=2}^{4}(x_i-x_1)^2]/5$$
$$1-(y_1-x_5)^2=\delta[5-(y_1-x_5)^2-(y_5-x_5)^2-\sum_{i=2}^{4}(x_i-x_5)^2]/5$$

The top expression is the threshold such that player 1 accepts player 5's offer, y_5; the bottom expression is the threshold such that player 5 accepts player 1's offer, y_1. In this SSPE, y_1, y_5 are the values that satisfy the above system of equations, while $y_i = x_i$ for $i \in \{2,3,4\}$. For this case to apply, we must have

$$\delta \geq \max_{n\in\{1,5\}}\left\{\frac{5[1-(x_5-x_1)^2]}{5-\sum_{i=1}^{5}(x_i-x_n)^2}\right\}.$$

Let $y_1(\delta), y_5(\delta)$ be the extreme members' proposals given δ. Then the upper bound on δ for the interior members to propose their ideal point is given by

$$\delta \leq \max\{\delta' : y_1(\delta') \leq x_2 \text{ and } y_5(\delta') \geq x_4\}.$$

If the above condition did not hold, then one of the extreme members would not accept the furthest interior member's ideal point (e.g. player 5 wouldn't accept player 2's ideal point if $y_1(\delta) > x_2$).

This candidate equilibrium cannot exist for $\delta < \max_{n\in\{1,5\}}\left\{\frac{5[1-(x_5-x_1)^2]}{5-\sum_{i=1}^{5}(x_i-x_n)^2}\right\}$. In this case, $|x_{6-\gamma} - x_\gamma| < |x_{6-\gamma} - y_\gamma(\delta)|$, where γ is defined as in case (ii) so that x_γ is strictly between $x_{6-\gamma}$ and the prescribed proposal $y_\gamma(\delta)$ given above. Consequently, player γ's ideal point x_γ is in the set of mutually acceptable agreements (in particular, it is acceptable to the opposite extreme, $6-\gamma$), so that it is no longer optimal for player γ to propose anything other than x_γ.

This candidate equilibrium cannot exist for $\delta > \max\{\delta' : y_1(\delta') \leq x_2 \text{ and } y_5(\delta') \geq x_4\}$. In this case,

$$1-(x_{9-2z}-x_z)^2 < \delta\left[5-(x_{9-2z}-x_z)^2-\sum_{i\neq z}(y_i(\delta)-x_{9-2z})^2\right]/5,$$

where the $y_i(\delta)$'s are the proposals given above and $z \equiv \arg\min_{n\in\{2,4\}}\{\delta' : y_{2n-3}(\delta') = x_n\}$, so that $y_z = x_z$ is not incentive compatible to player $9-2z$ (i.e. to the opposite extreme). Consequently, it would be suboptimal for player z to propose x_z.

Case (iv): two consecutive members propose their ideal points.

Suppose player $m \in \{2,4\}$ is the non-median, non-extreme member who proposes her ideal point (i.e. $y_m = x_m$). Then $m = 2$ implies $y_4 = y_5$, while $m = 4$ implies $y_2 = y_1$. Player 1's indifference condition is now

$$1-(y_5-x_1)^2=\begin{cases}\delta[5-(y_1-x_1)^2-2(y_5-x_1)^2-\sum_{i=2}^{3}(x_i-x_1)^2]/5, & \text{if } m=2\\ \delta[5-2(y_1-x_1)^2-(y_5-x_1)^2-\sum_{i=3}^{4}(x_i-x_1)^2]/5, & \text{if } m=4\end{cases}$$

while player 5's indifference condition is

$$1-(y_1-x_5)^2=\begin{cases}\delta[5-(y_1-x_5)^2-2(y_5-x_5)^2-\sum_{i=2}^{3}(x_i-x_5)^2]/5, & \text{if } m=2\\ \delta[5-2(y_1-x_5)^2-(y_5-x_5)^2-\sum_{i=3}^{4}(x_i-x_5)^2]/5, & \text{if } m=4\end{cases}$$

In this SSPE, y_1, y_5 are the values that satisfy the above system of equations, while $y_i = x_i$ for $i \in \{3, m\}$; $m = 2$ implies $y_4 = y_5$ and $m = 4$ implies $y_2 = y_1$.

Again let $y_1(\delta), y_5(\delta)$ be the extreme members' implied proposals given δ from case (iii), while letting $\bar{y}_1(\delta), \bar{y}_5(\delta)$ be the extreme members' implied proposals given δ from this case. Then the range of δ for which exactly two members propose their ideal point is

$$\delta \in \Big(\max\{\delta' : y_1(\delta') \le x_2 \text{ and } y_5(\delta') \ge x_4\},\\ \min\big\{\delta' : \{\bar{y}_1(\delta') \ge x_2 \text{ and } \bar{y}_5(\delta') \le x_4\} \text{ or } \{\bar{y}_1(\delta') \ge x_3\} \text{ or } \{\bar{y}_5(\delta') \le x_3\}\big\}\Big).$$

This candidate equilibrium cannot exist for $\delta < \max\{\delta' : y_1(\delta') \le x_2 \text{ and } y_5(\delta') \ge x_4\}$. In this case, $|x_{9-2z} - x_z| < |x_{9-2z} - \bar{y}_z(\delta)|$, so that x_z is strictly between x_{9-2z} and the prescribed proposal $\bar{y}_z(\delta)$ given above where z is defined as in case (iii). Consequently, player z's ideal point x_z is in the set of mutually acceptable agreements (in particular, it is acceptable to the opposite extreme, $9-2z$), so that it is no longer optimal for player z to propose anything other than x_z.

Define $\ell \equiv \{n \in \{2,3,4\} : x_{n-1} \le \bar{y}_1(\delta') < x_n < \bar{y}_5(\delta') \le x_{n+1}, \text{ for some } \delta'\}$. Define $q \equiv \{n \in \{2,3,4\} : n \in \{3, m\} \text{ and } n \ne \ell\}$.

This candidate equilibrium cannot exist for $\delta > \min\big\{\delta' : \{\bar{y}_1(\delta') \ge x_2 \text{ and } \bar{y}_5(\delta') \le x_4\} \text{ or } \{\bar{y}_1(\delta') \ge x_3\} \text{ or } \{\bar{y}_5(\delta') \le x_3\}\big\}$. In this case,

$$1-(x_n-x_q)^2 < \delta\left[5-(x_n-x_q)^2-\sum_{i\ne q}(x_n-\bar{y}_q(\delta))^2\right]/5$$

for some $n \in \{1,5\}$, where the $\bar{y}_i(\delta)$'s are the proposals given above, so that $y_q = x_q$ is not incentive compatible to at least one of the extreme players $n \in \{1,5\}$. Consequently, it would be suboptimal for player q to propose x_q.

Case (v): one member proposes her ideal point.

Suppose player $\ell \in \{2,3,4\}$ is the non-extreme member who proposes her ideal point, where ℓ would be defined as above, i.e. $\ell = \{n \in \{2,3,4\} : x_{n-1} \le \bar{y}_1(\delta') < x_n < \bar{y}_5(\delta') \le x_{n+1}, \text{ for some } \delta'\}$.

Then $y_1 = \ldots = y_{\ell-1}$ and $y_{\ell+1} = \ldots = y_5$. Player 1's indifference condition is now

$$1-(y_5-x_1)^2 = \begin{cases} \delta[5-(y_1-x_1)^2-3(y_5-x_1)^2-(x_2-x_1)^2]/5, & \text{if } \ell=2 \\ \delta[5-2(y_1-x_1)^2-2(y_5-x_1)^2-(x_3-x_1)^2]/5, & \text{if } \ell=3 \\ \delta[5-3(y_1-x_1)^2-(y_5-x_1)^2-(x_4-x_1)^2]/5, & \text{if } \ell=4 \end{cases}$$

while player 5's indifference condition is

$$1-(y_1-x_5)^2 = \begin{cases} \delta[5-(y_1-x_5)^2-3(y_5-x_5)^2-(x_2-x_5)^2]/5, & \text{if } \ell=2 \\ \delta[5-2(y_1-x_5)^2-2(y_5-x_5)^2-(x_3-x_5)^2]/5, & \text{if } \ell=3 \\ \delta[5-3(y_1-x_5)^2-(y_5-x_5)^2-(x_4-x_5)^2]/5, & \text{if } \ell=4 \end{cases}$$

In this SSPE, y_1, y_5 are the values that satisfy the above system of equations, where $y_\ell = x_\ell$ and $y_1 = \ldots = y_{\ell-1}$ and $y_{\ell+1} = \ldots = y_5$.

Again let $\bar{y}_1(\delta), \bar{y}_5(\delta)$ be the extreme members' implied proposals given δ from case (iv), while letting $\hat{y}_1(\delta), \hat{y}_5(\delta)$ be the extreme members' implied proposals given δ from this case. Then the range of δ for which exactly one member proposes their ideal point is

$$\delta \in \Big(\min\big\{\delta' : \{\bar{y}_1(\delta') \geq x_2 \text{ and } \bar{y}_5(\delta') \leq x_4\} \text{ or } \{\bar{y}_1(\delta') \geq x_3\} \text{ or } \{\bar{y}_5(\delta') \leq x_3\}\big\},$$
$$\min\big\{\delta' : \exists k \in \{1,\ldots,4\} \text{ s.t. } x_k \leq \hat{y}_1(\delta') \leq \hat{y}_5(\delta') \leq x_{k+1}\big\}\Big).$$

This candidate equilibrium cannot exist for $\delta < \min\big\{\delta' : \{\bar{y}_1(\delta') \geq x_2 \text{ and } \bar{y}_5(\delta') \leq x_4\} \text{ or } \{\bar{y}_1(\delta') \geq x_3\} \text{ or } \{\bar{y}_5(\delta') \leq x_3\}\big\}$. In this case, $|x_n - x_q| < |x_n - \hat{y}_q(\delta)|$, for both $n \in \{1,5\}$ so that x_q is acceptable to both extremes, so that it is no longer optimal for player q to propose anything other than x_q.

This candidate equilibrium cannot exist for $\delta > \min\big\{\delta' : \exists k \in \{1,\ldots,4\} \text{ s.t. } x_k \leq \hat{y}_1(\delta') \leq \hat{y}_5(\delta') \leq x_{k+1}\big\}$. In this case, $1-(x_n-x_\ell)^2 < \delta\left[5-(x_n-x_\ell)^2 - \sum_{i\neq\ell}(x_n-\hat{y}_i(\delta))^2\right]/5$ for some $n \in \{1,5\}$, where the $\hat{y}_i(\delta)$'s are the proposals given above, so that $y_\ell = x_\ell$ is not incentive compatible to one of the extreme players. Consequently, it would be suboptimal for player ℓ to propose x_ℓ.

Case (vi): no member can propose her ideal point.

From the previous case, the range of δ for which no members propose their ideal point is

$$\delta \geq \min\big\{\delta' : \exists k \in \{1,\ldots,4\} \text{ s.t. } x_k \leq \hat{y}_1(\delta') \leq \hat{y}_5(\delta') \leq x_{k+1}\big\},$$

given $\hat{y}(\cdot)$ is defined as above. Now define

$$q = \{k \in \{1,\ldots,4\} : x_k \leq \hat{y}_1(\delta) \leq \hat{y}_5(\delta) \leq x_{k+1}\}$$

That is, k is the unique value, such that all $\hat{y}_1, \ldots, \hat{y}_5$ fall between x_k and x_{k+1}. Then $y_1 = \ldots = y_q$ and $y_{q+1} = \ldots = y_5$. Player 1's indifference condition is now

$$1 - (y_5 - x_1)^2 = \delta[5 - q(y_1 - x_1)^2 - (5 - q)(y_5 - x_1)^2]/5.$$

while player 5's indifference condition is

$$1 - (y_1 - x_5)^2 = \delta[5 - q(y_1 - x_5)^2 - (5 - q)(y_5 - x_5)^2]/5.$$

In this SSPE, y_1, y_5 are the values that satisfy the above system of equations, where $y_1 = \ldots = y_q$ and $y_{q+1} = \ldots = y_5$.

This candidate equilibrium cannot exist for $\delta < \min\{\delta' : \exists k \in \{1, \ldots, 4\}\ \text{ : such that }\ : x_k \leq \hat{y}_1(\delta') \leq \hat{y}_5(\delta') \leq x_{k+1}\}$. In this case, $|x_n - x_\ell| < |x_n - y_\ell(\delta)|$, for both $n \in \{1, 5\}$ and where $y_\ell(\delta)$ is the proposal prescribed by the indifference conditions above and ℓ is as defined in case (iv), so that x_ℓ is acceptable to both extremes. Therefore it would be suboptimal for player ℓ to propose anything other than x_ℓ.

Since the candidate equilibrium for each case cannot exist outside the given range for δ and the ranges for cases (i)-(vi) comprise a partition of the unit interval, the equilibrium under unanimity is unique for any $\delta \in [0, 1]$ with general parameter values.

Special Case: Two Extremes Equidistant From Median

Consider now the special case when $0 = x_1 < x_2 < x_3 = \frac{1}{2} < x_4 < x_5 = 1$.

Then the general characterization boils down to the following three cases:

Case (i): three consecutive members, including the median, propose ideal point.

In this case, neither extreme accepts the other's ideal point, but accepts all other members' ideal points. The indifference conditions that determine the extreme members' proposals are:

$$1 - y_5^2 = \delta[5 - y_1^2 - y_5^2 - \sum_{i=2}^{4} x_i^2]/5$$

$$1 - (1 - y_1)^2 = \delta[5 - (1 - y_1)^2 - (1 - y_5)^2 - \sum_{i=2}^{4}(1 - x_i)^2]/5$$

The top expression is the threshold such that player 1 accepts player 5's offer, y_5; the bottom expression is the threshold such that player 5 accepts player 1's offer, y_1. The top and bottom expressions can be used to express y_1 as

$$y_1 = \sqrt{\frac{-5(1-\delta)+(5-\delta)y_5^2}{\delta} - \sum_{i=2}^{4} x_i^2}$$
$$y_1 = 1 - \sqrt{\frac{5(1-\delta)+\delta(1-y_5)^2+\delta\sum_{i=2}^{4}(1-x_i)^2}{5-\delta}}$$

In this SSPE, y_1, y_5 are the values that satisfy the above system of equations, while $y_i = x_i$ for $i \in \{2,3,4\}$. Let $y_1(\delta), y_5(\delta)$ be the extreme members' proposals given δ. Then the range on δ for this case to apply is given by

$$0 \le \delta \le \max\{\delta' : y_1(\delta') \le x_2 \text{ and } y_5(\delta') \ge x_4\}.$$

If the above condition did not hold, then one of the extreme members would not accept the furthest interior member's ideal point (e.g. player 5 wouldn't accept player 2's ideal point if $y_1(\delta) > x_2$).

Case (ii): two consecutive members, including the median, propose their ideal points.

In this case, the non-median, non-extreme member who proposes her ideal point is player λ (i.e. $y_\lambda = x_\lambda$), where λ is defined as in the simple majority subsection. Here, $\lambda = 2$ implies $y_4 = y_5$, while $\lambda = 4$ implies $y_2 = y_1$. Player 1's indifference conditions is now

$$1 - y_5^2 = \delta[5 - \tfrac{\lambda}{2}y_1^2 - \left(3 - \tfrac{\lambda}{2}\right) y_5^2 - x_\lambda^2 - \tfrac{1}{4}]/5,$$

while player 5's indifference condition is

$$1 - (1-y_1)^2 = \delta\left[5 - \tfrac{\lambda}{2}(1-y_1)^2/2 - \left(3 - \tfrac{\lambda}{2}\right)(1-y_5)^2 - (1-x_\lambda)^2 - \tfrac{1}{4}\right]/5.$$

In this SSPE, y_1, y_5 are the values that satisfy the above system of equations, while $y_\lambda = x_\lambda$ and $y_3 = \frac{1}{2}$; $\lambda = 2$ implies $y_4 = y_5$ and $\lambda = 4$ implies $y_2 = y_1$.

Again let $y_1(\delta), y_5(\delta)$ be the extreme members' implied proposals given δ from case (i), while letting $\bar{y}_1(\delta), \bar{y}_5(\delta)$ be the extreme members' implied proposals given δ from this case. Then the range of δ for which exactly two members propose their ideal point is

$$\delta \in \left(\max\{\delta' : y_1(\delta') \le x_2 \text{ and } y_5(\delta') \ge x_4\},\ \min\{\delta' : \bar{y}_1(\delta') \ge x_2 \text{ and } \bar{y}_5(\delta') \le x_4\}\right).$$

Case (iii): only the median member proposes her ideal point.

In this case $y_1 = y_2$ and $y_4 = y_5$. The extreme members' indifference conditions are now

$$1 - y_5^2 = \delta[5 - 2y_1^2 - 2y_5^2 - \tfrac{1}{4}]/5$$
$$1 - (1-y_1)^2 = \delta[5 - 2(1-y_1)^2 - 2(1-y_5)^2 - \tfrac{1}{4}]/5$$

In this SSPE, y_1, y_5 are the values that satisfy the above system of equations, where $y_3 = 1/2$, $y_1 = y_2$ and $y_4 = y_5$.

Again let $\bar{y}_1(\delta), \bar{y}_5(\delta)$ be the extreme members' implied proposals given δ from case (ii). Then only the median member proposes her ideal point for

$$\delta \geq \min\{\delta' : \bar{y}_1(\delta') \geq x_2 \text{ and } \bar{y}_5(\delta') \leq x_4\}.$$

B Additional tables

The tables below provide robustness results for the estimations discussed in the paper.

- Table 7 shows results from Tobit estimations of the same models as displayed in Table 2.
- Table 8 shows results from post-estimation hypothesis tests on the Tobit models in Table 7, paralleling those discussed in the main text and shown in Table 3.
- Table 9 shows results from OLS and Tobit regressions using absolute second-mover gifts (rather than normalized by first mover's gift) as dependent and independents.
- Finally, Table 10 replicates the results on social influence from Table 5 in Tobit models.

TABLE 7

Robustness: Tobit regressions of group choices on individual choices

	Gift-exchange decisions (Normalized amount returned)		Lottery decisions (Number of safe choices)	
Model	(1)	(2)	(3)	(4)
Constant	-0.119	0.006	-0.224	-0.930
	[0.218]	[0.195]	[0.649]	[0.896]
$x_{gt}^{(1)}$	0.047	0.051	0.062	0.034
	[0.066]	[0.070]	[0.043]	[0.096]
$x_{gt}^{(2)}$	0.348***	0.340***	0.348***	0.313**
	[0.099]	[0.108]	[0.098]	[0.140]
$x_{gt}^{(3)}$	0.274**	0.331***	0.318**	0.525***
	[0.118]	[0.088]	[0.146]	[0.116]
$x_{gt}^{(4)}$	0.326***	0.381***	0.101	-0.030
	[0.112]	[0.116]	[0.119]	[0.102]
$x_{gt}^{(5)}$	0.066	0.028	0.206**	0.224***
	[0.056]	[0.095]	[0.086]	[0.055]
Session & Phase FE	N	Y	N	Y
N	156	156	78	78
Pseudo-R^2	0.280	0.320	0.279	0.382
L (Non) R Censored	11 (145) 0	11 (145) 0	0 (78) 0	0 (78) 0

Notes: *, **, *** denote significance at the 10%, 5%, and 1%-level, respectively. Standard errors are clustered at the experiment session level, and shown in brackets.

TABLE 8

Robustness: Results from post-estimation hypothesis tests on Tobit models reported in Table 7, p-values

Hypothesis	Model (1)	(2)	(3)	(4)
Weak mean	0.003***	0.013**	0.004***	0.004***
Strong mean	0.001***	<0.001***	0.004***	<0.001***
Weak median	<0.001***	<0.001***	<0.001***	<0.001***
Strong median	<0.001***	<0.001***	<0.001***	<0.001***
Extreme-irrelevance	0.356	0.764	0.050*	<0.001***
Convex combination	0.032**	0.025**	0.719	0.610

Note: *, **, *** denote significance at the 10%, 5%, and 1%-level, respectively.

TABLE 9

Robustness: OLS and Tobit regressions of group choices on individual choices in gift-exchange games, using absolute choices (amount returned out of 10)

	OLS		Tobit	
Model	(1)	(2)	(3)	(4)
Constant	-0.426	0.884	-3.778***	-1.347
	[0.258]	[0.527]	[1.072]	[0.876]
$x_{gt}^{(1)}$	0.108	0.165	0.184	0.332
	[0.110]	[0.146]	[0.186]	[0.248]
$x_{gt}^{(2)}$	0.342**	0.328**	0.458**	0.347
	[0.102]	[0.122]	[0.209]	[0.224]
$x_{gt}^{(3)}$	0.266*	0.334**	0.218*	0.381***
	[0.123]	[0.103]	[0.130]	[0.110]
$x_{gt}^{(4)}$	0.289**	0.324**	0.654***	0.758***
	[0.099]	[0.107]	[0.146]	[0.149]
$x_{gt}^{(5)}$	0.072	0.021	0.178	0.096
	[0.042]	[0.095]	[0.110]	[0.149]
First-mover's gift	0.008	0.006	-0.017	-0.090
	[0.040]	[0.070]	[0.095]	[0.111]
Session-Phase FE	N	Y	N	Y
N	156	156	156	156
(Pseudo) R^2	0.772	0.817	0.304	0.375
L (Non) R Censored			71 (72) 13	71 (72) 13

Notes: *, **, *** denote significance at the 10%, 5%, and 1%-level, respectively. Standard errors are clustered at the experiment session level, and shown in brackets.

TABLE 10

Robustness: Tobit regressions of current individual choices on choices made before in a different group or the same group

	Gift-exchange (Normalized amount returned)		Lottery (Nb safe choices)
Decision in phase	1st	2nd	
Constant	-1.305***	-1.742***	-0.13
	[0.341]	[0.439]	[0.156]
Own decision in t–1	0.768***	0.687***	1.022***
	[0.073]	[0.051]	[0.026]
Diff to Group in t–1	0.062	0.173***	0.393***
	[0.044]	[0.054]	[0.048]
N	260	260	260
Pseudo-R^2	0.111	0.074	0.3501
Left (Non) Right Censored	26 (233) 1	31 (358) 0	0 (260) 0

Note: See also notes to Table 5 in paper. *, **, *** denote significance at the 10%, 5%, and 1%-level, respectively. Standard errors are clustered at the experiment session level, and shown in brackets.

C INSTRUCTIONS

The instructions which we have distributed to you are only for your private information. During the experiment, please do not communicate with any of the other participants. If you have any questions at any point during the experiment, raise your hand and the experimenter will help you. Also, please turn off all cell phones, mp3 players and other devices. If you violate this rule, we will need to exclude you from the experiment and you will forfeit payment from participating in the experiment. At the end of the session, we will only keep track of your ID number and your decisions for our research purposes.

Objectives
In this experiment we will ask you to make decisions that are simplified versions of decisions that you have to take in many real-world situations. Please think carefully about your decisions before making them, considering all possible choices!

Procedure
At the beginning of the experiment, we will randomly assign you to be either *making decisions in isolation in the main computer lab,* or *making decisions in a small room with four other participants*. You will draw a participant card with a number printed on it, which determines whether you stay in the main room or join one of the groups in the small rooms. If you join one of the small rooms, you will have to make both individual decisions in this experiment, and joint decisions with participants in the same room.

We will ask you to make two types of decisions: participating in a gift-exchange situation, and making choices between lotteries.

The gift-exchange situation
There are two participants in this situation, a first proposer and a second proposer. Those of you who are randomly selected to stay in the main lab will always be first proposers, and those of you in the small rooms will always be in the role of second proposers. In the gift-exchange situation, both players will be given 10 tokens (the experiment money) as an endowment. The first proposer will begin by offering a split of the 10 tokens to the second proposer, from 0 to 10 such that if they offer the second proposer some amount X, the second proposer will receive 3X. The remaining 10-X tokens are kept by the first proposer (but they don't get tripled). For instance, if the first proposer offers 5, (s)he will get to keep 5 for him(her)self and the second proposer will obtain 15. After seeing what the first proposer did, the second proposer offers a split of tokens from his(her) endowment. Again, if the second proposer offers some amount Y, the first proposer will receive 3Y (and the rest is kept by proposer 2, but it doesn't get tripled).

For example, suppose the first proposer offers 8 to the second proposer and the second proposer offers 7 to the first proposer. Then the first proposer receives:

2 (from first period) + 7 * 3 (from second period) = 23

and the second proposer receives:

8 * 3 (from first period) + 3 (from second period) = 27.

Lottery choices

You will be shown a set of lottery choices (a lottery means that your prize is determined randomly). The set involves 10 choices, and in each of them you will be asked to choose between two lotteries. Participants will be asked to think about the lotteries, and then will be asked to select which lottery they prefer.

An example of a lottery choice is the following: you are asked to make a choice between option 1 and option 2. Option 1 implies that your prize is determined by the roll of a 10-sided dice, and it is $6 if the roll is 1-4, and it is $4.80 if the roll is 5-10. Option 2 also implies that your prize is determined by the roll of a 10-sided dice, but now it is $11.50 if the roll is 1-4 and $0.30 if the roll is 5-10.

Sequence of events for participants in the small rooms

The experiment will be split into three phases for you. In every phase you will have to make the same set of decisions, but with different people. That is, between phases we will take some of you to different rooms, where you will make decisions with a different group of participants.

We start with taking you to your initial room, with four other participants and an experimenter assigned to the group. Then we run phase I, then regroup people, run phase II, again regroup people, and then run phase III. At the end of phase III you will be brought back to the main lab, where you will receive your payments for the experiment.

In each phase you will have to play two gift-exchange situations as second proposers (with first proposers in the main lab), and make one set of lottery choice decisions.

In the gift-exchange situations first the Experimenter announces to you how much the first proposer offered you in the game. Then you and your group members will be asked what you would choose to do in this game as second proposer if it was completely your decision. During this phase you and your group members cannot talk to each other (the Experimenter in the room will supervise this). After carefully thinking about your choice, each of you will have to write down your chosen counter-offer, together with your participant ID number (from the card you drew) to an answer sheet. You are asked not to show these answer sheets to other participants in the room. Once the Experimenter collected your individual answer sheets, he(she) leaves the room, and you and your group members can privately discuss what the group's decision should be. This discussion is completely unrestricted, but at the end of the day you have to come up with a joint decision. After you reached this decision, fill out the group answer sheet, open the door and give it to your Experimenter.

In each of the gift-exchange situations it will be randomly determined (with 50-50% probability) whether it is the group's joint decision which mattered (which determined the counter-offer in the situation) or one of the individual decisions of the group members. In the latter case, it will be randomly determined which group member's choice prevailed. We will only reveal you which decision mattered at the end of the experiment.

The lottery choices again start with each of you in the group making your individual decisions. The Experimenter will be in the room during this time. Once you filled out your lottery choice answer sheet and wrote down your participant ID number on the sheet, the Experimenter collects the answer sheets and leaves the room. After this you can freely discuss it with your group members what the group's decision should be in the lottery choices. At the end of the experiment, it will be randomly determined (with 50-50% probability) whether it is the group's joint decision which mattered or one of the individual decisions of the group members. In the latter case, it will be randomly determined which group member's choice prevailed.

All in all you will play 6 rounds of gift-exchange situations as second proposers, and make three rounds of lottery choices. In each round of the gift-exchange situations the first offer comes from a different participant in the main room (no group will interact with the same first proposer more than once).

Payoffs for participants in the small rooms

Your payoff in this experiment will depend on your choices, as well as on choices of participants you interact with. Moreover, your choices affect the payoffs of the participants in your room, and the participants in the main room who you interact with in the gift-exchange situations. All rounds of the gift-exchange situations matter, but in each of them only one of the counter-offer decisions count: it can be either an individual decision (and with some probability your decision) or the group's joint decision. In either case, the decision that becomes the second offer in the game determines everyone's payoff in the room in that round. At the end of the experiment we will add up the tokens you collected in the gift-exchange situations, and convert it to dollars using a fixed exchange rate.

As for lottery choices, you will fill out three sets of lottery choices, one in each of the phases. However, only one of these will matter: it will be randomly determined at the end of the experiment which phase. At the same time, it will also be randomly determined whether from this round it is the group's joint decision that determines lottery payoffs in the group, or one of the individual decisions, and if the latter then which member's decision in the group. From the selected answer sheet then we will randomly choose one of the lottery choices (out of the ten choices), see which lottery was selected on this sheet, and execute that lottery. This becomes everyone's lottery payoff from the group.

Lottery prizes are specified in (real) dollar terms.

Note that every choice you make is relevant with some probability: it can become the actual choice that determines your payoff!

At the end of the experiment you will get a printout summarizing which decisions mattered and how your payoff was calculated.

Participants in the main lab

You will play six rounds of the gift-exchange situation, each time as first proposer. In every situation you will interact with a different group of participants in the small rooms. The counter-offers to your offers will only be revealed to you at the end of the experiment.

After you made your first offer decisions, we will ask you to wait until the participants in the small room finished making all their decisions, since their decisions will determine your payoffs.

Each gift-exchange situation that you participate in is relevant for your payment. The tokens that you collect from these situations will be converted using a fixed exchange rate to dollars.

You will not be asked to make lottery choices in this experiment.

Please wait patiently until all participants have finished reading these instructions.