Voting as a War of Attrition*

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Abstract

We study committees selecting one of two alternatives when supermajority is required and agents have private information about their preferences. Delaying the decision is costly, so a form of multiplayer war of attrition emerges. Waiting allows voters to express the intensity of their preferences and may help to select the alternative correctly more often than simple majority. In a series of laboratory experiments, we investigate how various rules affect the outcome reached. We vary the amount of feedback and the communication protocol available to voters: complete secrecy about the pattern of support; feedback about this support; public communication; within-group communication. The feedback no-communication mechanism is worse than no feedback benchmark in all measures of welfare – the efficient outcome is chosen less often, waiting cost is higher, and thus net welfare is lower. However, adding communication restores net efficiency, but in different ways. Public communication does poorly in terms of selecting the correct alternative, but limits the cost of delay, while group communication improves allocative efficiency, but has at best a moderate effect on delay.

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1 Introduction

We experimentally study a class of voting mechanisms in which voters select one of two alternatives through a dynamic game resembling a war of attrition. For example, suppose that participants vote repeatedly on one of two alternatives until sufficient supermajority is established. Election of the Pope by the College of Cardinals of the Roman Catholic Church is one well-publicized case of the kind of institution we investigate. All cardinals participating in the election are locked in one room and keep voting until supermajority of 2/3 agrees on one candidate. The rules are designed to facilitate deliberation, but also they enforce a considerable degree of austerity[1] in the form of the cardinals suffering a personal cost of delaying a decision. In many other committee decisions, rules are perhaps not as explicit as in papal conclave, but there is an attempt to seek some supermajority, and there is cost of delay. Other examples include jury deliberation.

We do not frame our model explicitly as repeated voting, but rather, as in ascending auctions, we adopt an old metaphor of a clock. Initially, all n voters are gathered and asked to express their preferences for one of two alternatives. Then, as the clock starts ticking, the waiting cost begins to accumulate. The action of each voter is to irreversibly cease supporting their preferred alternative at the time of their choosing. Thus, we investigate a type of a *war of attrition* with many players, but only with two possible alternatives.

There is a plethora of specific rules that affect the equilibrium performance of such a multiplayer war of attrition. The following aspects have to be specified to pin down a particular type of mechanism.

Firstly, a key feature of the design is the level of supermajority required for decision. We frame this in terms of the *minimal blocking minority*, which we will denote as m. It is the number of voters who, by voting in unison on one alternative, can prevent the other alternative from being selected at that particular moment of time. After voters register their support for one of the alternatives, they declare when they cease supporting that alternative. When the support for either alternative falls below m, the clock stops. The alternative whose support fell below that threshold first is rejected by the committee, and the other alternative is selected. For example, the minimal blocking minority of one, $m = 1$, represents the case in which one voter is able to veto an alternative, which amounts to unanimity. Another polar case is $m = (n + 1)/2$ (where odd n is the size of the committee) which represents simple majority. In our experiments, we consider absolutely the simplest case, where there are $n = 3$ voters and unanimity is required, $m = 1$.

The second class of rules establishes the voter's cost of waiting. We may distinguish two particular types of war of attrition, based on how easy it is for an individual to stop accumulating the cost they would pay at the end of the game. In the *individual cost* case, each voter stops paying as soon as they indicate that they cease supporting their alternative, even if the decision is not made yet and the war of attrition continues. In practice, this can be imagined as leaving the room in which committee holds its meeting. In contrast to that, in the *common cost* case, voters indicate when they want to cease supporting their alternative, but their cost keeps accumulating until the decision is finally made. This would be a good representation of a situation when committee members are

[1] Baumgartner (2003)

forced to sit in the room even if they indicated that they gave up.[2] Of course, beyond these two simple cases, there may be more complex rules that map profiles of exits into waiting costs incurred by the individuals. In this paper, we focus on the individual cost case.

The third category of rules clarifies how information is revealed to participating voters as the game progresses. For example, voters may be locked in individual rooms, completely oblivious to the initial distribution of support and the subsequent pattern of exits, and wait there until they are let out by the rules of the mechanism. We call this the *No Feedback* scenario. Alternatively, voters may sit in a common room along with other voters and observe how many other voters support each alternative at every stage of the game – we call this the *Simple Feedback* scenario. Finally, in addition to feedback about the evolution of support, voters may be permitted to communicate with each other. We consider two specific protocols here, both involving a free-form public cheap-talk communication phase before the waiting phase. The *Public Communication* scenario assumes that all voters in the committee observe all messages. In contrast, the *Group Communication* mechanism assumes that only voters supporting the same alternative (members of one group) can communicate with each other, and their messages are not observable by the supporters of the other alternative. Of course, myriad other communication protocols can be considered.

We are interested in both positive and normative performance of our voting mechanisms. In particular, we want to establish how the rules affect the committee's decision and when a good social outcome is achieved.

Our analysis proceeds in two steps. Initially, we sketch some partial theoretical results that can be derived using well-known methods of mechanism design. Having proposed a series of hypotheses, we move on to the main part of this study, where we present the results of lab experiments. We use experimental methods not only because we would like to have an idea whether theory-based speculations have some predictive power, but particularly because we know that sharp theoretical results are simply impossible in some cases. Namely, it is well known that wars of attrition have multiple equilibria; the literature focuses on the symmetric one, using as justification the fact that the underlying game is symmetric and players are anonymous. We cannot appeal to symmetry, as the game that emerges in our context becomes asymmetric as soon as it is revealed to voters who is in majority or minority. This leaves us with no guidance as to which of the multiple equilibria is more likely to emerge.

Sketch of results. First, we focus on the No Feedback mechanism. We take advantage of the fact that this mechanism does enforce symmetry, and thus it is one mechanism that can be studied theoretically. Consistent with the experimental literature on wars of attrition, the aggregate measures agree qualitatively with the theoretical predictions quite well, although quantitatively there are some departures.

Then we consider three mechanisms in which committee members know ex ante who is in the majority and in minority. We test whether there is evidence of instant exit and sorting among the group members. *Instant exit* may occur because the majority voters have an incentive to race to exit in order to avoid paying the waiting cost, forcing the

[2] In terminology proposed by Bulow and Klemperer (1999), the former corresponds to "oligopoly" type of generalized war of attrition, while the latter to "standards" type, although this terminology does not necessarily fit our context.

other members of their group, who will remain in the game, into a pivotal position. In other words, the majority voter who successfully exits before the other member of her group free rides on her. Group sorting occurs when the group members exit in order of their preferences, more indifferent first. We find some evidence for instant exit hypothesis and group sorting hypothesis for Group Communication treatment, but not always for Simple Feedback and Public Communication. This suggests that communication within groups, not visible to opponents, is essential to achieve sufficient coordination within groups as to who among the non-pivotal voters should exit, and when.

In terms of the relative strength of the two voting groups, contradictory conjectures can be formed as to how the introduction of this asymmetry may affect the outcomes. For example, one may argue that the majority will become empowered relative to the control No Feedback mechanism, because the intensity of preferences of the pivotal voter in the majority is statistically higher than the corresponding intensity for the minority. On the other hand, if instant exit is strong enough and the non-pivotal members of majority exit quickly, then both sides may immediately become equal in size, and thus minority may become stronger than in No Feedback mechanism. It turns out that, indeed, when players are told about their minority-majority status, minority wins more often in various feedback treatments than in the benchmark No Feedback mechanism.

In terms of normative performance, Simple Feedback treatment has an unquestionably negative effect on welfare measures: the alternative is selected correctly less often, waiting cost is higher, and therefore net welfare is lower. Providing feedback empowers the minority, and thus lowers the chances that the majority's preferred alternative is selected when the minority's preferred alternative should be selected. At the same time, this increases the chances of the opposite error: that minority wins when the majority should.

When we compare Public and Group Communication treatments the Simple Feedback treatment we obtain the following results. Relative to Simple Feedback treatment, Public Communication lowers the waiting cost without affecting how correct the collective choice of the alternative is. Group Communication does better than Public Communication on the allocative welfare front, but not as well in terms of waiting cost. These two effects cancel out, so that the net welfare is not statistically different between Group and Public Communication (and not statistically different than in the No Feedback mechanism).

Since individual preferences are highly heterogeneous in our experiments, we are able to replicate the results of our earlier paper (Kwiek et al. (2016)) that simple majority does not perform as well as supermajority (in allocative welfare).

2 Literature

From the point of view of the theoretical literature, our paper is closely related to studies on wars of attrition, which, of course, is a classical topic. See, for example, the summary in Fudenberg and Tirole (1996), section 4.5.2., as well as Krishna and Morgan (1997), or Myatt (2005). Multiplayer wars of attrition have been studied by Bulow and Klemperer (1999) who distinguished different types of wars of attrition by the cost that the participants pay. Our paper differs in that we study a collective choice problem with two alternatives, while Bulow and Klemperer (1999) consider a rivalrous good allocation problem. A closer version of a multiplayer war of attrition to ours is presented Ponsati and Sakovics (1996), who, like us, consider voting on only two alternatives, but in contrast to us, they focus on the positive question of equilibrium uniqueness and contemplate only the rules that closely correspond to our No Feedback mechanism.

The efficiency question for mechanisms similar to the ones studied in the present paper was asked by Kwiek (2014). The question there was about the effect of the size of supermajority on the type of efficiency that below we call allocative efficiency. Welfare analysis in the present paper is of the "second-best" type too, as we also restrict ourselves to this type of timing games. If general incentive compatible mechanisms could be used, then the predicted efficiency would be greater. There is a vast mechanism design literature on this; for example, a Vickrey-Clarke-Groves mechanism achieves efficient outcome in dominant strategies, when the welfare criterion required is allocative efficiency or transfers are allowed (Vickrey (1961), Clarke (1971), Groves (1973)). Kwiek (2017) studies a general class of voting games without transfers but with penalties, to which our game belongs: it turns out that if such a broad class is allowed, a different version of the Vickrey-Clarke-Groves mechanism is efficient in dominant strategies.

The number of studies experimentally testing wars of attrition is not very large. Hörisch and Kirchkamp (2010) and Oprea *et al.* (2013) investigate wars of attrition with two players and independent private information.[3] In a prequel to this paper, (Kwiek *et al.* (2016)), we use a simplified two-value framework to confront the basic hypothesis that supermajority may be more efficient than simple majority, and that heterogeneity of preference intensities is a determinant of how strong this effect is. This is tested in both static and dynamic versions of the game.

Moving on to a the literature on experiments in voting, Palfrey (2012) in his comprehensive survey of experiments in political economy devotes one section to mechanisms that reflect preference intensity. The mechanisms he reports are based on the idea of linking many voting decisions together.[4] The mechanism in our current paper and in Kwiek *et al.* (2016) differs from these studies in that it is concerned with a voting decision on a single issue, rather than leveraging one issue against another. But it does belong to the class of mechanisms that are capable of reflecting voters' intensity of preferences.

Several previous papers have investigated the impact of communication on turnout and the efficiency of voting outcomes (for example, Grosser and Schram, (2006) or Goeree and Yariv (2011)).[5] Studies by Kittel *et al.* (2014) and Palfrey and Pogorelskiy (2017) introduce a distinction between public communication and group communication, a distinction that is key in our investigation as well. They investigate a static, one-shot voting decision, while ours is a dynamic mechanism that could be described as repeated voting. On the other hand, our and their environments assume that voting is costly, so not surprisingly we observe a similar equilibrium response: abstention in their model and early exit in ours. Since their environment assumes no differences in intensity of preferences, abstention caused by the cost of voting is welfare-reducing. Since the intensities of

[3]Dechenaux *et al.* (2015) presents a recent survey on a more general class of related mechanisms.

[4]For example, Casella (2005) hypothesizes that storable votes, deployable over time in voting decisions of particular importance to an individual, may help to express the intensity of voters' preferences; Casella *et al.* (2006) are the first of a few studies to test this mechanism in a laboratory experiment. A more general version of this idea (involving not necessarily sequential voting) is developed by Jackson and Sonnenschein (2007) and tested by Hortala-Vallve and Llorente-Saguer (2010).

[5]More broadly, many experimental studies have shown that in various settings, pre-play communication can affect outcomes (e.g. Cooper *et al.* 1992).

preferences are heterogeneous in our environment, the cost of voting becomes a sorting device that may enable more efficient outcomes in an appropriately fine-tuned voting mechanism.

3 Theory: the model and some results

The essential ingredients of our model is the set of n voters and set of two alternatives $k \in \{A, B\}$, one of which must be selected.

The payoff that each voter receives depends on the outcome, which consists of two elements. The first element is the alternative that is collectively selected, and the second is the length of time that the individual waits.

With regards to attitudes towards alternatives alone, player i prefers one of the alternatives (ordinal component) with a certain intensity (cardinal component). The set of players who support the same alternative will be called a *group*. The ordinal component is captured by variable $a_i \in \{A, B\}$ denoting which alternative player i prefers; for example, $a_i = A$ (or simply $i \in A$) means that i prefers A. The intensity of preferences of voter i is captured by variable $x_i \geq 0$. This cardinal component makes statements like "I am almost indifferent between A and B, but prefer A slightly" and "I strongly prefer A to B" meaningfully different. In both cases $i \in A$, but in the former x_i is closer to zero than in the latter. The second element that determines the voter's payoff is the cost of waiting. Let t_i be the length of time that i is forced to wait. Ultimately, her payoff is $x_i - t_i$ if her preferred alternative a_i is selected, and $-t_i$ if it is not.

This study focuses on an environment in which both ordinal and cardinal components of preferences are private information. Thus, voter i is the only one to know which alternative she prefers and how intensely. From the perspective of all external observers, including other voters, these are random variables drawn from commonly known distributions. In particular, assume that voters may prefer A or B with equal probability. Assume also that random variable X_i, whose realization is x_i, is statistically independent across i and has a c.d.f. F and density f. The reciprocal hazard ratio associated with this random variable, $H(x) = (1 - F(x)) / f(x)$, will later turn out to be an important object.

This environment fits the standard mechanism design problem with quasi-linear preferences. We call t_i the nontransferable waiting cost, but it may also be interpreted as transferable payment to a third party, say a socially wasted tax. Either way, we postulate that interpersonal comparisons of individual payoffs are possible, and therefore one can define various welfare criteria based on cardinal preferences. In this paper we adopt utilitarian efficiency, whereby welfare is defined as the sum of individual payoffs.

Depending on the context, it may be reasonable to focus on *allocative welfare*, where the total waiting cost of $\sum_j t_j$ is ignored, and the welfare is defined simply as a sum of intensities for all voters whose preferred alternative is selected. That is, if k is selected, then the allocative efficiency is $\sum_{i \in k} x_i$. A second reasonable criterion is *net welfare*, which includes the cost of waiting. Namely, if k is selected then net welfare is $\sum_{i \in k} x_i - \sum_j t_j$. For example, net welfare is more valid if the whole population are members of the committee and so the waiting cost is a social loss. Allocative welfare may be more relevant, for example, if the committee's decision has a huge externality on a wider population, and therefore waiting costs of individual committee member is not relevant for the population (like perhaps in Pope's election).[6]

3.1 Equilibrium in incentive compatible mechanisms

An important benchmark mechanism that may be used in the above environment is simple majority. Voters are asked to express their ordinal preferences and the alternative which gathers a majority support is selected. Since the game ends instantaneously, the waiting cost is zero. Allocative and net efficiency are the same by construction.

There exists a myriad mechanisms using penalties, such as waiting time, or other payments, and the Introduction gives a flavor of possible rules. To characterize any Bayesian incentive compatible mechanism, we take advantage of the standard tools developed by Myerson (1981). We then check how those results apply to the class of mechanisms we study.

Fix a mechanism and its equilibrium. Define $p_k(a,x)$ to be the equilibrium probability that alternative k is selected if the realization of ordinal and cardinal preferences for all agents is (a,x), where $a=(a_1,...,a_n)$ and $x=(x_1,...,x_n)$ are the profiles of, respectively, ordinal and cardinal components of voters' preferences. Let $P_k(a_i,x_i)=E_{a_{-i},x_{-i}}p_k(a,x)$ be the corresponding expected probability, if the realization of i's type is (a_i,x_i). Let also $\pi_i(a_i,x_i)$ be the associated equilibrium payoff of i, and $C_i(a_i,x_i)$ the associated expected waiting cost. Myerson (1981) shows[7] that

Lemma 1. *A given mechanism is incentive compatible if and only if $p_k(a,x)$ and $\pi_i(a_i,x_i)$ satisfy conditions: (i) $P_{a_i}(a_i,\cdot)$ is non-decreasing, (ii) $\frac{\partial}{\partial x_i}\pi_i(a_i,x_i)=P_{a_i}(a_i,x_i)$, and (iii) $P_{a_i}(a_i,0)=P_{a_i}(-a_i,0)$ and $C_i(a_i,0)=C_i(-a_i,0)$.*

Moreover,

Lemma 2. *Net expected welfare of voter i in an incentive compatible mechanism is*

$$NW_i=E_{A_i}\pi_i(a_i,0)+E_{A_i,X_i}P_{a_i}(a_i,x_i)H(x_i) \tag{1}$$

Allocative expected welfare is

$$AW_i=E_{A_i,X_i}P_{a_i}(a_i,x_i)x_i$$

That is, the expected net payoff of voter i depends only on two objects, namely the payoff the indifferent type, $\pi_i(a_i,0)$, and the allocation function $p_k(a,x)$. Knowing these two objects is enough to characterize the overall welfare performance of this mechanism-equilibrium pair, at least in theory.

3.2 The symmetric benchmark: No Feedback

Coming back to the subject matter of this paper, the result described in Lemma 2 applies to all our mechanisms as well. If only it was possible to characterize equilibrium $\pi_i(a_i,0)$

[6] Another reason why allocative welfare may be appropriate is in the case when t_i represents monetary transfer to some third party, and therefore it is not lost from the perspective of the welfare of the society.

[7] The version relevant in the current context is reported by Kwiek (2017).

and $p_k(a,x)$ for a given set of voting rules, then we would know the mechanism's theoretical welfare, both net and allocative. Different types of mechanisms may, of course, result in different expected payoffs and allocation functions, and it is difficult to say what they are without full equilibrium analysis.

There is one set of voting rules, however, for which it is possible to theoretically characterize welfare performance. The *No Feedback* mechanism with *individual cost* is a game with the following simple timing and cost rules:

No Feedback mechanism: Voters sit in individual rooms. At the beginning of the game they are asked to announce their preferred alternative. They are also told to stay in the room for as long as they want to keep supporting that alternative after the waiting starts. By irreversibly exiting the room, they make the total support for that alternative drop by one. Then, the alternative whose support falls below a threshold of minimal blocking minority, m, is declared the losing alternative, while the other one is announced to be selected by this committee. Because they are kept in individual rooms, voters are never informed about how many other voters support which alternative and how this pattern changes over time.

Individual cost: Voters pay the cost only for the time they sit in the room, but as soon as they leave, the cost stops accumulating.

The strategy in this game is essentially the time of exit as a function of intensity x_i. As long as anonymity can be preserved, the game is and continues to be symmetric as the time passes; it is therefore reasonable to assume that all voters use symmetric strategies.

Assumption 1. *Symmetry: in equilibrium, all players' exit time is a function of intensity only, and, moreover, all players use the same function.*

Under Assumption 1, we can easily deduce $p_k(a,x)$. Define $\tilde{x}_{k,(m)}$ to be the mth order statistic of the vector of intensities of voters who prefer k.[8] It is evident that under the assumption of symmetric strategies,[9] the allocation function is

$$p_A(a,x) = \begin{cases} 1 & \text{if } \tilde{x}_{A,(m)} \geq \tilde{x}_{B,(m)} \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

Moreover, because the mechanism has individual cost, we can conclude that the equilibrium payoff of a voter with zero intensity of preferences is zero, $\pi_i(a_i, 0) = 0$.

3.3 Asymmetry in a war of attrition

No Feedback voting is easy to implement in practice, but we are not aware of any real-life examples of such mechanism. Realistic dynamic voting rules of the type we consider here have at least the following feature – all participants of the game can see the evolution of support for each alternative. We call this *feedback*.

[8]That is, the mth largest element of this vector; if m is larger than the number voters supporting k, then $\tilde{x}_{k,(m)} = 0$.

[9]If all players use the same exit function of intensity only, then this function must be strictly increasing, and hence the order of exit times is the same as the order of intensities.

As soon as members of the majority group learn that they are in majority and the members of the other group learn that they are in minority, the asymmetry becomes an inherent feature of the game, making Assumption 1 questionable. Namely, it is unreasonable to expect that the equilibrium exit time depends solely on the intensity of preferences and not on the group membership.

The problem with asymmetry goes beyond a simple fact that asymmetric games admit asymmetric equilibria. It is known that in a standard two-player war of attrition there are multiple equilibria, in fact, a continuity of them. Likewise here, the following is an equilibrium: all voters in one group exit immediately no matter what stage the game reached, regardless of their valuations, and all voters in the other group keep supporting their own alternative no matter what stage the game reached, regardless of their valuations. As the result, the game in this equilibrium ends immediately and the group which plays a strategy of giving up immediately loses the vote with probability one.[10] We will call this phenomenon *asymmetric collapse*.

Of course, asymmetric collapse has profound efficiency consequences. If, for example, the majority is so much more aggressive that it wins always, then the supermajority rule just replicates the simple majority rule. In fact, it is also possible that the exact opposite happens, whereby the minority ends up being so aggressive that it wins always, leading to a far worse welfare outcome than simple majority. We do not expect this to occur in practice.

If asymmetric collapse does not occur – that is, if both sides of the voting game win with probability sufficiently far from zero – then other possible phenomena are worth studying because they are relevant for welfare. In particular, we will check for two patterns of behavior.

Instant exit occurs when all voters in one group, except precisely m of them, exit immediately. Consequently, if there is instant exit within both groups in the game, then we would observe an immediate wave of exits, followed by a phase of waiting when nothing happens until a single exit triggers the end of the game. It is perhaps worth emphasizing that instant exit does not necessarily imply asymmetric collapse. We may observe histories in which there is instant exit of one of the non-pivotal majority voters, but then minority losing anyway; there may even be asymmetric collapse of majority.

The second effect is *group sorting*, which occurs when players of one group exit in order of their intensity of preferences: the lowest first, then the second lowest etc.[11] Group sorting is an expression of coordination within the group.

The mechanism with feedback has an equilibrium in which instant exit and group sorting occur. The waiting game that ensues after the wave of instant exits is essentially a two-player war of attrition among the voters whose values are mth order statistics, that is, $\tilde{x}_{A,(m)}$ and $\tilde{x}_{B,(m)}$. This phase is not symmetric, because the posterior distribution of $\tilde{x}_{A,(m)}$ and $\tilde{x}_{B,(m)}$ after instant exit are different from each other. Even if equilibrium

[10] There are ways to modify (perturb) models of war of attrition in such a way that a unique equilibrium is selected, see Myatt (2005), but the selected equilibrium is nevertheless sensitive to the perturbation used.

[11] Bulow and Klemperer (1999) identified *instant sorting* in their mechanism. Although their environment is somewhat different, instant sorting is similar to our instant exit and group sorting taken together. Myatt (2005) uses term *instant exit* to mean something different than us; it is closer to what we call asymmetric collapse.

with instant exit and group sorting exists, the allocation function defined by Equation 2 would not arise in this case.[12]

We will consider four mechanisms previewed in the Introduction, all with individual cost. Apart from the No Feedback benchmark mechanism, we will investigate Simple Feedback, Public Communication and Group Communication. These four mechanisms will directly correspond to four treatments in our laboratory experiment. Next section specifies the experimental design in general terms, then defines the treatments, provides a series of predictions that we want to verify in the experiments, and, finally, describes procedural details of our lab experiments.

4 Experimental design, treatments and predictions

All our experiments have the following features in common and are known to the participants, either explicitly or can be deduced.

All committees have three voters, $n = 3$. We make it impossible that there are committees in which all voters support the same alternative. That is, from the perspective of an individual voter, there are only two possibilities: either she is a member of a majority group of two voters against a lone opponent, or she is a sole voter against a group consisting of two opponents, and both of these cases occur with equal probabilities.

Simple majority, $m = 2$, is one possible mechanism, but it is so straightforward that we do not verify its performance experimentally. When we want to discuss simple majority, we merely assume that each voter declares the support for her preferred alternative, and majority wins with probability one.

The only other possible supermajority level is unanimity, where $m = 1$, and this case is the main object of interest for us. There are three possible ways in which the game can evolve. Either the minority voter gives up first, thus ending the game. Or one of the majority voters exists first, moving the game into a phase in which each of two remaining players supports a different alternative. In this case, the game may end up with the minority voter exiting and thus stopping the game, or the remaining majority voter exiting and thus stopping the game.

All the mechanisms that we test are of the individual cost kind.

The intensity of preference, measured in Experimental Monetary Units (EMU) can vary from 1 to 60 and so it is (almost) continuous. The probability distribution function (p.d.f.) is depicted on Figure 1. The mean is 12.8 EMU and the median is 6 EMU. Therefore, it is very likely that voter's value of the preferred alternative is small, but it is also possible that the value is very high relative to the expected value.

[12] If $\beta_j(b)$ denotes the inverse bidding function of the pivotal player j, the first order condition for pivotal bidder i is

$$\frac{\partial \beta_j(b)}{\partial b} = \frac{1 - F_j(\beta_j(b))}{f_j(\beta_j(b))\,\beta_i(b)}$$

where F_j and f_j are c.d.f. and p.d.f., respectively, of the value of the pivotal player j. Suppose the allocation function defined by Equation 2 arises. Then the bidding functions of the two pivotal players in the phase following instant exit must be the same, and so would be their inverses, and their slopes. Thus, it must be that the inverse hazard functions associated with F_j and F_i are the same, but this cannot hold if these two distributions are different.

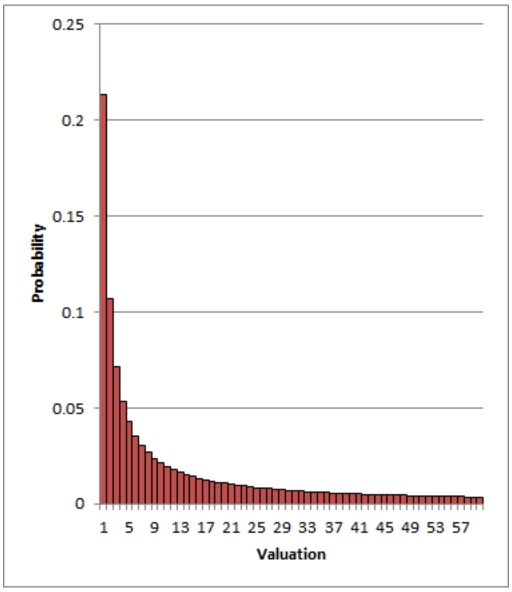

Figure 1: Left: p.d.f. of preference intensity, $f(x_i)$

This particular distribution of preference intensities generates particular average welfare scores. Since the average intensity of an individual is 12.8, simple majority generates on average 2 times this value, or 25.7, the average sum of all three intensities is 3 times this value, or 38.5, and, finally, first best allocation results in $E \max \left\{ \sum_{i \in A} x_i, \sum_{i \in B} x_i \right\}$, which can be calculated to be 30.2.

4.1 Treatments

The four mechanisms described in general terms correspond to four laboratory treatments.

No Feedback (NF): At the beginning of the game individual voters are told their individual intensity of preferences, x_i. After the clock starts, voters can Exit and any time. By doing that, they make the total support for that alternative drop by one. Then, the alternative whose support falls below a threshold of minimal blocking minority, $m = 1$, is declared the losing alternative, while the other one is announced to be selected by this committee. Voters are never informed about how many other voters support which alternative and how this pattern changes over time.

The No Feedback mechanism that we test experimentally enforces anonymity in a deliberate way. The strategies used by voters cannot depend on things that are not observable, such as the identity of other players in the game, the majority-minority status, the pattern of play, or the name of the alternative.[13] Thus, we are confident that the players in the experiment behave symmetrically.[14]

[13] In instructions for participants of the experiments we avoid calling the alternatives names, such as Right or Left, or even A or B. We just describe them as "your preferred alternative" and "the alternative you do not prefer" or something similar.

[14] Of course, participants may have a player-specific unobservable type, or face an unobservable preference shock in one particular game, making the exit function appear random and/or asymmetric.

Since we have theoretical predictions for this type of mechanism, we can compare them to empirical results. For this reason, the No Feedback mechanism is our benchmark.

Once we accept plausible Assumption 1 and apply the insights of Lemma 2, we can simulate the average equilibrium welfare performance of this No Feedback committee: allocative welfare of supermajority is 30.0, and net welfare of supermajority is 22.1. To see the performance of various mechanisms, we will check how high their allocative welfare is – in particular, where in the interval between welfare levels of simple majority 25.7 and of first best 30.0 it falls. We will also be interested in waiting costs.

Our three feedback treatments are as follows.

Simple Feedback (SF): All the elements are the same as in No Feedback benchmark, except that the participants are told the evolution of support during the game. In particular, at the beginning of the game, committee members receive a message whether they belong to the minority group of one voter or a majority group of two voters. Also, during the game, as soon as one of the majority players exits, the remaining two voters receive the message that this event occurred.

Public Communication (PC): All elements are like in the Simple Feedback treatment, with the following exception: before the game starts, all three players participate in a free-form public (visible by all three voters) cheap-talk communication.

Group Communication (GC): All elements are like in the Simple Feedback treatment, with the following exception: before the game starts, two players in the majority group participate in a free-form cheap-talk communication visible only to them but not to the single player in the minority.

We now turn to the hypotheses that we will check in our experiments. We start with a series of probable, or possible, positive effects that our three feedback treatments may have, then we move on to the main issue of what their combined effect on efficiency could be.

4.2 Conjectures

Our preliminary hypothesis compares the theoretical prediction of the No Feedback mechanism with the performance of the corresponding mechanism in the lab:

Conjecture 1. *Consider the No Feedback mechanism. Allocative welfare in supermajority is higher than in simple majority; net welfare is lower.*

Our next step is to check whether there is any evidence of asymmetric collapse. More generally, we ask which side is empowered by feedback? That is, does the majority become more aggressive after voters learn who belongs to which group? Or is it the minority that stays for longer in the waiting game and wins more often than in the No Feedback mechanism? These are empirical questions, because the theory provides no clear-cut answer here.[15] We have already stated that there are multiple equilibria, with diametrically different outcomes – there is one in which the minority wins always, and a different one in which the majority wins always, and many less extreme ones.

[15]This dilemma does not arise in Bulow and Klemperer (1999) who consider only symmetric equilibria.

Even if we abstract from fixed-point arguments at the foundation of equilibrium concepts, and instead try to speculate *ad hoc* as to who is going to be empowered by feedback, one can still argue in favor of both directions. For example, voters who learn at the very beginning of the game that they are in majority may behave more aggressively, because the pivotal voter in that group is the one with a higher value of the two, and thus she is likely to have a higher value than the minority opponent. Higher stakes may translate into a more aggressive behavior, and this may have a strategic effect on the minority player, making her even less aggressive, and so on. This suggests the following possibility:

Conjecture 2. *Minority wins less often in Simple Feedback, Public Communication and Group Communication treatments than in the No Feedback benchmark.*

Since the No Feedback benchmark will have around 1/3 of committees won by the minority group, Conjecture 2 says that in other treatments this number will be less than 1/3. The closer this number to zero, the stronger is evidence for asymmetric collapse in favor of the majority.

There is, however, an opposite argument, that is somewhat related to the instant exit hypothesis. In No Feedback case, the minority player does not know that she is in minority, so she may exit early even if she has a high intensity of preferences, counting on the fact that the other player in her group may stay for longer. Early exit saves a lot in terms of waiting cost. When we consider any of the three feedback treatments, the player in the minority group knows that she is pivotal, and therefore knows that exiting early will necessarily leave her without her preferred alternative and the associated value. In other words, if a high value player learns that she is pivotal, she may be convinced to stay in for longer. The reverse is true in the case of players who learn that they are in majority because they learn that they are definitely not pivotal. Hence, we admit a possibility of a result that would go in the opposite direction than Conjecture 2:

Conjecture 3. *Minority wins more often in Simple Feedback, Public Communication and Group Communication treatments than in the No Feedback benchmark.*

That is, the fraction of committees won by minority in feedback treatments should be greater than 1/3 according to this conjecture. If this number becomes close to 1 then we would say that there is asymmetric collapse in favor of minority. However, we do not expect this to go beyond 1/2.

Conjectures 2 and 3 are contradictory, and – to restate what has already been said – we cannot convincingly argue in favor of either one using pure logic. Our lab experiments will test this question head-on.

Next, we address the question of whether there is any evidence of instant (or at least earlier) exit hypothesis in feedback mechanisms. Obviously, this question (and some other) can be asked only if there is not a major asymmetric collapse; that is, only if either Conjecture 3 is true, or alternatively, even if Conjecture 2 is true, but the "minority wins less often" there is not too close to zero. The fraction of committees in which a majority player exits first should be 2/3 in the No Feedback mechanism. If there is any truth to the instant exit hypothesis, this number should be greater in feedback mechanisms.

Conjecture 4. *The fraction of committees in which the first player to exit is a member of the majority group is greater in three feedback mechanisms than in No Feedback.*

Another way to measure the instant exit hypothesis is to check whether the absolute difference between exit times of two majority voters is higher in feedback committees than in no feedback. A successful coordination would mean that this difference is higher.

Conjecture 5. *The absolute difference between exit times of two majority voters is higher in feedback mechanisms than in the No Feedback benchmark.*

The other effect that we test is group sorting. Such coordination among the two majority voters may be measured by how often the majority member who exits first in her group has the lower value. Since we expect a monotonic relationship between intensity and exit in No Feedback benchmark, a decent coordination should occur there. But in Simple Feedback majority members learn that they are in majority, and thus not pivotal. There may be a conflict between incentive to exit instantly and incentive to coordinate group sorting. Instant exit may add to miscoordination whereby players with somewhat higher values end up exiting before their lower value group-mate. Comparing Simple Feedback with both communication treatments, and especially Group Communication, we think that majority group members may be able to coordinate as to who is of the lower value and should exit first.

Conjecture 6. *Coordination among the two majority voters: how often the group member who exits first in her group has the lower value?*

1. *The coordination will deteriorate in Simple Feedback, relative to No Feedback.*
2. *The coordination will improve in Communication treatments, relative to Simple Feedback.*

Another empirical question is the effect of pre-play cheap talk communication in the committee on waiting cost. It is known that communication in two-player wars of attrition tends to shorten the duration. In our context this corresponds to Public Communication working towards improving net efficiency. The effects of Group Communication on the other hand may be completely opposite – there may be more conflict, more sorting and thus more waiting.

Conjecture 7. *Waiting cost in Public Communication is lower relative to Simple Feedback.*

4.3 Procedural details

We design a between-subject experiment to test our hypotheses. The experimental sessions were conducted at the SSEL laboratory at the University of Southampton, and our subjects were students recruited through ORSEE (Greiner (2015)). Participants from a broader range of academic disciplines were included. The experiment was programmed in z-tree (Fischbacher (2007)). No subject participated in more than one session. Participants were paid an average of £14 at the end of each session, including a £4 show-up fee. Sessions lasted around 1.5 hours, including instructions, comprehensive exercises and payment time.[16]

[16] Upon arrival to the laboratory, participants received a 5 digit identification number, and were randomly allocated to a PC terminal, where they could find the information sheet and consent forms. After

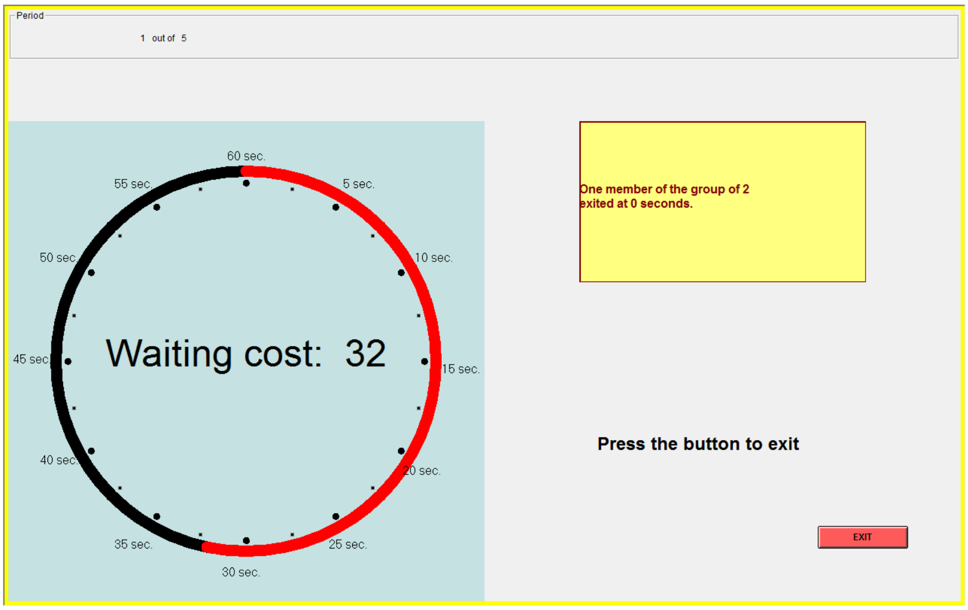

Figure 2: Screen

The experimental parameters mirror the theoretical model described above. Each session consisted of a series of independent periods. At the beginning of each period, participants were randomly assigned to three-member committees, and within them, to two groups supporting two different alternatives (and randomly re-matched in every round - strangers treatment). Each participant received a valuation according to the distribution presented in Figure 1. Next, in all treatments except the No Feedback voting, participants were informed whether they belonged to a group of two voters, or a group of one voter. Then, in both communication treatments, the participants could engage in a 60-second communication phase, in which they could type any messages via their terminals. In the Public Communication treatment, all three members of the committee could see the messages. In the Group Communication treatment, only two members of the majority group could see the messages; the minority player simply waited for the game to start. After these pieces of information, and after a five-second warning, the true waiting game started. The computer displayed a clock showing how many seconds have elapsed since the beginning of the waiting - seconds represented the accumulated waiting cost in EMUs. The waiting could last for 60 seconds. Figure 2 shows a typical screen of the clock during the decision phase. Each member decided when to cease supporting their preferred alternative. Participants could leave even before the waiting game started (i.e. during the five-second warning). In all treatments involving feedback (SF, PC and GC) all players received a message when one of the majority voters pressed exit.

At the end of each session participants draw three random periods and were paid the sum of earnings in these periods, plus a pre-announced endowment. The endowment was

collecting the signed consent forms, the instructions with some examples were distributed and read aloud. The experiment started with the completion of four comprehension exercises, where the experimenters were available to individually answer participants' questions. This exercises were designed to assure the comprehension of the experiment by all the participants. Instructions with examples and comprehension exercises for one treatment are provided in the Appendix.

given to avoid participants going into negative payoffs which are possible in our game.

One Experimental Monetary Unit (EMU) was equal to 8 pence, and endowment was 120 EMU. The cost of one second of waiting was 1 EMU so the maximum cost of waiting was 60 EMU.

A total of 192 students participated in 13 sessions. Table 1 describes the number of sessions, periods, number of voters, votes and committee decisions by treatment.

Table 1: Summary of Treatments

Treatment	Sessions	Periods	♯Players	♯Votes	♯Committees
NF	3	40	45	1800	600
SF	3	40	42	1680	560
PC	4	30*	60	1950	650
GC	3	30	45	1350	450
Total	13		192	6780	2260

* one session had 40 periods

5 Results

Wars of attrition are games in which discussing results presents one specific difficulty. Namely, intended actions of some players are inherently unobservable. For example, if the minority player exits early the experimenter will not see when the majority players would exit.[17] For this reason we do not investigate the exact frequencies of actions of individual players, but rather focus on committee-level analysis.

As an overview organizing the discussion in this section, we start by showing the aggregate efficiency performance of the four mechanisms that we study, and then we move to identify the various sources of differences.

5.1 Brief overview of welfare performance

Table 2 shows the summary of allocative and net welfare and the associated waiting cost, by treatment. For comparison, it also shows welfare realized in the experiments under simple majority, the first best and the total sum of voters' valuations in a committee. The first line shows the theoretical prediction for the No Feedback mechanism. Table 3 presents closely related average payoffs for the minority and majority players.[18]

Figure 3 is an alternative way to present some of these empirical results. Allocative welfare of each treatment is measured on the horizontal axis and the waiting cost is on the vertical axis. Thus, the lines of the unit slope indicate points of exactly the

[17]A static version of the war of attrition can be investigated instead: players are asked to declare when they want to exit, and the computer calculates the outcome. This offers an opportunity to register intended exit times of all players. Even if the static and the dynamic timing game are theoretically equivalent, the experimental results show systematic (and significant) differences in outcomes.

[18]Of course, 2 times the average payoff of the majority player plus the average payoff of the minority player equals to the net welfare of the committee.

Table 2: Welfare

Treatment	Allocative Welfare	Net Welfare	Waiting cost per committee	Simple Majority	First Best	Sum of Values
NF (th*)	30.0	22.1	7.9	25.7	30.2	38.5
NF	27.4	20.2	7.2	25.5	29.6	37.1
SF	26.2	16.5	9.7	24.1	29.5	37.5
PC	27.4	20.9	6.5	25.7	30.2	38.7
GC	27.6	19.2	8.4	24.0	29.3	37.0

* theoretical prediction

Table 3: Average Payoff.

Treatment	Average Payoff of Majority player	Average Payoff of Minority player
NF (th)		
NF	8.4	3.4
SF	5.9	4.7
PC	7.6	5.7
GC	7.3	4.6

same net welfare; moving south-east increases net welfare. The four black dots represent experimental treatments, and the white dot represents the theoretical prediction of the No Feedback committee. All values are expressed as the fraction of the average sum of values in that treatment.

We can see in Table 2 that the allocative efficiency of the supermajority is greater than simple majority in all treatments. The same fact can be observed in Figure 3 once we realize that the simple majority score is 2/3 of the sum of values measured on the horizontal axis – all dots that represent treatments are to the right of 66.7%.

Moving to a formal verification of the hypothesis that the distribution of Allocative Efficiency under supermajority and simple majority is the same, we apply the Wilcoxon matched-pairs signed-ranks test to conclude that this hypothesis can be rejected in all treatments (p-values are 0.004, 0.013, 0.004 and 0.0002 for NF, SF, PC and GC, respectively). Thus, we do find support for the first of our hypotheses.

Next, we recasts these welfare observations in a formal regression framework. The results are presented in Table 4. Note that Simple Feedback is not statistically distinguishable from Public Communication with regards to allocative efficiency, whereas there is a statistically significant difference between the two as far as net efficiency goes. In other words, Public Communication added to Simple Feedback does not affect allocative efficiency whereas it does improve net efficiency. This result confirms our Conjecture 7.

These are the headline results of this paper. The analysis below will try to establish the sources of these differences. For example, glancing at Figure 3 suggests that the empirical allocative welfare levels are consistently lower than the theoretically predicted, even if waiting cost in all four empirical mechanisms is sometimes higher and sometimes lower than the theoretical NF waiting. We want to identify potential sources of the differences between theoretical and empirical results and among the treatments themselves.

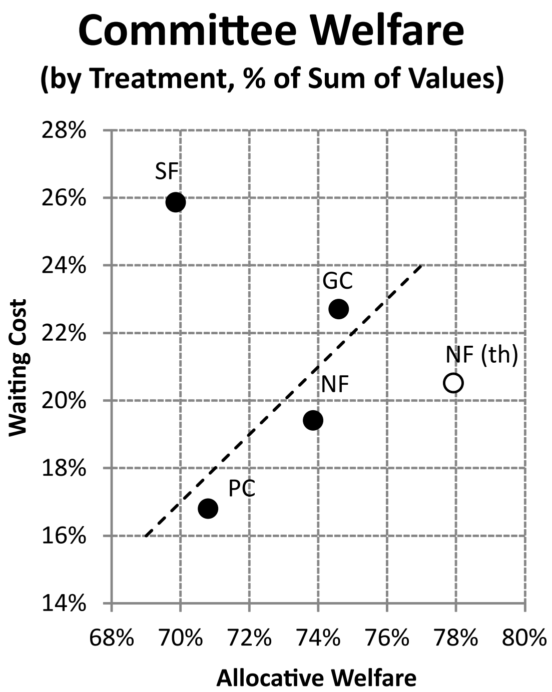

Figure 3: Committee allocative welfare vs waiting cost (by treatment, % of Sum of Values). Dashed line of unit slope shows constant net welfare.

Table 4: Regression analysis of welfare

Dep variable:	Allocative Efficiency			Net Efficiency		
Constant	27.4***	1.63**		20.2***	5.50***	
	(0.42)	(0.63)		(0.78)	(1.10)	
SF	-1.17	-1.44**	-1.44**	-3.7**	-3.86**	-3.86**
	(1.11)	(0.53)	(0.53)	(1.61)	(1.56)	(1.57)
PC	-0.04	-1.17**	-1.03*	0.74	0.10	0.58
	(0.85)	(0.52)	(0.48)	(1.57)	(1.53)	(1.48)
GC	0.24	0.32	0.51	-0.94	-0.90	-0.20
	(0.97)	(0.49)	(0.49)	(0.83)	(1.13)	(1.19)
Sum of Valuations		0.69***	0.69***		0.40***	0.40***
		(0.02)	(0.02)		(0.03)	(0.03)
Period Dummies	No	No	Yes	No	No	Yes
N			2260			

5.2 Asymmetric collapse hypothesis

First, we want to see what the overall effect of treatments on the likelihood of winning by group is. That is, we want to establish which of the two contradictory possibilities – Conjecture 2 or Conjecture 3 – reflects the reality better.

The first indication that Conjecture 3 is correct comes from Table 3. Namely, positive payoffs observed in three feedback treatments are inconsistent with asymmetric collapse on either side.

The direct test comes from Table 5, which presents the percentage of committees that

Table 5: Incidence of Winning by Group.

Treatment	Majority (minority exit first)	Majority (majority exit first)	Minority
NF	33.0	34.2	32.8
SF	28.9	30.4	40.7
PC	37.7	23.7	38.6
GC	27.6	35.1	37.3

All entries are %.

Table 6: Instant exit hypothesis.

Treatment	% of committees in which 1st player to exit is a member of the majority	Absolute difference in exit time between two majority voters
NF	67.0	3.6
SF	71.7	4.4
PC	62.3	2.6
GC	72.4	4.9

were won by the majority and the minority group for each treatment. Note that the wins by majority are split between wins that were achieved because the minority voter dropped out first, and those that were won when the minority voter dropped out after one of the majority voters had already left.

We see that each of three winning-by-group categories occurs on average 1/3 of times in the No Feedback benchmark. Given the anonymity underpinning the No Feedback mechanism it is almost impossible that this number was different, other than by pure chance. The interesting results are in the remaining three feedback treatments – in all of them the minority wins more often than 1/3 of times. The effect is the strongest for Simple Feedback. This supports Conjecture 3 and goes against Conjecture 2.

5.3 Instant exit hypothesis

The fact that there is no asymmetric collapse enables us to test other hypothesis. The next step is to report what the experiments imply about instant exit.

The first column of Table 6 shows how often the first player to exit is a member of majority, and thus a non-pivotal player. As expected, in No Feedback treatment, the member of majority group exits first in around 2/3 of all the committees.[19] We see that this fraction slightly increases in Simple Feedback, indicating a moderate instant exit. Similar effect occurs in Group Communication. In these two cases we find evidence in support of Conjecture 4. However, Public Communication leads to a very different result – not only the fraction of all committees in which the first player to exit is in majority does not increase, it actually decreases. Thus, in this case, we reject Conjecture 4.

[19] Ties, when the member of majority and the member of minority both announce the same exit time, are counted in.

Table 7: Group sorting hypothesis.

Treatment	Group sorting miscoordination (difference in values 1 or higher)	Group sorting miscoordination (difference in values 6 or higher)
NF	42.0	25.4
SF	37.4	23.6
PC	41.0	24.4
GC	33.7	20.6

All entries in %.

We also look at the difference in exit time between two majority voters.[20] As stated in Conjecture 5, we expect that this difference will increase in feedback committees relative to No Feedback. The last column of Table 6 shows that this difference is 3.6 seconds in No Feedback benchmark. It increases in Simple Feedback and Group Communication treatments in a statistically significant manner, providing evidence in favor of Conjecture 5. However, Public Communication treatment is again the odd one out; this difference in exit times lower than in No Feedback benchmark.

5.4 Group sorting hypothesis

We move on to verify Conjecture 6 that deals with group sorting. We calculate how often the first member of majority to exit has a higher valuation.[21] We call this fraction a group sorting miscoordination and report these values in Table 7. The first column reports the fraction of all committees that miscoordinate this way, while the second column shows only the fraction of committees for which this miscoordination is relatively high – in this case the difference in values is 6 or higher.

We see that the majority voters decide who exits first not in a completely random fashion – the numbers in the first column are not equal to 50% – so there is some sorting. But even in No Feedback benchmark, where we could expect a lot of group sorting, 42% of majority groups fail to achieve sorting. More than a quarter of majority groups (25.4%) whose value difference is 6 or higher still fail to achieve group sorting.

Group sorting seems to marginally improve when members of majority learn that they are members of majority (Simple Feedback), and thus we can reject the claim in point 1 of Conjecture 6: there is no evidence of players racing to exit and trying to preempt their opponent. Group Communication further improves group sorting, providing evidence in favor of point 2 of Conjecture 6. Public Communication treatment, however, is again the odd one out; group sorting is almost as poor as in No Feedback.

5.5 Sources of misallocation

Questions investigated up to now could have an indirect effect on allocative efficiency. Now, we zoom in on this issue directly. We want to trace the sources of inefficiency: how

[20]This is calculated only for committees in which this number can be calculated, that is, the ones won by the minority.

[21]Again, we calculate this only for committees for which we know the identity of that member of majority.

Table 8: Misallocation by group.

Treatment	Misallocation in minority win	Misallocation in majority win	% of committees won by group with the highest sum of values
NF	25.3	18.0	74.8
SF	16.2	23.0	74.1
PC	16.4	21.7	76.5
GC	22.0	19.6	76.7

All entries are %.

often and why a group fails to win when they should.

We split committees into those in which, in efficiency terms, the minority should win or the majority should win; we call them *minority win* and *majority win* committees, respectively. We ask how often the other alternative is selected in each of these two cases. Table 8 shows this type of misallocation, by treatment.

What we see is one consequence of Conjecture 3 that feedback empowers the minority. Introducing feedback seems to shift the misallocation: the misallocation is lower in minority win, and higher in those in which the majority should win. Namely, we see that within those committees in which minority should win, the misallocation goes down from 25.3% when we allow feedback. This is a good news for allocative efficiency. However, the bad news is that in those committees in which majority should win, the feedback increases the incidence of minority winning. This shift seems to be higher in Simple Feedback and in Public Communication, but not as big in Group Communication. In any case, we cannot see from this table if any of the feedback treatments beats the No Feedback benchmark overall, and so we still do not know what the source of inefficiencies is.

Table 8 is very rough as it treats all errors in the same way, regardless of how costly in welfare terms such misallocation is. We will now try to account for the magnitude of its welfare loss. Figure 4 shows misallocation by group and by treatment, like Table 8, but also cumulatively, by throwing away from this calculation misallocating committees with progressively higher and higher welfare loss, as measured on the horizontal axis. For example, the blue curve on the left panel representing No Feedback starts at 18% and then goes down as we remove committees with small welfare loss measured on the horizontal axis, and keep only those with higher loss.

The conclusion that emerges from Figure 4 is somewhat more subtle than what we saw in Table 8. When we compare Simple Feedback and Public Communication with No Feedback benchmark then we see that there is a clear shift: both feedback treatments create more misallocation when Majority should win, and less misallocation when minority should win. The last feedback treatment on the other hand, Group Communication, is different. When minority should win, Group Communication limits the misallocation relative to No Feedback exactly like Simple Feedback and Public Communication. However, when the majority group should win, Group Communication does not admit more misallocation like the other two feedback treatment do. If anything, it leads to even less misallocation than No Feedback, the fact that was not clear in Table 8. Hence, Group Communication does better in both cases – when majority should win and when minority should win.

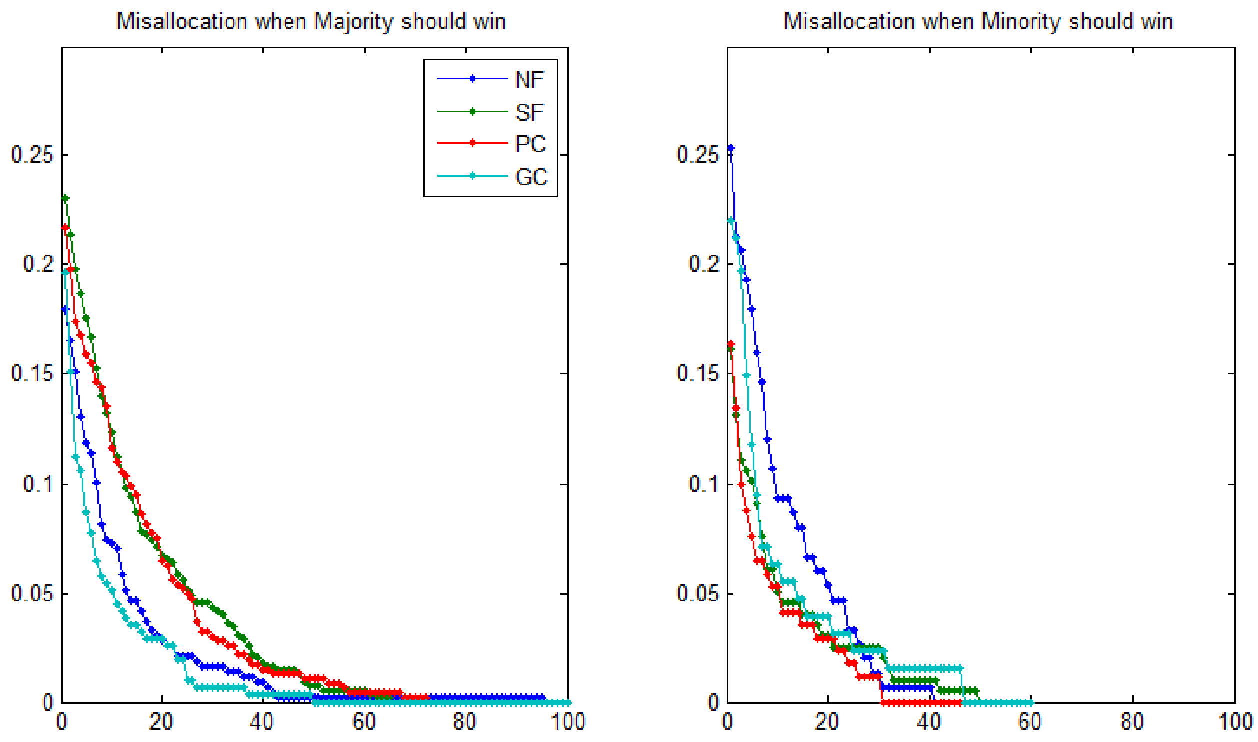

Figure 4: Cumulative misallocation by group

Figure 4 seems to provide a good explanation of the overall allocative welfare performance of our treatments presented earlier in Table 2 and Figure 3. Simple Feedback and Public Communication perform poorly in terms of allocative welfare, which – while not obvious in Figure 4 – is consistent with it. Since the panel on the left represents the cases that occur more often, the loss associated with more frequent misallocation dominate the gain associated with less frequent misallocation on the right panel. Group Communication, on the other hand, beats the No Feedback benchmark on both accounts, and thus leads to the best allocative welfare of all four mechanisms.

To confirm these result in a regression framework, we verify how treatments affect welfare separately for minority and majority win committees in Table 9.

What we see is that Simple Feedback and Public Communication affect allocative welfare in a statistically significant way through poorer performance in majority win committees. In minority win committees, the effect on allocative welfare is positive albeit not in a statistically significant way. Group Communication performs better than No Feedback in both minority and majority win committees but not in a statistically significant way.

Net welfare is lower in Simple Feedback than in No Feedback through a poorer performance in majority win committees. The superiority of Public Communication over Simple Feedback comes from performing better in minority win committees. ...

Table 9: Regression results: minority versus majority win committees

Dep variable:	Allocative welfare		Net welfare	
	minority win	majority win	minority win	majority win
Constant	0.95	1.9***	3.11	6.36***
SF	1.82*	-2.39***	0.72	-5.24***
PC	1.30	-1.92**	5.21***	-1.56
GC	1.35	0.21	2.35	-1.78
Sum of Valuations	0.62***	0.70***	0.32***	0.42***
Period Dummies	No	No	No	No
N	603	1657	603	1657

Table 10: Stoppage at zero.

Treatment	% of decisions at zero
NF	60.5
SF	50.9
PC	72.5
GC	

5.6 Waiting cost

First thing to notice column four in Table 2, in which we see that waiting cost per committee in No Feedback is remarkably similar to theoretical prediction. Simple Feedback increases this waiting cost, but introducing Public Communication reduces is dramatically. This provides evidence in favor of Conjecture 7.

Another indirect way to see the effect of treatments on waiting duration is the incidence of decisions being made at time zero. This is very high (more than half) as can be seen in Table 10. The pattern is consistent with previous paragraph.

5.7 Individual-level analysis

This last subsection abandons the committee-level approach, and reports some general observations on individual behavior. To get an overview of individual voting patterns we distinguish voters into three groups: those that exited at time 0, those that exited at time t within the course of the voting round ($0 < t < 60$), and those that never exited. As can be seen in Table , in all of the treatments, most voters either exit at 0 or never exit. This means that there is a large group of voters - the most populous of the three groups - for whom we do not know their intended exit time.

We next examine the relationship between a voter's valuation and their exit decision in a regression framework. We consider two types of dependent variables, the variable exit indicates whether a voter exited in a certain round (either at time 0 or within the

Table 11: Summary of voting types – All.

Treatment	Exit at 0 (& pivotal)	Exit at $t > 0$ (& pivotal)	Never Exit
NF	35.9 (17.6)	19.7 (15.7)	44.4
SF	32.3 (14.8)	24.5 (18.3)	43.3
PC	40.2 (22.6)	13.6 (10.4)	46.3
GC	42.4 (20.4)	14.8 (12.6)	42.8

All entries are %.

Table 12: Summary of voting types – Majority.

Treatment	Exit at 0 (& pivotal)	Exit at $t > 0$ (& pivotal)	Never Exit
NF	34.8 (7.2)	15.1 (9.2)	50.2
SF	32.9 (6.6)	23 (13.8)	44.1
PC	37.2 (10.9)	12.9 (8.2)	49.9
GC	42.1 (9.2)	12.4 (9.1)	45.4

All entries are %.

Table 13: Summary of voting types – Minority.

Treatment	Exit at 0	Exit at $t > 0$	Never Exit
NF	38.3	28.8	32.8
SF	31.1	27.3	41.6
PC	46	14.9	39.1
GC	42.9	19.6	37.6

All entries are %.

Table 14: Regression results on propensity to exit and exit-time

Dep variable:	Exit (0/1)			Exit time (secs)		
Valuation	-0.012***	-0.012***	-0.012***	0.149***	0.149***	0.149***
SF	0.013	0.013	0.003	0.808***	0.808***	0.787**
PC	-0.012	-0.012	-0.020	-0.359	-0.438*	-0.444*
GC						
Period Dummies	No	Yes	Yes	No	Yes	Yes
Characteristics*	No	No	Yes	No	No	Yes
N			9030			

* Gender, nationality, area of study

round) and as a second left-hand side variable we consider exit time (in secs). For the case of voters that do not exit, we assign them as exit time the actual duration of the round, which obviously is a very conservative lower bound of their intended exit time. What we see is that higher valuations reduce the probability of exiting and also that higher valuations are associated with higher exit times. So there seems to be a tendency for voters with higher valuations to stay longer in a voting round.

6 Conclusions

We report results from a series of experiments that examine the joint impact of feedback and pre-voting communication on voting outcomes in individual cost committees. We obtain a series of results. First, in line with theoretical predictions, with the high heterogeneity of preference intensities, the committee with a stringent supermajority requirement performs better in efficiency terms than simple majority. Second, revealing their majority-minority status makes the minority (pivotal) voter win more often; it also makes the first majority voter exit earlier. Third, pre-play public communication shortens the waiting time and thus improves the net efficiency performance of committee decisions, but the effect on allocative efficiency is not significant relative to Simple Feedback and it is worse than in No Feedback. Within group communication also improves net efficiency but in a completely different way. Allocative efficiency is better than in Simple Feedback, but waiting cost is not as low as in Public Communication.

Thus, in positive analysis, the paper sheds light on equilibrium selection problem in our multiplayer war of attrition, and, as far as normative questions are concerned, it highlights the desirable efficiency properties of supermajorty in committees and the efficiency-enhancing but subtle role of communication.

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Appendix

This Appendix gives an example of instructions, examples and quizzes for one treatment.

Appendix A

INSTRUCTIONS

Introduction

Thank you for participating in this experiment on decision-making. During this experiment you will earn money. How much you earn depends on your decisions, the decisions of other participants, and an element of chance. This money will be paid to you, in cash, at the end of the experiment.

During the experiment we will speak in terms of Experimental Monetary Units (EMU), instead of Pounds. Your payoff will be calculated in terms of EMU and then converted to Pounds at the end of the experiment, at a rate of 1 EMU = 8 pence. You will start the experiment with an initial endowment of 120 EMU (£9.60).

After the instructions are read aloud and all the participants have understood them, the experiment will start. You will see the first screen, where you will have to type the number you received at the entrance. This will be your ID number. The experiment is divided into 40 periods. In each period, you will face the same situation described in the next section. After this, we will ask you to complete a short survey.

At the end of the experiment, the computer will randomly select three periods. The payoff that you obtained in these periods will be added to the initial endowment, and will make up the total amount of EMU earned in the experiment.

Please do not talk to anyone. Your participation in the experiment and any information about your earnings will be kept strictly confidential. Everyone will be paid in private and you are under no obligation to tell others how much you earned. Your receipt of payment and consent form are the only places on which your name will appear. This information will be kept confidential in the manner described in the consent form.

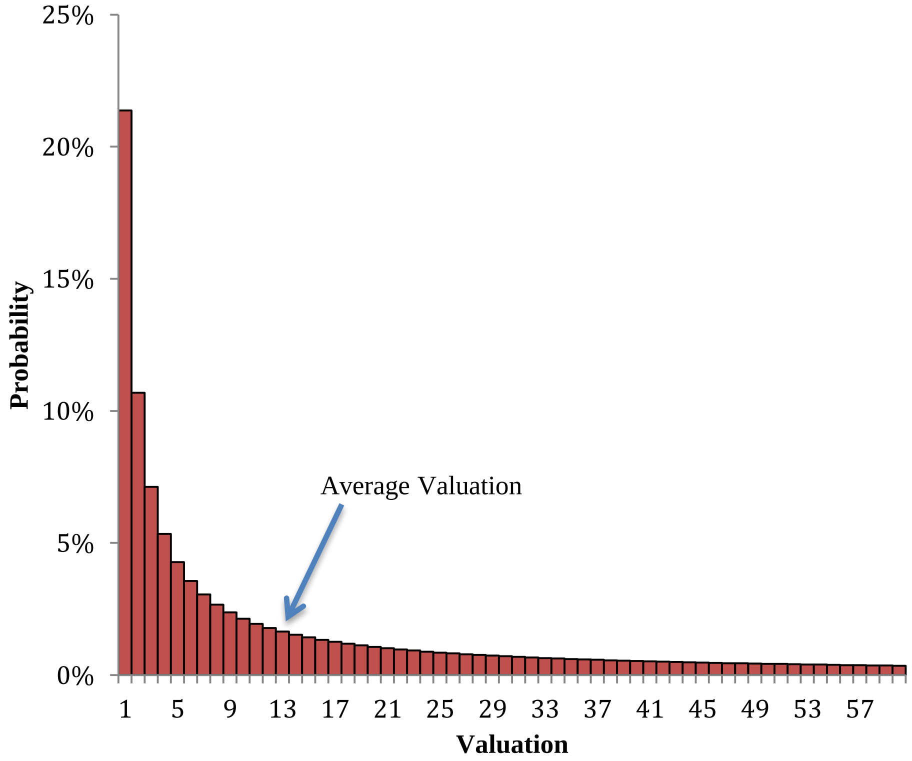
The group decision problem in each period.

At the beginning of each period you will be randomly assigned to a three-member committee. The composition of your committee may vary from period to period.

The committee will select one of two alternatives through a procedure to be explained below.

You, and the other members of the committee, will receive a number that represents each member's respective valuation of their preferred alternative. Committee members do not know the valuations of other committee members, they only know their own.

This valuation can be any integer number between 1 and 60, but these numbers do not have the same chance of occurring. In particular, you are more likely to receive a small valuation than a large one. The Figure below shows the likelihood of receiving various valuations.



For example, the probability of receiving valuation 1 is just over 21%. The probability of receiving valuation 2 is almost 11%. The probability of receiving valuation 21 is 1%. The probability of receiving valuation 60 is 0.36%.

Notice also that the probability of receiving a valuation between 1 and 5, inclusive, is almost 50%. The probability of receiving a valuation between 6 and 60, inclusive, is just over 50%.

In every period and in every committee, there will be 1 member supporting one of the alternatives (group of 1), and 2 members supporting the other alternative (group of 2).

The committee decision in each period is made according to the following **waiting game,** which lasts at most 60 seconds. After each member receives a valuation, and learns whether they are in a group of 1 or 2, the computer starts the clock.

- Initially, you are presumed to support your preferred alternative. To indicate that you want to cease supporting your alternative, you have to press the "EXIT" button. You may exit at any time. You may exit even before the clock starts, to indicate that you cease supporting your alternative immediately.
- The waiting game stops as soon as the last supporter of one of the alternatives exits. The alternative that still has supporters is selected by the committee.
- Waiting is costly. It costs 1 EMU per second to keep supporting your alternative. Your actual **waiting cost** is determined by your exit time, or the time when the waiting game stops.

The computer displays the clock showing how many seconds have elapsed since the beginning of the period. This is also your accumulated waiting cost in EMUs. Also, the computer will display a message as soon as any member exits the waiting game.

If an alternative is not selected after 60 seconds, the computer will stop the clock and select an alternative randomly, in proportion to the number of supporters at this time.

Payoff calculation in each period.

If your preferred alternative is selected, your payoff in EMUs will be equal to your valuation, minus the waiting cost. If your preferred alternative is not selected, then you do not get the valuation, but you still pay the waiting cost.

Information at the end of each period.

At the end of each period you will receive the following pieces of information.

1. Exit times of other members of the committee.
2. Whether you were in a group of 1 or 2.
3. The alternative that was selected.
4. Your payoff in EMU.

Examples of how your payoff in a period is determined.

Example 1.

Suppose that your valuation is 24 and you intend to exit 38 seconds into the waiting game. Suppose that it turns out that you were in a group of 2 and the other member of your group exits 8 seconds into the game, whereas the member of the group of 1 exits 19 seconds into the game. The waiting game stops 19 seconds into the game, when the last supporter of the other alternative exits. Your alternative is selected. Your period payoff will be: 24 minus your waiting cost 19, which equals 5 EMU.

Example 2.

Suppose that your valuation is 15 and you intend to exit 18 seconds into the game. Suppose that it turns out that you were in a group of 2 and the other member of your group exits 8 seconds into the game, whereas the member of the group of 1 intends to exit 19 seconds into the game. The waiting game stops 18 seconds into the game, when the last supporter of your alternative exits. Your alternative is not selected. Your period payoff will be: 0 minus your waiting cost 18 EMU.

Example 3.

Suppose that your valuation is 2 and you intend to exit 21 seconds into the game. Suppose that it turns out that you were in a group of 1, and the two members of the group of 2 intend to exit 24 seconds, and 16 seconds into the game, respectively. The waiting game stops 21 seconds into the game, when the last supporter of your alternative exits. Your alternative is not selected. Your period payoff will be: 0 minus your waiting cost 21 EMU.

Comprehension questionnaire

Question 1.

Suppose that your valuation is 1 and you intend to exit 3 seconds into the game. Suppose that it turns out that you are in a group of 1 and the two members of the group of 2 intend to exit 2 seconds and 1 second into the game, respectively.
The waiting game stops __________ seconds into the game.
Your alternative (is / is not) __________ selected.
Your payoff will be: ________________________ = ______ EMU.

Question 2.

Suppose that your valuation is 53 and you intend to exit 22 seconds into the game. Suppose that it turns out that you are in a group of 2 and the other member of your group intends to exit 29 seconds into the game, whereas the member of the group of 1 intends to exit 27 seconds into the game.
The waiting game stops __________ seconds into the game.
Your alternative (is / is not) __________ selected.
Your payoff will be: ________________________ = ______ EMU.

Question 3.

Suppose that your valuation is 28 and you intend to exit 11 seconds into the game. Suppose that it turns out that you are in a group of 1 and the two members of the group of 2 intend to exit 29 and 3 seconds into the game, respectively.
The waiting game stops __________ seconds into the game.
Your alternative (is / is not) __________ selected.
Your payoff will be: ________________________ = ______ EMU.

Question 4.

Suppose that your valuation is 3 and you intend to exit 17 seconds into the game. Suppose that it turns out that you are in a group of 2 and the other member of your group intend to exit 4 seconds into the game, whereas the member of the group of 1 intend to exit 18 seconds into the game.
The waiting game stops __________ seconds into the game.
Your alternative (is / is not) __________ selected.
Your payoff will be: ________________________ = ______ EMU.