

# Voting Games and Computational Complexity

by

Glenn W. Harrison and Tanga McDaniel<sup>†</sup>

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## ABSTRACT

Voting rules over three or more alternatives suffer from a general problem of manipulability. However, if the rule is “difficult” to manipulate, in some formal computational sense that is intrinsic to the rule or some cognitive sense specific to the set of voters, then one might not observe manipulation in practice. We evaluate this hypothesis using controlled laboratory experiments. We conclude that one voting rule, due originally to Condorcet, is indeed *behaviorally incentive-compatible despite being theoretically manipulable* if the underlying preference environment is sufficiently diverse that voters have difficulty ascertaining others’ preferences.

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<sup>†</sup> Professor of Economics, Department of Economics, College of Business Administration, University of Central Florida (gharrison@research.bus.ucf.edu), and Assistant Professor, Department of Economics, Appalachian State University (mcdanielm@appstate.edu), respectively. We are grateful to Richland County Government for funding, and to David Kennison, Elisabet Rutström, Sandi Teel, Melonie Sullivan, Peyton Young and two referees for their comments. We are particularly grateful to the late Richard McKelvey for encouragement and comments. Harrison also thanks the U.S. National Science Foundation for support under grants NSF/HSD 0527675 and NSF/SES 0616746. Supporting instructions, data and statistical code are stored at the ExLab Digital Archive at <http://exlab.bus.ucf.edu>.

## 1. Introduction

Voting rules over three or more alternatives suffer from the general problem of manipulability. Vote manipulation increases the challenge of determining who the true winner of an election should be or inferring voter preferences from an election outcome. Yet, if the rule is “difficult” to manipulate, in some formal computational sense that is intrinsic to the rule or some cognitive sense specific to the set of voters, then one might not observe manipulation in practice. We evaluate this hypothesis using controlled laboratory experiments. We conclude that one rule, originally due to Condorcet, is indeed *behaviorally* incentive-compatible despite being theoretically manipulable if voter preferences are sufficiently diverse.

Our goal is to see if one can use a relatively simple and attractive voting rule to elicit preferences over the public provision of a real commodity. For our purpose a voting rule is attractive if explaining it, and determining a winner using it, are straightforward. The objects of social choice in our experiments are five categories of music, so we cannot use binary choice voting rules. The Gibbard-Satterthwaite Theorem implies here that the only voting rule which is strategy proof for all possible preferences is dictatorial. However, we suggest there exist some voting rules which fall prey to the Gibbard-Satterthwaite Theorem only when one assumes agents have infinite capacity to calculate best responses. Relaxing that assumption opens up a range of voting rules which may be difficult, in a well-defined computational sense, to successfully manipulate. In such a setting it is plausible that the subjects would resort to truthful revelation of preferences, in an attempt to “maximize the pie” instead of “ruining the pie by fighting over it.” In other words, the threat of a Pyrrhic Victory from the manipulation game may provide a behavioral incentive for subjects to respond truthfully.

Our method is to design a series of controlled laboratory experiments in which we can elicit

values over some real commodity. Our subjects made group choices over five musical categories such as the list of five in bold in Table 1. Subjects ranked the categories and circled one CD *within* each category. Subjects then received the circled CD from the winning category as determined by the group vote. Thus, the individual chose the CD within the category, but the group chose the category according to some defined voting rule. By having a choice of ten specific CDs within each category, we avoided uncertainty as to what constitutes “R&B” or “Rap,” etc.

We deviate from previous experimental voting studies in two important ways. First, we begin with the assumption that the goal is to elicit sincere votes. Hence we approach the voting problem from a slightly different angle than existing strategic voting experiments. Second, instead of induced values, whereby subjects are endowed with preferences that are controlled as part of the experimental design, our experiment seeks to elicit subjects’ homegrown (i.e., non-experimentally induced) preferences over a real commodity.<sup>1</sup>

Previous research has illustrated strategic voting in different environments. For example, Plott and Levin [1978] and Eckel and Holt [1989] analyze strategic agenda setting under majority rule. Yuval [2002] finds sophisticated voting under sequential voting by veto,<sup>2</sup> and Guarnaschelli, McKelvey and Palfrey [2000] show how unanimity rules under jury procedures increase strategic voting relative to majority rule. Yuval [2002] finds that sincere voting is more likely to emerge in larger groups. Generally, the computational difficulty of sophisticated voting increases as the voting space enlarges to include more options or more voters; experimental results typically support this

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<sup>1</sup> There is a large literature on the elicitation of homegrown values using experimental procedures, surveyed by Harrison [2006] in the context of environmental values. The main methodological challenge in this setting is to control the information that subjects will bring to the task since they have personal histories with the commodity (e.g., Harrison, Harstad and Rutström [2004]). Our design avoids those problems by aggregating specific CDs into broad categories, and eliciting preferences over that category rather than a specific CD.

<sup>2</sup> Sophisticated voting involves forward looking strategies that may require the subject to sacrifice short term gains. This terminology is useful when voting involves multiple stages. For our experiments, the terms “sophisticated” and “strategic” voting can be used interchangeably.

intuitive claim. Herzberg and Wilson [1988] take the view that sophisticated voting in the laboratory is rare, indicating that, behaviorally, it is not the problem that theory presupposes. They point to individuals' limited computational abilities and uncertainty over others' voting strategies as possible explanations for the frequency of myopic and sincere strategies observed. Although sophisticated voting takes place in their experiment, albeit infrequently in comparison to sincere voting, its occurrence is not monotonically increasing in the complexity of the experiment (where complexity here refers to the length of the agenda).

Relative to previous experiments, the voting task faced by our subjects is quite simple and does not involve agendas or sequential voting. By design, strategic behavior does not require great foresight. Even so, we show that a voting rule that is simple to explain and implement may still be cognitively difficult to strategize against. Our elicitation of homegrown values is a methodological innovation in this area of the literature; moreover, as CDs are a familiar commodity to students, this procedure reduces the conceptual complexity of the voting task for subjects relative to common induced value methods.

Our control experiment uses an extremely simple voting rule, Random Dictator, which provides strong incentives for truthful revelation of the *most* preferred choice of the individual. As the name suggests, one group member is chosen by a random draw after the individual choices are made and her stated preferences determine the group vote over categories. This is not a popular voting rule with social choice theorists since it fails to reliably deliver Pareto-efficient outcomes, but it is ideal for experimental purposes where the sole objective is to elicit true homegrown values for the most preferred alternative.

Why do we need to use a rule such as Random Dictator? The reason is that it begs the very question of study, manipulability, if one relies on observed field rankings under some voting rule which has no strong *a priori* basis for encouraging truth-telling. Such an approach is adopted by

Levin and Nalebuff [1995; p.4]:

“We have also taken some of the [voting] methods and applied them to voting data gathered from British Union elections (data collected separately by N. Tideman and I.D. Hill). An interesting feature of these British elections is that voters are required to rank the candidates. As a result, knowing the voter ranking, we can simulate elections under a variety of electoral systems. It is perhaps remarkable that among the 30 elections we examined, with the exception of plurality rule and single transferable vote, none of the other seven [voting rule] alternatives considered gave a different top choice.”

There can be no claim that the other voting rules would generate the same outcome unless some voting rule such as Random Dictator, which is arguably demand-revealing on an *a priori* basis, is used in the original union elections. The reason is that strategic behavior itself is likely to vary with the voting rule, as well as the very propensity to engage in manipulation. Thus it is premature to draw the conclusion stated.

The research experiment employs a voting rule attributed to Condorcet by Young [1988]. It is a natural and intuitive extension of the idea of simple majority rule, to allow for the possibility of Condorcet cycles forming. These cycles are avoided by searching over all non-cyclic group rankings to find the one receiving greatest support in terms of pairwise comparisons. For problems of the dimensionality considered here we can easily determine this ranking by exhaustive evaluation; for larger dimensional problems we can use more efficient algorithms. Once this ranking has been determined, the group choice is just the distinguished element. We refer to this as a “Condorcet-Consistent” voting rule (hereafter referred to as CC).

The primary methodological innovation we offer is the use of a control experiment to elicit homegrown values for the top individual preference which have a strong *a priori* justification for being called “true values.” This control experiment takes the place of experimenter-induced values in standard experimental practice. We can then compare the top choice in the research experiment with the top choice in the control experiment to test our hypothesis.

Our main hypothesis is that subjects will vote sincerely when the voting rule is difficult to strategize against. We find support for this hypothesis when we evaluate it in a domain that we characterize as employing “diverse” preferences, since individuals are assumed to know relatively less about the tastes of other group members. We conclude this hypothesis is *not* generally valid under “simple” preferences, where taste are likely to be more homogeneous. In the latter case the validity of the hypothesis depends on whether or not the subjects are provided with detailed information about the voting rule.

## 2. Attractive Voting Rules

Consider the simple problem of getting people to vote on a group allocation of resources across a range of services that a local government can provide with a given budget. The fact that we will have many agents, many alternatives, and incomplete information on preferences immediately raises the Gibbard-Satterthwaite Theorem: the only voting rule which is strategy-proof for all possible preferences is “dictatorial” (Moulin [1988; ch.10]). The term “strategy-proof” here means that truth-telling is a dominant strategy for each agent, so that he does not need to know anything about the other agents’ preferences in order to figure out that truthfully stating his preference the best he can do. A “dictatorial” rule is one that gives one voter all of the power for all preference profiles, and is therefore not particularly interesting for *field* applications.

In this section we discuss several “escape routes” from the Gibbard-Satterthwaite Theorem. This provides some background to the solution we then examine. We propose two voting rules which meet our objectives of eliciting preferences from individuals for use in a group decision in a controlled laboratory setting. It is important to note that we are not seeking a rule which generates Pareto-efficient outcomes, merely one which elicits truthful responses. Moreover, we would like to

have a voting rule which is (i) easy to explain to subjects, (ii) easy to implement, and (iii) difficult for subjects to strategically manipulate.

## 2.1 Random Dictator

One simple voting rule chooses a voter at random and imposes her stated preferences on all the others. Since an individual's stated preferences will then only affect the outcome if she is the "dictator," the individual has no incentive to misrepresent. Although this voting method might seem artificial and unfair, it clearly gives the individual voter a positive incentive to tell the truth.

It is easy to see that this voting rule is not always going to result in a Pareto outcome. For example, assume that everyone except the dictator has identical and strict rankings, but that the dictator is indifferent between all alternatives and chooses at random. Random Dictator has been discarded by most economists searching for Pareto-efficient voting rules that are also demand-revealing. If one is only interested in eliciting preferences, however, the possible inefficiency of the voting rule can be ignored. Such a narrow focus is justifiable in a laboratory setting.

## 2.2 Condorcet-Consistent Voting

What if the set of true preferences that agents have is such that a "Condorcet winner" (CW) exists? A CW is an alternative that defeats every other alternative in pairwise comparisons. There is no assurance, without very restrictive assumptions on preferences, that a CW exists for all possible preference profiles.<sup>3</sup>

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<sup>3</sup> Fishburn [1973; p.95] has some neat numerical intuition for this. For a given number of agents, generate all possible preference orderings for all agents, assuming that each combination occurs independently and equiprobably. Then the probability that a CW does *not* exist when the number of alternatives is 3, 4, 5, 6, and 7 is 0.056, 0.111, 0.160, 0.202, and 0.239 when there are just 3 agents, for example. For any number of voters greater than two, the probability that a CW does not exist approaches one as the number of alternatives approaches infinity. For a given number of alternatives, the probability of there being no CW when there is an arbitrarily large number of voters is less than one but rapidly increases in the number of voters (e.g., for 3, 4, 5, 6 or 7 alternatives the probabilities are 0.088, 0.176, 0.251, 0.315 and 0.369).

So much for the bad news. The good news, however, is that *if a CW exists and the number of agents is odd then a voting rule which selects it is strategy-proof* (see Moulin [1988; Lemma 10.3, p.263]). Moreover, it is also known that in such a setting no coalition of the group can jointly misrepresent their preferences and make *every* coalition member better off. Coalition formation may not be a serious problem for large and decentralized surveys, but could be for smaller group decision-making in a centralized location such as a committee room.

Following a suggestion by Black [1958], why not have a two-stage voting rule in which we first see if there is a CW, select it if it exists, and go on to some other rule if a CW does not exist? An appealing feature of this rule is that there is *some* probability that a CW will exist, so why waste it?<sup>4</sup>

Another alternative is to use the extension of Condorcet's voting rule proposed by Young [1986][1988][1995] and Young and Levenglick [1978]. A CW is defined above as any alternative that defeats every other alternative in pairwise comparison. In other words, a majority of voters must find such an alternative preferable to all other alternatives (the majority that supports the CW might differ in each pairwise vote). A simple example in which this does not occur is as follows. Let the alternatives be  $A$ ,  $B$  and  $C$ , and let the symbol  $X \succ Y (Z)$  denote a majority vote of  $Z$  preferring  $X$  over  $Y$ . If we have  $A \succ B (8)$ ,  $A \succ C (6)$ ,  $B \succ A (5)$ ,  $B \succ C (11)$ ,  $C \succ A (7)$  and  $C \succ B (2)$ , then we obtain the cyclic social ranking  $A \succ B$ ,  $B \succ C$ , and  $C \succ A$ . A CW as defined thus far does not exist.

Condorcet proposed that such cycles be dealt with by choosing the social ranking that was "most likely." Young [1988] attaches the following structure to this notion. First, posit a model in which (i) each agent votes sincerely in any pairwise comparison with some probability (strictly)

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<sup>4</sup> Alternatively, we could allow each agent to submit two sets of preferences if he chooses: the first set will be used to select a CW if one exists according to the set of such preferences submitted, and the second set will be used with one of the voting rules if there is no CW. One would have to have some credible way of assuring agents that we would not use the first set of preferences in place of the second set if a CW was not found, but that could be easily done by various logistical devices and/or independent auditors of the procedure. The first set of preferences would then be assumed by the observer to represent the true preferences, even if the latter set of preferences *might* be the ones used to determine the *actual* outcome of the vote.

greater than one-half that is the same across all voters, (ii) each voter's preference on each pair of alternatives is independent of his preference on any other pair, and (iii) each voter states his preferences independently of other voters. Then search for the *non-cyclic* social ranking that has maximal support from the voters. Specifically, let each pairwise comparison,  $i$  versus  $j$ , within a ranking receive a weight equal to the number of voters supporting  $i$  over  $j$ . The support for a ranking is then the sum of these weights. For example, given the two rankings ABC and CBA calculate the sum of voters preferring A over B, A over C and B over C and compare this to the number preferring C over B, C over A and B over A. The top alternative from the ranking with greatest support is the winner. More formally, the CC voting rule can be defined using these assumptions, following Young [1995; p.55] as follows:

Given a voting outcome and a ranking  $R$  of the alternatives, the conditional probability of observing the vote, given that the true ranking is  $R$ , is proportional to  $p^{s(R)}(1-p)^{M-s(R)}$ , where  $M = nm(m-1)/2$  and  $s(R)$  is the total pairwise support for  $R$ . Hence  $R$  has maximum likelihood if and only if it has maximal support.

Thus the CC voting rule is simply the maximum likelihood, acyclic ranking.

The CC voting rule is also a well-posed maximization problem which will always have a solution. In fact, it can be obtained as the solution to the following integer programming problem (cf. Young [1995; p.55, fn.4]), which can also be viewed as a constructive definition of the CC rule:

$$\begin{array}{ll}
 \text{maximize} & Z = \sum_{ij} V_{ij} X_{ij} \\
 \text{subject to} & X_{ij} \in \{0,1\} \quad \forall i,j \\
 & X_{ij} + X_{ji} = 1 \quad \forall i,j \\
 & 1 \leq X_{ij} + X_{jk} + X_{ki} \leq 2 \quad \forall i \neq j \neq k,
 \end{array}$$

where  $X_{ij} = 1$  denotes a social preference for alternative  $i$  over  $j$ ,  $X_{ij} = 0$  denotes the reverse preference, and  $V_{ij}$  denotes the number of votes obtained by  $i$  over  $j$ .

The first two constraint sets ensure that we express a strict social preference for all pairwise

alternatives. The third constraint set ensures that social preferences are non-cyclic. The objective function to be maximized is the voting support for the social preference. This is a straightforward programming problem that may be solved using GAMS (see Brooke, Kendrick and Meeraus [1992]). For the numerical example given above, the social ranking that is consistent with Condorcet's notion of the most probable ranking is  $A \succ B \succ C$ .

There are four main virtues to using the CC ranking. First, it always exists and selects the CW whenever one exists. Second, it is very easy to explain to subjects, providing one does not go into details about the need to solve integer programming problems! Third, it generates a ranking rather than a single choice, and there are circumstances under which the former is more useful than the latter.<sup>5</sup> Fourth, it is computationally difficult for subjects to strategically manipulate. The last property is an important one for our main hypothesis.

### 2.3 The Computational Difficulty of Manipulation

Computational difficulty is defined rather narrowly in the computer science literature. Essentially, difficulty or complexity is measured with respect to the potential amount of time it takes to compute the solution to a problem. If the computation time of a solution is a polynomial function of the problem's size, then the problem is said to be tractable. Formally, such problems belong to a class of problems called *NP*. The hardest problems within this class are called *NP-complete* (Garey and Johnson [1979]).<sup>6</sup>

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<sup>5</sup> Specifically, we envisage embedding our social elicitation procedure into a two-stage procedure in which the valuation of private citizens as a group is first elicited and then pooled with the rankings of the elected government of these citizens. Thus we might give the private citizens a 50% weight. In order to pool the rankings of these two agents we need to have the rankings of the former as well as the rankings of the latter. More generally, obtaining the rankings of any one group allows us to pool them with rankings obtained for other groups or individuals. Thus one might be interested in the valuation of New Mexico as a state for siting a nuclear waste site, or one might be interested in the SouthWest regional valuation for such a commodity, or one might be interested in the national valuation. Our proposed ranking could be employed in all of these contexts.

<sup>6</sup> A related literature, on *information-based complexity*, examines the interaction between the amount of information that

For our purposes, the voting “problem” has two definitions: (i) determine the winning candidate, and (ii) determine if an individual can strategically misrepresent his preferences successfully. If the first part can be shown to be a difficult computational problem then it would follow that the second part is likely to be hard, since it would be expected to involve solving many sub-problems of the first part.

For any number of alternatives,  $n$ , there are  $n!$  non-cyclic rankings. Thus, with five alternatives the number of non-cyclic rankings is 120. Because the steps involved in the computation of the outcome of the voting rule increases polynomially with the number of alternatives, holding the number of voters constant, this voting rule satisfies the criteria stated earlier for a tractable computational problem. That is, it is easy to explain and easy to implement in cases where  $n$  is relatively small (e.g.,  $n \leq 6$ ).

The literature discusses voting rules that are computationally difficult to strategize against. For instance, Bartholdi, Tovey and Trick [1989a][1989b] prove that the Kemeny [1959] Ranking rule has the property that computing the ranking of candidates and the winning candidate are  $NP$ -complete problems, and that it can be computationally hard to strategize against. Kemeny Ranking is a voting rule which finds a “consensus ranking” of the alternatives. That is, it finds the social ranking of the alternative which minimizes the sum of the distances between voters’ preferences. For our purposes the CC voting rule is operationally equivalent to Kemeny Ranking.<sup>7</sup> This implies that computing the winning candidate using the CC is also an  $NP$ -complete problem.

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one has about a problem (e.g., the preferences of the agents in some allocation problem) and the difficulty of calculating a solution that meets certain criteria: see Traub, Wasilkowski and Woźniakowski [1988] and Traub and Werschulz [1998]. This literature is much closer to the class of problems considered by economists and computer scientists engaged in mechanism design for complex allocation problems: see Cramton, Shoham and Steinberg [2006] for surveys.

<sup>7</sup> It is common to identify the two as the same, as in Levin and Nalebuff [1995; p.15]. However, there are some ambiguities in the original presentation of several rules by Kemeny [1959], noted by Young [1995; p.61]. Nonetheless, if one adopts the most common interpretation of Kemeny’s rule it is identical to the CC rule.

However, proofs of computational complexity involve heavy reliance on “worst-case” scenarios. These problem instances require solution times that grows *exponentially* with the problem size. Most cases concerning experimental economists are not “worst-case” in this respect, since the problem size is fixed (as is the case in our experiments). Recent developments in the formal theory of complexity focus on “average case” characterizations, and complexity that derives from problems being ill-posed (e.g., Traub and Werschulz [1998]). Moreover, even if a problem’s solution does not require an exponential amount of time to compute, the computational problem may be “tough enough” that given individuals have a difficult time determining how to misrepresent their preferences successfully (cf. Smith [1982; p. 934, fn.17]).

If the CC voting rule is computationally difficult to strategize against, we should observe the same responses in that treatment as in our control experiment where subjects have a strong incentive to tell the truth. In that case we will say that the voting rule is *behaviorally incentive compatible*.

The experimental literature contains many instances of problems in which subjects have “collapsed” to truth-telling, despite the fact that such responses can be quickly shown not to be NE. The preference distortion game induced on the marriage problem by Harrison and McCabe [1995] is one example. As the dimensionality of the problem was increased by experimental treatment, they report a significantly greater tendency for subjects to report their true preferences. The preference distortion game induced on the airport landing slot problem by Rassenti, Smith and Bulfin [1982], and on the gas network problem by McCabe, Rassenti and Smith [1989], are similar instances. More generally, there has recently been an explosion of interest in “combinatorial auctions” in which the complexity of the allocation problem requires attention to ways in which the message space and solution can be made more computationally tractable (see Cramton, Shoham and Steinberg [2006]).

### 3. Experimental Design

Subjects in our lab experiment were asked to vote over categories of CDs. CDs as a commodity are familiar to most individuals and can easily be grouped into natural musical categories. Moreover, CDs can be found within major music categories which are in the same price range. Given that our objective is to obtain a preference ranking over *categories* from individuals, this serves to reduce the likelihood that an individual would rank categories based on the expected price of the CDs within the categories.

In each experiment subjects were asked to rank five different categories of music, such as the categories shown in Table 1. They were told that one category of music would be chosen for the group and that the category would be determined by a group vote. Every individual in the group received the *specific* CD of his or her choice from the selection of CDs in the *category* chosen by the group. Each of the five categories had a selection of ten CDs, again as illustrated in Table 1. Thus although the group could impose the category “Rap” on some individuals, it could not force them to select a particular CD from the list of 10 available. After subjects made choices on their voting slip, the experimenter entered individual rankings into a computer program that determined the winning CD category.

We discuss three further aspects of our experimental design: the choice of voting rules, the provision of information about the voting rule, and the use of different preference profiles. Table 2 shows the complete experimental design.

#### 3.1 Voting Rules

The Random Dictator (RD) voting rule is theoretically incentive compatible for the individual’s top choice. Using RD we can therefore elicit individuals’ true first preference for a

commodity. With this information and a sufficiently randomized sample, we can use a different elicitation mechanism and compare the stated preferences of individuals for their top choice in the two different voting mechanisms. If the stated first preferences are statistically different between the two mechanisms, the extent of bias can be determined by comparison with the (theoretically true) preferences elicited with the RD mechanism.<sup>8</sup>

As a second mechanism we chose the CC voting rule. Our maintained assumption is that the CC voting rule is operationally too difficult for subjects to strategize against, even if they can strategize against it in principle. If that is indeed the case, then the top preferences stated by individuals in the RD treatment should not be significantly different from the top preferences stated by individuals who vote using the CC voting rule.

### **3.2 Information**

One treatment condition for the CC voting rule experiments is the amount of information subjects were given concerning the logistics of the voting rule. The appendix shows the information provided.

In the “information” treatment, the specifics of the CC voting rule were spelled out explicitly to subjects and examples were supplied. In the “no information” treatment, subjects were only told that the social ranking chosen would be the one which would most likely receive the support of a majority of the voters. This is an important treatment because field survey counterparts to the CC voting rule are not likely to provide explicit information regarding the specifics of the voting rule

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<sup>8</sup> It is appropriate to include information in the instructions for the RD experiments about the (correct) logic of truthfully revealing preferences, since this is the control experiment for our laboratory design. We do not envisage the RD rule being used in a field context, but in a lab context it is appropriate to ensure that we elicit truthful preferences for comparison with alternative voting rules for which such statements may not be truthfully made. Subjects were asked to provide their full ranking of categories in this treatment in order to maintain consistency with the other treatments.

nor provide examples. Our goal with this treatment is to determine if information regarding the exact method of aggregating preferences makes a difference to the voting outcome.

In the RD voting rule experiments subjects were told that the social ranking would be determined by the preferences of one individual in the group and that individual would be determined by a random drawing of subject ID numbers. Subject ID numbers were randomly assigned. Therefore, subjects had no reason to assume that the experimenters could match their ID number to their name or to their location in the room, etc.

### 3.3 Preference Profiles

To intentionally, successfully manipulate an election outcome, an individual must have some knowledge of other voters' preferences. To better understand the importance of knowledge about others' preferences we use two different preference profiles in the experiment. We conjecture that, given our subject pool, the voting rule should be easier to manipulate with "simple" preferences and harder to manipulate with "diverse" preferences.

However, what are "diverse" or "simple" preferences? The five categories of music in the Simple preference treatment were: Jazz/Easy Listening, Classical, Rhythm & Blues, Rock, and County & Western. Because all of our subjects were college students, our prior was that most subjects would rank Rock or R&B first.<sup>9</sup> We believe the voting rule might be easier to manipulate in this treatment because students may conjecture that most of the subjects in the group have similar preferences.<sup>10</sup> Therefore, a subject who prefers Rock music has no reason to misrepresent his

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<sup>9</sup> This prior is based on the fact that we have some idea of what college students at the University of South Carolina listen to. This prior may not hold for subjects drawn from other universities.

<sup>10</sup> We would like to have a formalization of the ease of manipulating different preferences, and hence a metric for determining if any given set of preferences falls into the "diverse" or "simple" category. However, such formality is difficult without putting significantly more structure on the problem than we are willing to do in our setting since we are eliciting "homegrown preferences" over music categories. Such structure could be naturally imposed with induced

preferences if he believes that most of the people in the group also prefer Rock, but a subject who prefers Classical might. A person who prefers Classical first and Rock second may (contingent on his belief about the group's preference with respect to Classical) have an incentive to rank Rock *last* if he believes that Rock is more likely to be ranked first by the group than is Classical.

Another example illustrates the type of manipulations that are possible in terms of the top preference or the lower rankings. Suppose a voter has the following ranking: Classical, Jazz, C&W, Rock and R&B, and this individual observes several subjects in the room wearing cowboy hats or sunglasses during an overcast day. He might then infer that a large portion of the group has the following ranking: C&W, Jazz, R&B, Rock and Classical. To make the task of manipulation a potentially rewarding one, further assume that he believes these group preferences to be close to a majority, but not clearly a majority.

It is unlikely that this poor individual will be able to realize his most preferred category, Classical, since the rest of the group hate Classical. Therefore, it would be “wasteful” to rank Classical first. But he could attempt to move Jazz higher on the eventual group ranking, by reporting it as his #1 choice instead of his true preference. Thus he could, as the result of this manipulation, end up with his second preference (Jazz) instead of his third preference (C&W). Indeed, to reduce the chances of C&W even further he might distort his true rankings by listing C&W at the very bottom of his report.

A voter's success at manipulating a voting rule depends on the assumptions he is making about the other voters' preferences. That is not to say all students have perfectly homogeneous preferences where music is concerned. However, for our subjects, assuming nearly homogeneous preferences seems appropriate when the categories of music are defined very broadly. When music

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preferences. This is a direction for future research.

categories are narrowly defined, preferences are expected to be more heterogeneous making successful manipulation more difficult.

In the Diverse preference treatment we provided a narrower definition of the Rock and R&B categories. The five categories of music for these experiments were: Jazz/Easy Listening, Classical, Heavy Metal, Rap, and Country & Western. While there are many people who enjoy Heavy Metal and/or Rap, we did not believe that a majority of the students in our pool would prefer either of them to the other three categories. Also, one might expect to find significant variation in preferences among the other three categories of music.

#### **4. Experimental Results**

We recruited 111 subjects from the University of South Carolina. All were students, recruited from a variety of classes on campus. Each subject was told that there would be a \$5 show-up fee, and that they could expect to earn more than that. The breakdown of subjects according to experiment ID is shown in Table 2: there were 62 subjects in the Simple preference experiments, and 49 subjects in the Diverse preference experiments. No subject participated in more than one experiment, so there was no risk of an “income effect” from previous choices. Since the categories in the Simple and Diverse preference treatments differed by design, we evaluate voting behavior separately for each. All data, computer software, statistical code, and instructions are available at <http://exlab.bus.ucf.edu> for public download. The appendix lists the instructions used.

The raw student preferences over musical categories, ignoring issues of strategic bias for the moment, tended to confirm our *a priori* classification of these as Simple or Diverse preference profiles. Panels A and B of Table 3 list the musical categories and the percentage share of the sample listing that category as their #1 preference by institution. There is much more concentration in the

case of the Simple preference profile than with the Diverse preference profile.

We focus our analysis on the results for the first choice of subjects, since there are no incentives for subjects to truthfully reveal their complete ranking under the Random Dictator voting rule. If the individual were selected to be the dictator, then their first choice would apply to all; otherwise, their ranking and first choice are irrelevant.

As a first test we ignore the effect of information and compare voting outcomes under Random Dictator and the combined CC outcomes. Fisher's exact test examines the null hypothesis that there is no association between the musical categories listed as #1 and the voting institutions. The null hypothesis in this test is that the top-ranked category does not depend on the voting institution, and the alternative is that it does depend on the institution. The null is that any differences in the conditional probabilities of the top-ranked category and the voting institution are random, so "association" here just means "non-random." The  $p$ -value from this test reflects the exact probability, under the null, of observing this particular arrangement of the data, assuming the total number of observations of each top-ranked category and institution is given. So a smaller  $p$ -value implies that it is less likely that these observed data were generated at random, and more likely that there is some dependence between the top-ranked category and the institution.

Panel C in Table 3 shows the  $p$ -values for comparisons between institutions. The first comparison shows the null hypothesis is rejected for the case of Simple preferences, and cannot be rejected for the case of Diverse preferences. Under our maintained hypothesis that the preferences elicited under the RD institution reflect true preferences, this indicates subjects may have been engaging in some mis-representation in the CC institution when there were Simple preferences, but that they did not engage in mis-representation in the CC institution when there were Diverse preferences.

From the second and third comparisons of panel C in Table 3 we conclude the following: (i) the hypothesis that the RD and CC voting outcomes are not associated is only rejected at the 15.1% level with Simple preferences when there is *no* information provided about the CC voting rule (RD vs CCN), but the hypothesis is rejected at the 3.4% level when the RD and CC outcomes are compared when there *is* information provided (RD vs CCI), and (ii) under Diverse preferences we cannot reject the null hypothesis, whether or not information about the CC voting rule was provided. The last comparison across all three institutions also suggests the institution matters only for Simple preferences.

Our design is intended to detect if any manipulation of the top ranked category occurs, and not to pinpoint the exact form of the misrepresentation.<sup>11</sup> However, we can examine the pattern of rankings beyond the top-ranked category, to see if any pattern can be identified. Table 4 shows the ranks given in the case of the Simple preferences design. We aggregate several categories to eliminate noise in the less-important categories. If subjects place their most preferred category last, for example, we would expect to see the pattern of choices for RD *in panel A* the same as the pattern of choices for CCN or CCI *in panel E*. Similarly, if subjects place their most preferred category *second* last, we would expect to see the pattern of choices for RD *in panel A* the same as the pattern of choices for CCN or CCI *in panel D*. Similarly for other possible misrepresentations of this kind. We find no evidence of this type of manipulation, using a Fisher Exact Test and a critical value of 5%. Of course, this could be due to some subjects placing their top-ranked category second in one of the CC institutions, other subjects placing it third, others placing it fourth, and others placing it fifth. We do know from Table 3, and the associated tests, that the top-ranked choice was not placed first, and

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<sup>11</sup> It is possible to construct experiments in which the formal preference distortion game is written out, and can be evaluated. Harrison and McCabe [1995] illustrate in the context of the “two-sided marriage market” in which outcomes are determined by the Gale-Shapley algorithm. They evaluate if subjects converge on Nash Equilibria of the implied misrepresentation game, and the opportunity cost of observed deviations from that prediction.

hence that *some* manipulation occurred, but these data do not allow us to say much more than that.

To check these results for sample composition, and to control for the possible effect of providing more detailed instructions to subjects in some treatments, we test the hypothesis using a multinomial logit model of the first choice of the subject. Tables 5 and 6 report the estimates from these models. The key binary treatment variable for our hypothesis indicates whether the rankings were generated with the CC voting rule, with the RD voting rule the default alternative. We also included a binary indicator variable to identify those sessions in which additional information was provided about the voting rule. Finally, we control for sample variations in socio-economic characteristics gender, race, income, and household size. We report marginal effects of all variables on the probability of picking the listed category as the first choice. These marginal effects are calculated over all observations, and then averaged, rather than being approximated at the means of the observations (Bartus [2005]).

The results in Table 5 for Simple preferences collapse first choices into R&B, Rock and All Others.<sup>12</sup> These estimates confirm that the voting rule did significantly affect choices, and that the provision of information also significantly affected choices. The use of the CC voting rule is a significant determinant of All Others being selected first, although the effect on Rock and R&B as *individual* categories is split and not statistically significant. The provision of information about the CC voting rule has a significant effect on both Rock or All Others being selected first. We estimate significant demographic effects on preferences, as one might *a priori* expect. For example, the racial dummy variable picks up sharply contrasting preferences for R&B over Rock, explaining why the effect of the voting rule on All Others gets muted. As we switch from CC to RD the first-place

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<sup>12</sup> This aggregation is natural given the raw responses tabulated in Table 3, since the categories Rock and R&B accounted for the vast bulk of the preferences, consistent with our *a priori* use of the term “Simple.” In fact, in one treatment, CCI, we did not observe any subject picking Jazz, Classic, or Country & Western as their first choice. Our qualitative conclusions are formally the same if we modeling every category separately, but the estimates of the underlying multinomial model are not numerically robust.

votes for All Others increases significantly by 16 percentage points, but Blacks switch from R&B and others switch from Rock. So the joint effect on R&B and Rock is roughly 16 ( $= 6.4 + 9.4$ ) percentage points as it has to be, but is not statistically significant. Hence it is valuable to be able to control for sample differences across treatments using this statistical specification.

Turning to the Diverse preferences, Table 6 reports estimates derived from a similar multinomial logit model. In this case, as we see from Table 3, there was much more spread in the categories receiving first preference. Hence we only need to aggregate Rap and Country&Western, perhaps for the first and only time, into an All Others category. In this case we find no statistically significant evidence that the choice of voting rule, or the provision of information about the properties of the CC voting rule, had any effect on stated preferences. For example, the raw results in Panel B of Table 3 indicate that the chance of the Classics category being selected as the top preference dropped by 22 percentage points with the use of the CC institution. The estimates from the statistical model in Panel B of Table 6 indicate that only 14 percentage points of this drop can be attributed to the pure effect of the institution once we allow for the other experimental design factors and differences in sample characteristics, and that the 95% confidence interval for this effect is between -45 percentage points and +18 percentage points. Thus the statistical analysis strengthens the qualitative conclusion drawn from the non-parametric Fisher test.

We therefore conclude from the statistical analysis that the use of the CC institution *does* significantly affect behavior with Simple preferences, and that the use of the CC institution does *not* significantly affect behavior with Diverse preferences. The effects of the information treatment are *only* statistically significant in the experiments with Simple preferences. The provision of information on the workings of the voting rule only appears to affect behavior when subjects are in an environment in which the preference structures are simple enough allow them to *think* that they can successfully manipulate their revealed preferences.

## 5. Conclusions

Our main hypothesis is valid when one evaluates it in a domain of “diverse” preferences, but it is not generally valid under “simple” preferences. Our results therefore provide some initial support for the claim that voting behavior will tend to collapse to truth-telling when the computational complexity of mis-representation is high enough. The most natural extension of our approach is to consider alternative voting rules to the CC rule: Levin and Nalebuff [1995] review a rich menu. One can also examine the issue of eliciting truthful rankings over an entire set, rather than just the distinguished element, using a variant of our control experiment.

At a methodological level we have shown how one can evaluate alternative voting rules operating on homegrown preferences rather than experimenter-induced preferences. There may be some advantages to using induced preferences in future work that complements our approach, in order to gain more control over the difficulty of the misrepresentation task.

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**Table 1: Musical Categories and Individual Compact Discs**

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**Category A: Jazz/Easy Listening**

- (1) Najee, "Share My World"
- (2) Kenny G, "Breathless"
- (3) Art Porter, "Undercover"
- (4) Russ Freeman & the Rippingtons, "Sahara"
- (5) Tony Bennet, "Unplugged"
- (6) George Howard, "A Home Far Away"
- (7) Enigma 2, "The Cross of Change"
- (8) Billy Joe Walker, "Life is Good"
- (9) Barry Manilow, "Singing in the Big Bands"
- (10) Nat King Cole, "The Greatest Hits"

**Category B: Classical**

- (1) John Williams & the Boston Pops Orchestra, "It Don't Mean a Thing if it ain't got that Swing"
- (2) Vivaldi, "The 4 Seasons" Gil Shattam Orpheus: Fritz Kreisler.
- (3) Mahler, Symphony #5. The New York Philharmonic: Leonard Bernstein.
- (4) Yo Yo Ma, The New York Album. Baltimore Symphony Orchestra: David Zinman.
- (5) Handel, "Messiah" Atlanta Symphony Orchestra & Chamber Chorus: Robert Shaw.
- (6) Cecilia Bartoli, "Mozart Portraits" Vienna Chamber Orchestra: György Fischer.
- (7) Van Clyburn in Moscow. Brahms Rachmaninoff. Moscow Philharmonic Orchestra: Kiril Konorashin.
- (8) Kiri, "Her Greatest Hits Live" London Symphony Orchestra: Steven Barlow.
- (9) Tchaikovsky, "Nutcracker" London Symphony Orchestra: Sir Charles Mackerras.
- (10) The Best of Wolfgang Amadeus Mozart. Academy of St. Martin-in-the-fields: Neville Marriner.

**Category C: Heavy Metal**

- (1) Pantera, "Far Beyond Driven"
- (2) Queensryche, "Promised Land"
- (3) Magadeth, "Youthanasia"
- (4) Motley Crüe, "Motley Crue" (featuring Hooligan's Holiday)
- (5) Mother Tongue "Mother Tongue"
- (6) Obituary, "World Demise"
- (7) Jackyl, "Push Comes to Shove"
- (8) Alice in Chains, "Jar of Flies"
- (9) Alice Cooper, "The Last Temptation"
- (10) Cinderella, "Still Climbing"

**Category D: Rap**

- (1) Pete Rock and CL Smooth, "The Main Ingredient"
- (2) Lighter Shade of Brown, "Layin in the Cut"
- (3) Craig Mack, "Project: Funk Da World"
- (4) Ghetto Mafia, "Draw the Line"
- (5) Common Sense, "Resurrection"
- (6) Stevie B, "Funky Melody"
- (7) Salt-n-Pepa, "Very Necessary"
- (8) j. Little, "Puttin' it Down"
- (9) Celly Gel, "Heat 4 Yo Azz"
- (10) Hammer, "The Funky Headhunter"

**Category E: Country and Western**

- (1) Garth Brooks, "In Pieces"
  - (2) George Ducas, "George Ducas"
  - (3) Shenandoah, "In the Vicinity of the Hearth"
  - (4) Chris Ledoux, "Haywire"
  - (5) Willie Nelson, "Healing Hands of Time"
  - (6) Vince Gill, "When Love Finds You"
  - (7) Pam Tillis, "Sweetheart's Dance"
  - (8) Noah Gordon, "I Need a Break"
  - (9) Rodney Crowell, "Let the Picture Paint Itself"
  - (10) Ricky Lynn Gregg, "Get a Little Closer"
-

**Table 2: Experimental Design**

Experiment ID <sup>†</sup>	Treatment			Sample
	Preference Profile?	Voting Rule?	Detailed Information?	
(S)CCN	Simple	Condorcet Consistent	No	13
(S)CCI	Simple	Condorcet Consistent	Yes	18
(S)RD	Simple	Random Dictator	No	31
(D)CCN	Diverse	Condorcet Consistent	No	13
(D)CCI	Diverse	Condorcet Consistent	Yes	17
(D)RD	Diverse	Random Dictator	No	19

† When the context makes the use of simple or diverse preferences clear, we use the generic labels CCN, CCI or RD. The label CC refers below to the pooled responses from CCN and CCI.

**Table 3: Percentage of First Votes***A. Simple Preferences*

Category	RD	CCN	CCI	CC (combined)
Jazz	0.0	7.7	0.0	3.2
Classic	22.6	0.0	0.0	0.0
R&B	19.3	15.4	33.3	25.8
Rock	45.2	69.2	66.7	67.8
Country & Western	12.9	7.7	0	3.2
Total	100%	100%	100%	100%

Legend: RD = Random Dictator, CCN = Condorcet-Consistent without information, CCI = Condorcet-Consistent with information, CC aggregates CCN and CCI.

*B. Diverse Preferences*

Category	RD	CCN	CCI	CC (combined)
Jazz	21.0	30.8	41.2	36.7
Classic	42.1	23.1	17.7	20.0
Heavy Metal	21.1	15.4	29.4	23.3
Rap	5.3	15.4	0.0	6.7
Country & Western	10.5	15.4	11.8	13.3
Total	100%	100%	100%	100%

*C. P-values for Fisher's Exact Test*

Institutions to compare/Profile	<i>p</i> -value	
	Simple	Diverse
RD vs. CC	0.009	0.558
RD vs. CCN	0.151	0.723
RD vs. CCI	0.034	0.404
All categories	0.044	0.605

**Table 4: Percentage of Votes at all Ranks**

Simple preferences treatment

Category “All Others” aggregates Jazz, Classical, and Country &amp; Western

Category	RD	CCN	CCI	CC (combined)
<b><i>A. First Preference</i></b>				
R&B	19.3	15.4	33.3	25.8
Rock	45.2	69.2	66.7	67.8
All Others	35.5	15.4	0	6.4
<b><i>B. Second Preference</i></b>				
R&B	22.6	38.5	27.8	32.3
Rock	25.8	23.1	11.1	16.1
All Others	51.6	38.4	61.1	51.6
<b><i>C. Third Preference</i></b>				
R&B	19.3	7.7	11.1	9.7
Rock	16.1	0	16.7	9.7
All Others	65.6	92.3	72.2	80.6
<b><i>D. Fourth Preference</i></b>				
R&B	22.6	23.1	22.2	22.6
Rock	6.4	7.7	5.6	6.5
All Others	71.0	69.2	72.2	70.9
<b><i>E. Fifth Preference</i></b>				
R&B	16.1	15.4	5.6	9.7
Rock	6.5	0	0	0
All Others	77.4	84.6	94.4	90.3

**Table 5: Statistical Model of Responses with Simple Preferences**

Marginal effects from multinomial logit model of a particular category being the first choice.  
Robust standard errors.

Variable	Estimate	Standard Error	p-value	95% Confidence Interval	
<i>A. Probability that "R&amp;B" is ranked first</i>					
CC	0.064	0.11	0.57	-0.16	0.29
INFO	-0.033	0.088	0.71	-0.205	0.14
FEMALE	-0.0068	0.072	0.93	-0.15	0.14
RACE	0.86	0.041	<0.001	0.78	0.94
INCOME	-0.0034	0.0017	0.043	-0.0067	-0.0001
NHHD	0.26	0.16	0.11	-0.060	0.58
<i>B. Probability that "Rock" is ranked first</i>					
CC	0.094	0.12	0.44	-0.15	0.33
INFO	0.28	0.097	0.004	0.091	0.47
FEMALE	-0.011	0.102	0.92	-0.21	0.19
RACE	-0.63	0.053	<0.001	-0.74	-0.53
INCOME	0.003	0.0019	0.107	-0.0007	0.007
NHHD	-0.36	0.14	0.009	-0.63	-0.09
<i>C. Probability that "Other" is ranked first</i>					
CC	-0.16	0.071	0.026	-0.30	-0.019
INFO	-0.25	0.047	<0.001	-0.34	-0.16
FEMALE	0.017	0.094	0.85	-0.17	0.203
RACE	-0.23	0.046	<0.001	-0.32	-0.14
INCOME	0.0004	0.001	0.79	-0.0025	0.003
NHHD	0.102	0.12	0.38	-0.13	0.33

Legend: CC is a binary variable to identify the responses to the Condorcet Consistent voting rule; INFO is a binary variable to identify if additional information was provided about the properties of the voting rule; FEMALE is a binary dummy for sex; RACE is a binary variable to identify subjects that self-reported their race as Black or African-American; INCOME measures annual household income in thousands of dollars; and NHHD is a binary dummy for households with more than one member. "Other" includes Jazz, Classical, and Country & Western.

**Table 6: Statistical Model of Responses with Diverse Preferences**

Marginal effects from multinomial logit model of a particular category being the first choice.  
Robust standard errors.

Variable	Estimate	Standard Error	p-value	95% Confidence Interval	
<i>A. Probability that "Jazz" is ranked first</i>					
CC	0.053	0.17	0.75	-0.27	0.38
INFO	0.022	0.16	0.89	-0.29	0.33
FEMALE	0.43	0.16	0.007	0.121	0.74
RACE	-0.32	0.057	<0.001	-0.431	-0.206
INCOME	-0.003	0.0049	0.49	-0.013	0.006
NHHD	0.16	0.28	0.57	-0.39	0.717
<i>B. Probability that "Classical" is ranked first</i>					
CC	-0.14	0.16	0.39	-0.45	0.18
INFO	-0.072	0.16	0.66	-0.39	0.25
FEMALE	-0.09	0.14	0.51	-0.36	0.18
RACE	-0.31	0.062	<0.001	-0.43	-0.19
INCOME	-0.0018	0.004	0.69	-0.010	0.007
NHHD	-0.13	0.21	0.52	-0.55	0.28
<i>C. Probability that "Heavy Metal" is ranked first</i>					
CC	0.03	0.18	0.86	-0.32	0.38
INFO	0.05	0.19	0.78	-0.311	0.42
FEMALE	-0.307	0.066	<0.001	-0.44	-0.18
RACE	-0.24	0.054	<0.001	-0.35	-0.14
INCOME	-0.0008	0.003	0.78	-0.006	0.005
NHHD	0.18	0.22	0.42	-0.25	0.605
<i>D. Probability that "Rap" or "Country &amp; Western" is ranked first</i>					
CC	0.052	0.13	0.68	-0.196	0.299
INFO	-0.003	0.13	0.98	-0.25	0.24
FEMALE	-0.034	0.071	0.63	-0.174	0.105
RACE	0.87	0.043	<0.001	0.79	0.95
INCOME	0.0059	0.0027	0.026	0.0007	0.011
NHHD	-0.204	0.056	<0.001	-0.31	-0.094

Legend: CC is a binary variable to identify the responses to the Condorcet Consistent voting rule; INFO is a binary variable to identify if additional information was provided about the properties of the voting rule; FEMALE is a binary dummy for sex; RACE is a binary variable to identify subjects that self-reported their race as Black or African-American; INCOME measures annual household income in thousands of dollars; and NHHD is a binary dummy for households with more than one member.

## Appendix A: Experimental Instructions

The experiments were all conducted by hand, with a personal computer used to calculate the outcome in the CC voting experiments. The instructions are presented first for the Simple preference profiles and each of the three variants, and then the detailed definitions of musical categories for the two preference profiles are presented. The actual instructions had page breaks inserted, so that there was not too much material on any one page. The actual instructions were also in 12 point font.

### A.1 Random Dictator

#### WELCOME TO THE EXPERIMENT

ID \_\_\_\_\_

#### These are your instructions

This is an experiment in the economics of decision making. The instructions are simple and you will benefit by following them carefully. Funding for this experiment has been provided by Richland County government.

#### The Task

In this experiment we are going to create a committee in which you will vote for the allocation of a commodity. All votes will be written and will not be revealed to any other participant. The people you see in the room (with the exception of the experimenters) are all participants in this experiment. Do not show or discuss your vote with any other participant. The identification number on the top of the Voting Slip you find enclosed in your envelope will be used to identify subjects at the end of the experiment.

#### The Issue

The commodity you are voting for is a music compact disc (CD). On your Voting Slip there are five different categories of music. Within each category there are ten CDs by various artists. From these five categories of music one will be chosen for the group. The category which is chosen will depend on the result of the voting procedure which is described below. Each person in the experiment will receive one CD from the chosen category. Each person will be able to choose which one of the ten CDs from the chosen category he or she would like to receive. You may choose a CD that someone else chooses since we can obtain copies of the same CD.

#### How Will the Music Category be Chosen?

On the Voting Slip each person is asked to rank the five categories by assigning a "1" to the most preferred category, a "2" to the second most preferred category, and so on. The least preferred category should be assigned a "5".

After everyone has ranked the 5 categories of music, we will collect all of the Voting Slips and have one of you draw a number from the urn at the front of the room. The urn contains N cards numbered 1 - N. These numbers correspond to your ID numbers. There is one card in the urn for each of you. We will then find the Voting Slip with the corresponding ID number. The category of music which is ranked first by the person with this ID number will determine the category of music from which everyone in the group will receive a CD. That is, if the person whose ID is chosen ranked Category B first, everyone in the group would receive the CD of his/her choice from the Classical music category. If Category D was ranked first, everyone in the group would receive a CD from the Jazz and Easy Listening category.

With this type of voting rule you only affect the allocation of CDs if your ID number is drawn from the urn. That is, if your ID number is not drawn, you do not determine the category from which everyone in the group will receive a CD. If your ID number is drawn everyone in the group, including you, will receive a CD from the category which you ranked first. Therefore, you can do no better than to state the ranking of CDs you most prefer. There are N people in today's experiment, so there is a 1-in-N chance that your ID number will be chosen.

Remember that only one of the categories will be chosen, and the group will vote to determine that category.

## When Do You Get the CD?

At the end of the experiment we will give each person a notarized IOU stating that we will give you the CD you have chosen anytime after **three working days from today**. Your CD can be picked up in the office of XXX at the University of South Carolina, College of Business Administration, Department of Economics. XXX is in the Economics Department, and her office number is XXX. Her office hours are Monday - Friday, 9:00 a.m. - 4:00 p.m..

## A Trial Experiment for Candy!

Before we begin the actual experiment, we will run a "trial experiment" in order to demonstrate the voting procedures described above. The good you will be asked to vote for is a bag of candies.

A Trial Voting Slip is included in your instruction packet. This is the green sheet of paper in your packet. On your Trial Voting Slip there are three different kinds of candy. From these three kinds of candy one will be chosen for the group. The category which is chosen will depend on the result of the voting procedure which was described above. Each person is asked to rank the three categories of candy by assigning a "1" to the most preferred category, a "2" to the second most preferred category, and a "3" to the least preferred category. Within each category, please circle the one candy in that category you most prefer. When everyone has ranked the three categories, we will collect the Trial Voting Slips.

[NEXT 2 PARAGRAPHS JUST FOR RANDOM DICTATOR]

To determine which kind of candy the group prefers, we will have one of you draw a number from the urn at the front of the room. This urn contains N cards numbered 1 - N. We will match this number with the corresponding ID number on the Trial Voting Slips. The category of candy which is ranked first on this Trial Voting Slip will determine the **category** of from which everyone in the group will be able to choose a kind of candy. The kind of candy each person will receive will be the kind which is circled on the Trial Voting Slip for the category which was chosen. You cannot change your mind about which kind of candy you would like to receive after the category has been chosen. Everyone will receive the candy immediately after the Trial Voting Experiment.

We will not ask the person whose ID is chosen to identify himself to the group, and the experimenters will not know the name of the person whose ID is chosen. This is true for both parts of the experiment. Also, the ID numbers were randomly assigned; therefore, no one will know your ID based on where you are seated in the room.

Let's begin the trial experiment.

## Now for the Actual Experiment

A Voting Slip is included in your instruction packet. This is the yellow sheet of paper in your packet. Please make sure that you write the number that is on your ID card in the space provided in the upper right hand corner of the Voting Slip. Also, within each category circle the number of the CD you would like to receive if that category is chosen. You will not be able to change your mind after the experiment. If you do not circle a number in a category, and that category is chosen, you will not receive a CD.

Let's begin the experiment.

## A.2 Condorcet-Consistent

### WELCOME TO THE EXPERIMENT These are your instructions

ID \_\_\_\_\_

This is an experiment in the economics of decision making. The instructions are simple and you will benefit by following them carefully. Funding for this experiment has been provided by Richland County government.

### The Task

[SAME TEXT]

## The Issue

[SAME TEXT]

### How Will the Music Category be Chosen?

On the Voting Slip each person is asked to rank the five categories by assigning a "1" to the most preferred category, a "2" to the second most preferred category, and so on. The least preferred category should be assigned a "5".

To determine which category the group prefers, we will find the category that a majority of people in the group prefers to all of the other categories. This means we will compare all of the categories two at a time to see if there is one which beats all of the others in pairwise comparisons. If there is no category which a majority of the group prefers to all of the others, we will determine which ranking of the categories would most likely receive a majority of the voters' support. We will then select the category which is ranked the highest.

After everyone has ranked the 5 categories of music, we will determine the group ranking. The category which is chosen using this voting rule will determine the category from which everyone in the group will be able to choose a CD. That is, if category B is chosen, everyone in the group will choose a CD from the Classical music category. If category A is chosen, everyone in the group may choose a CD from the Rock music category, and so forth.

Remember that only one of the categories will be chosen, and the group will vote to determine that category.

### When Do You Get the CD?

[SAME TEXT]

### A Trial Experiment for Candy!

[SAME INTRODUCTORY TEXT]

To determine which category of candy the group prefers, we will find the category that a majority of the group prefers to all of the other kinds. If there is no category which a majority of the group prefers to all of the others, we will determine which ranking of the candies would most likely receive a majority of the voters' support. Each person in the group will be able to choose which one of the three kinds of candy in the most preferred category he/she will receive. This will be the candy which is circled on the Trial Voting Slip. You will not be able to change your mind after the category is chosen. Each person will receive his/her candy immediately after the Trial Voting Experiment.

Let's begin the trial experiment.

### Now for the Actual Experiment

[SAME TEXT]

### A.3 Condorcet-Consistent with Information

[SAME TEXT AS THE CONDORCET-CONSISTENT TREATMENT IN SECTION A.2, AND THEN NEW MATERIAL STARTING AT THE END OF THE SECTION ON **How Will the Music Category be Chosen?**]

To help you understand how the voting rule works we will go through two examples.

### A Simple Example of How the Voting Rule Works

Assume that there are 3 candidates for election: Beth, John, and Kevin. Also assume that there are 10 voters. The voters were asked to rank the candidates as described above. The table below reports the election results:

	Beth	John	Kevin
Beth	-	2	6
John	8	-	8
Kevin	4	2	-

By reading across the rows of the table, we can determine how many people prefer one candidate over each of the others. For example, in row one, 2 people prefer Beth to John, and 6 people prefer Beth to Kevin. In row two, 8 people prefer John to Beth, and 8 people prefer John to Kevin. In row three, 4 people prefer Kevin to Beth and 2 people prefer Kevin to John.

To determine the most preferred candidate, we look at all pairwise comparisons:

- If 2 people prefer Beth to John, and 8 people prefer John to Beth, then we conclude that a majority of the voters prefer John to Beth ( $J > B$ ).
- If 6 people prefer Beth to Kevin, and 4 people prefer Kevin to Beth, then a majority of the voters prefer Beth to Kevin ( $B > K$ ).
- If 8 people prefer John to Kevin and 2 people prefer Kevin to John, then a majority of the voters prefer John to Kevin ( $J > K$ ).

The group ranking which is implied by the numbers in the above table is  $J > B > K$ . We conclude that a majority of the voters would prefer John to Beth or Kevin.

In this first example the outcome was easy to determine because there was a candidate which beat all of the others in pairwise comparisons. If you look in row 2 of the table you will notice that more than half of the voters prefer John to either Beth or Kevin.

### A Tougher Example of How the Voting Rule Works

Now look at another example where the outcome is not as easy to determine. Again, assume that there are 3 candidates and 10 voters.

	Beth	John	Kevin
Beth	-	3	8
John	7	-	1
Kevin	2	9	-

- Here, 3 people prefer Beth to John and 7 people prefer John to Beth. John is preferred to Beth by a majority of the voters ( $J > B$ ).
- 8 people prefer Beth to Kevin, and 2 people prefer Kevin to Beth. Beth is preferred to Kevin by a majority of the voters ( $B > K$ ).
- 1 person prefers John to Kevin, and 9 people prefer Kevin to John. Kevin is preferred to John by a majority of the voters ( $K > J$ ).

Notice that John is preferred to Beth and Beth is preferred to Kevin, but Kevin is preferred to John. Therefore, we don't know who should come first, Beth or Kevin. The votes form a cycle.

In order to choose a winner we find the group ranking which is preferred by the largest possible majority. There are 6 different possible rankings which are possible when there are 3 candidates. For these 3 candidate the 6 possible rankings are:

- (1)  $B > J > K$
- (2)  $B > K > J$
- (3)  $J > K > B$
- (4)  $J > B > K$
- (5)  $K > J > B$
- (6)  $K > B > J$

We can determine how many voters would vote for each of the 6 rankings by adding up the votes in the table above. There can be a maximum of 20 votes for each of the 6 rankings. This is because there are 10 voters and 2 comparisons in each ranking. We can determine how many people would vote for each comparison in each ranking, and the ranking which receives the most votes is the one that the most voters would support.

In this example:

- 3 people prefer Beth to John, and 1 person prefers John to Kevin. Therefore, the first ranking is supported by 4 people.
- 8 people prefer Beth to Kevin, and 9 people prefer Kevin to John. Therefore, the second ranking is supported by 17 people.

By the same method we determine that:

- 3 people support the third ranking;
- 15 people support the fourth ranking;
- 16 people support the fifth ranking; and
- 5 people support the sixth ranking.

Therefore, the ranking which receives the most support is  $B > K > J$ .

### Summarizing

After everyone has ranked the 5 categories of music, we will determine the group ranking by finding the ranking of categories which is supported by the most voters. Because the method described above is a very tedious, we have programmed the computer at the front of the room to find this ranking for us. We will input each voter's ranking and the computer will calculate the number of votes received for each possible ranking of the music categories. There are five categories of music, so there are 120 possible rankings.

The category which is ranked first using this voting rule will determine the category from which everyone in the group will be able to choose a CD. That is, if category B is ranked first, everyone in the group will choose a CD from the Classical music category. If category A is ranked first, everyone in the group may choose a CD from the Rock music category, and so on.

Remember that only one of the categories will be chosen, and the group will vote to determine that category.

## A.4 The Categories

### Simple Preferences

TRIAL VOTING SLIP

ID \_\_\_\_\_

YOUR RANKING

Category A: chocolates

\_\_\_\_\_

- (1) Hershey's Chocolate Kisses

- (2) Reeses Peanut Butter Cups
- (3) Dove Milk Chocolate Miniatures

**Category B: hard candy** \_\_\_\_\_

- (1) Starlite mints
- (2) Jolly Rancher assorted candy
- (3) Butterscotch candy

**Category C: chewy candy** \_\_\_\_\_

- (1) Caramels
- (2) Gummy bears
- (3) Tootsie rolls

Remember to circle the number of the candy you most prefer in each category.

**VOTING SLIP**

ID \_\_\_\_\_

YOUR RANKING

**Category A: Jazz/Easy Listening** \_\_\_\_\_

- (1) Najee, "Share My World"
- (2) Kenny G, "Breathless"
- (3) Art Porter, "Undercover"
- (4) Russ Freeman & the Rippingtons, "Sahara"
- (5) Tony Bennet, "Unplugged"
- (6) George Howard, "A Home Far Away"
- (7) Enigma 2, "The Cross of Change"
- (8) Billy Joe Walker, "Life is Good"
- (9) Barry Manilow, "Singing in the Big Bands"
- (10) Nat King Cole, "The Greatest Hits"

**Category B: Classical** \_\_\_\_\_

- (1) Vivaldi, "The 4 Seasons" Gil Shattam Orpheus: Fritz Kreisler
- (2) Mahler, Symphony #5. The New York Philharmonic: Leonard Bernstein
- (3) Yo Yo Ma, The New York Album. Baltimore Symphony Orchestra: David Zinman
- (4) Handel, "Messiah" Atlanta Symphony Orchestra & Chamber Chorus: Robert Shaw
- (5) Cecilia Bartoli, "Mozart Portraits" Vienna Chamber Orchestra: György Fischer
- (6) Jim Clyburn in Moscow. Brahms Rachmaninoff. Moscow Philharmonic Orchestra: Kiril Konorashin
- (7) Kiri, "Her Greatest Hits Live" London Symphony Orchestra: Steven Barlow
- (8) Tchaikovsky, "Nutcracker" London Symphony Orchestra: Sir Charles Mackerras
- (9) The Best of Wolfgang Amadeus Mozart. Academy of St. Martin-In-The-Fields: Neville Marriner
- (10) John Williams & the Boston Pops Orchestra, "It Don't Mean a Thing if it ain't got that Swing"

**Category C: Rhythm and Blues** \_\_\_\_\_

- (1) Janet Jackson, "Janet"
- (2) Freddie Jackson, "Here it is"
- (3) C&C Music Factory, "Anything Goes"
- (4) Prince, "Come"
- (5) Toni Braxton, "Toni Braxton"
- (6) Boyz II Men, "II"
- (7) TLC, "CrazySexyCool"
- (8) Vanessa Williams, "The Sweetest Days"

- (9) Salt "n" Pepa, "Very Necessary"
- (10) Barry White, "The Icon is Love"

**Category D: Rock/Pop** \_\_\_\_\_

- (1) Hootie and the Blowfish, "Cracked Rear View"
- (2) Nirvana, "Unplugged in New York"
- (3) John Secada, "Heart Soul & A Voice"
- (4) Bonnie Raitt, "Longing in Their Hearts"
- (5) Jimi Hendrix, "Woodstock"
- (6) Cranberries, "No Need to Argue"
- (7) Michael Bolton, "The One Thing"
- (8) Mariah Carey, "Music Box"
- (9) Eric Clapton, "From the Cradle"
- (10) REM, "Monster"

**Category E: Country and Western** \_\_\_\_\_

- (1) Garth Brooks, "In Pieces"
- (2) George Ducas, "George Ducas"
- (3) Shenandoah, "In the Vicinity of the Hearth"
- (4) Chris Ledoux, "Haywire"
- (5) Willie Nelson, "Healing Hands of Time"
- (6) Vince Gill, "When Love Finds You"
- (7) Pam Tillis, "Sweetheart's Dance"
- (8) Noah Gordon, "I Need a Break"
- (9) Rodney Crowell, "Let the Picture Paint Itself"
- (10) Ricky Lynn Gregg, "Get a Little Closer"

Remember to circle the number of the CD you most prefer in each category.

**Diverse Preferences**

**VOTING SLIP**

ID \_\_\_\_\_

YOUR RANKING

**Category A: Jazz/Easy Listening** \_\_\_\_\_

- (1) Najee, "Share My World"
- (2) Kenny G, "Breathless"
- (3) Art Porter, "Undercover"
- (4) Russ Freeman & the Rippingtons, "Sahara"
- (5) Tony Bennet, "Unplugged"
- (6) George Howard, "A Home Far Away"
- (7) Enigma 2, "The Cross of Change"
- (8) Billy Joe Walker, "Life is Good"
- (9) Barry Manilow, "Singing in the Big Bands"
- (10) Nat King Cole, "The Greatest Hits"

**Category B: Classical** \_\_\_\_\_

- (1) John Williams & the Boston Pops Orchestra, "It Don't Mean a Thing if it ain't got that Swing"
- (2) Vivaldi, "The 4 Seasons" Gil Shattam Orpheus: Fritz Kreisler.
- (3) Mahler, Symphony #5. The New York Philharmonic: Leonard Bernstein.
- (4) Yo Yo Ma, The New York Album. Baltimore Symphony Orchestra: David Zinman.
- (5) Handel, "Messiah" Atlanta Symphony Orchestra & Chamber Chorus: Robert Shaw.

- |   |                   |
|---|-------------------|
| (6) Cecilia Bartoli, "Mozart Portraits" Vienna Chamber Orchestra: György Fischer. |                   |
| (7) Van Clyburn in Moscow. Brahms Rachmaninoff. Moscow Philharmonic Orchestra.    | Kiril Konorashin. |
| (8) Kiri, "Her Greatest Hits Live" London Symphony Orchestra: Steven Barlow.      |                   |
| (9) Tchaikovsky, "Nutcracker" London Symphony Orchestra: Sir Charles Mackerras.   |                   |
| (10) The best of Wolfgang Amadeus Mozart. Academy of St. Martin-in-the-fields:    | Neville Marriner. |

**Category C: Heavy Metal** \_\_\_\_\_

- (1) Pantera, "Far Beyond Driven"
- (2) Queensryche, "Promised Land"
- (3) Magadeth, "Youthanasia"
- (4) Motley Crue, "Motley Crue" (featuring Hooligan's Holiday)
- (5) Mother Tongue "Mother Tongue"
- (6) Obituary, "World Demise"
- (7) Jackyl, "Push Comes to Shove"
- (8) Alice in Chains, "Jar of Flies"
- (9) Alice Cooper, "The Last Temptation"
- (10) Cinderella, "Still Climbing"

**Category D: Rap** \_\_\_\_\_

- (1) Pete Rock and CL Smooth, "The Main Ingredient"
- (2) Lighter Shade of Brown, "Layin in the Cut"
- (3) Craig Mack, "Project: Funk Da World"
- (4) Ghetto Mafia, "Draw the Line"
- (5) Common Sense, "Resurrection"
- (6) Stevie B, "Funky Melody"
- (7) Salt-n-Pepa, "Very Necessary"
- (8) j. Little, "Puttin' it Down"
- (9) Celly Gel, "Heat 4 Yo Azz"
- (10) Hammer, "The Funky Headhunter"

**Category E: Country and Western** \_\_\_\_\_

- (1) Garth Brooks, "In Pieces"
- (2) George Ducas, "George Ducas"
- (3) Shenandoah, "In the Vicinity of the Hearth"
- (4) Chris Ledoux, "Haywire"
- (5) Willie Nelson, "Healing Hands of Time"
- (6) Vince Gill, "When Love Finds You"
- (7) Pam Tillis, "Sweetheart's Dance"
- (8) Noah Gordon, "I Need a Break"
- (9) Rodney Crowell, "Let the Picture Paint Itself"
- (10) Ricky Lynn Gregg, "Get a Little Closer"

Remember to circle the number of the CD you most prefer in each category.

**A.5 Socioeconomic Characteristics**

**Introduction**

ID # \_\_\_\_\_

In this initial survey most of the questions ask your attitudes and opinions. There are no right or wrong answers, and your responses are confidential. Please think carefully about each question and give your best answers. Because we are asking only a few people to answer these questions and participate in the experiment, your completing the survey is extremely important. The first few questions are somewhat personal in nature but help us know that the



9. What is the highest level of *education* you have completed? (Circle only one.)

- 01 Less than 9th grade
- 02 Some high school, but did not graduate
- 03 High school with a diploma
- 04 Some college, but no degree
- 05 College with a degree
- 06 Graduate degree

10. What is your *marital status*?

- 01 Never married
- 02 Currently married, with spouse present
- 03 Currently married, but no spouse present
- 04 Widowed
- 05 Divorced

11. Are you currently *employed*?

- 01 Full Time
- 02 Part-time - Are you looking for full time work? 01 Yes 02 No
- 03 No - Are you looking for work? 01 Yes 02 No

12. If you are currently employed, is your average travel time to work less than 15 minutes?

- 01 Yes 02 No 03 Not Applicable

13. Are you registered to vote?

- 01 Yes - In which of the last elections did you vote? (Circle all that apply)
  - 01 Federal
  - 02 State
  - 03 County?
- 02 No

14. Are you generally satisfied or generally dissatisfied with the outcome of the most recent County election? 01 generally satisfied 02 generally dissatisfied

15. Do you belong to a Compact Disk Club?

- 01 Yes

Which one(s)? \_\_\_\_\_

- 02 No