O P E R A T I O N S R E S E A R C H A N D D E C I S I O N S
No. 3–4 2010

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COGNITIVE EFFORT OF VOTERS UNDER THREE DIFFERENT VOTING METHODS – AN EXPERIMENTAL STUDY

This paper deals with the comparison of the processes of decision making by voters under the approval voting rule (in two variants: classical and categorization) and majority rule. Under the majority rule, each voter chooses a single alternative. Under approval voting, they can vote for as many alternatives as they wish. Under the categorization method, they divide alternatives into three groups: approvable, not approvable and neutral. We conducted a process tracing experiment with respondents choosing an office manager from 13 candidates characterized by 14 attributes. The process of collecting information on candidates from the data presented on the screen was observed by a coordinator. For this experiment, the concept of cognitive effort was defined as the quantity of information gathered. The cognitive effort made under the three methods was compared. The highest cognitive effort was observed in the case of the categorization method and the lowest in the case of approval voting.

Keywords: *approval voting, majority rule, cognitive effort, process tracing experiment*

1. Introduction

It is a well known phenomenon that different voting methods may lead to different results and elicit different winning alternatives (see: [8], [9], [3]). Not only theoretical research but also empirical studies on representative samples of real voters were con-

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ducted by LASLIER and VAN DER STRAETEN in France [4], [5] and by PRZYBYSZEWSKI and SOSNOWSKA in Poland [11]. The differences between the results can be attributed to the very logic of the methods and their mathematical properties. However, contemporary psychological research on decision making suggests that the way in which preferences are formed and elicited may influence their structure. In 2006, Steven Brams, the co-inventor of approval voting, during discussion on the empirical evidence from the cited survey studies, came up with the idea of studying different thinking processes underlying voters' decisions according to different voting rules.

The paper deals with the comparison of processes of decision making by voters under approval voting (in two variants: classical and categorization) and majority rule. Under the majority rule (MAJ), each voter chooses a single best alternative from the list of alternatives. The alternative which is chosen most frequently – i.e. by the largest number of voters – wins. This is the most popular method of voting, widely used in many types of elections, national elections in particular. The method follows the "one man – one vote" principle. It is easy to understand but may thwart popular second best candidates. Approval voting (APP) was introduced by BRAMS AND FISHBURN [1]. Voters choose the alternatives of which they approve. Each voter may choose none, one, two or more alternatives. For each alternative, the number of voters who have chosen this alternative is computed, and the alternative with the highest score wins. This method is used by many scientific societies and the Security Council of the United Nations (in 1996, to narrow the list of potential candidates for the Secretary General). Voters may vote for more than one candidate, thus they may be able to express their opinions more clearly in the cases where they treat some candidates identically or almost identically.

Under the categorization method (CAT), each voter divides candidates into 3 groups – approvable, not approvable and neutral. An approvable candidate receives one point, strictly not approvable – minus one and neutral – zero. The sum of the points obtained by each candidate is computed. The candidate with the highest score wins. This method is a variant of approval voting, where candidates are divided into two groups – approvable and not approvable, and lack of approval is indicated by zero points. Under the categorization method, voters may use different levels of disapproval. Strictly not approvable candidates are singled out. This method is more complicated than the majority rule and approval voting, but voters gain the opportunity to express their opinion more precisely. We use the term "categorization method" to emphasize the psychological process of categorization associated with the voting method. This voting method is also known as "combined approval with disapproval voting (CAV)" [2], but this term seems lengthy. Disapproval voting is used as the name for a group of voting methods where disapproved alternatives are selected.

In this paper, we describe an experiment designed to compare the psychological aspects of the decision making process associated with the cognitive effort used under the three voting methods presented above. The methodology of the experiment was imported from psychological research.

Human decision processes have also been studied intensively by psychologists. In rational choice theory, the point of interest is the outcome of a voting procedure. However, in psychological research the focus is on the process of preference construction and choice making. From this perspective, choice consists of a set or a sequence of mental operations and motivational processes. The most prominent concepts are: differentiation-consolidation theory [14], confirmation of initial dominance structure [7], predecisional distortion of information [13].

Some of these processes are driven by contradictory motives. As posed by theorists who conduct research within the accuracy–effort framework [8], [13], decision makers try to make decisions that are both easy to reach (require little effort) and at the same time accurate enough. Solving this conflict leads to differences between the numbers of attributes processed, differences between the number of alternatives taken into account and sometimes to some distortions in the way that the data is perceived and interpreted. Obviously, the importance of the decision is a factor but also the procedure may cause differences in information processing.

Voting methods differ in the task that a voter is to fulfil. Majority rule requires the choice of a single, "best" alternative. On the other hand, approval methods require the voter to categorize the alternatives into two ("approved" and "other") or three ("approved", "disapproved" and "other") categories.

However, from the perspective of "cognitive misers" who avoid cognitive effort, approval voting can be perceived as much more difficult and time consuming than the majority voting rule, since under approval voting a voter needs to look through the entire list of candidates, whereas under majority voting a voter might stop at the first candidate on the list who is sufficiently good, using a simple satisfying heuristic [13]. The advantage coming from the possibility of expressing one's opinion better is balanced by the disadvantage of the additional time and effort needed, i.e. there is a trade-off between accuracy and effort.

In the paper, the authors report on an experiment on collecting information for decision making under the three voting methods. For the needs of this experiment, the concept of cognitive effort was defined as the quantity of information collected during the psychological process. The cognitive effort made under all three methods was compared. The highest cognitive effort was observed in the case of the categorization method and the lowest one in the case of approval voting. In section 2, we describe the experiment and the results are presented in section 3. The conclusions are included in section 4.

2. Experiment

The aim of the experiment was to find differences in the processes of decision making under different voting rules: majority rule, approval voting and the categoriza-

tion method. We compared the cognitive effort made under each method. By the cognitive effort we mean the quantity of actions undertaken in order to acquire the information necessary for decision making. A precise definition of cognitive effort used in this paper results from the experiment and will be formulated below. We formulate a hypothesis concerning the cognitive effort made under the voting methods studied.

H1: The cognitive effort which voters put into searching and integrating the information on alternatives is different for the three voting methods. One might say that H1 is obvious, but we aim to find arguments for the thesis which are different from mere intuitive thinking. One formal argument could be obtained from computing the minimal number of comparisons of pairs of alternatives necessary to cast one's vote under each voting method. This, however, is of little use when applied to real-life voters, because of abundant empirical evidence (for a review of different strategies see [10]) that people do not make pairwise comparisons when choosing between more than two candidates. The method of comparing pairs of alternatives may be useful in decision support methods. In this study, we analyze the cognitive process of collecting information about alternatives. Moreover, we obtained the result that the cognitive effort invested by subjects participating in majority voting was higher than in the approval voting group, while the conclusions offered by the number of pairwise comparisons indicate that it should be otherwise (in the case of standard majority voting, $n - 1$ comparisons are necessary for n alternatives, which is less than the corresponding numbers for the other methods).

The experiment was conducted using a group of $N = 33$ undergraduate students of Warsaw School of Economics, a leading Polish economics university, in spring 2009. The students majored in quantitative methods. The experiment was run as a part of the tutorial classes accompanying a lecture course on social choice. The experiment was conducted in Polish. Subjects were randomly assigned to three independent groups $n_1 = 12$, $n_2 = 12$ and $n_3 = 9$ persons. The relatively small numbers of participants are typical of psychological methods based upon in-depth interviews and similar methods used in process tracing research. The method of analysis selected is suitable for small groups. To test the hypothesis, an experimental study was designed for process tracing. It consisted of the task of choosing under three voting methods. To avoid automatic responses referring to previously built dominance structures, a set of new alternatives, which the participants were not familiar with, was prepared.

The material – a list of alternatives and their attributes – was presented in the form of an information board/matrix (see Table 1). There were 13 candidates and 14 attributes, so that the matrix had 13 rows and 14 columns. Information on the candidates was given in rows, on attributes – in columns. The participants were informed that their task would be to vote for anonymous candidates applying for the position of dean's office manager using data from the information matrix. They were asked to learn as much information about the alternatives as they needed to be ready to vote.

Table 1. The information matrix as presented to the subjects

A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q
	No.	Age	Gender	Qualifi-cation	English	Russian	Other	Professional experience	Avail-ability	Communication skills (0–5)	Reaction to stress (0–5)	Organizational skills (0–5)	Ability to work in a team (0–5)	Leadership skills (0–5)	Dealing with new challenge (0–5)
1															
2	1														
3	2														
4	3														
5	4														
6	5														
6	6														
8	7														
9	8														
10	9														
11	10														
12	11														
13	12														
14	13														

Each candidate was described by a sequence of 14 characteristics presented in the form of a description or by a figure on a scale. Gender, age, education, foreign languages spoken, professional experience, availability and specifications of other important characteristics were presented by description. Communication skills, coping with stress, organizational skills, ability to work in a team, leadership skills, and openness to new challenges were presented by figures on a scale of 0–5. The subjects were informed that the candidates received these points during psychological tests. The subjects were divided into three independent groups. They were informed that they are members of a group which was making its group decision by a strictly specified method of voting. The first group (consisting of 12 people, one of whom was removed due to technical problems) was to use the majority voting method. The second group (12 people) was to use approval voting and the third one (9 people) – the categorization method. The subjects did not contact each other. The groups were formed by means of random assignment.

The information matrix was displayed on a computer screen in such a way that only the numbers of the candidates and the labels of the attributes were visible. The participants had to click either on a cell, row or column of the matrix to obtain the information they needed. Thus each trial consisted of a sequence of the following actions:

- opening a cell (single attribute of an alternative)
- opening a row (all the attributes of a single alternative)
- opening a column (a particular attribute for all the alternatives)

All the actions taken by subjects were observed and recorded by the coordinator. Subjects were allowed to make notes on a sheet of paper. When a subject opened any section of the information matrix, the previous one was automatically closed, which was necessary to record the sequence of information processing. However, the sections could be reopened any number of times. This method was designed to mimic the naturalistic situation of data gathering, which is usually sequential. Moreover, it prevented information overload (as the possible number of pieces of data far exceeded the capacity of short-term memory, which is assumed to be 7 ± 2 "chunks" of information [6]. We followed the psychological assumption that the human brain always uses only a part of the information available at one time. Thus it was impossible that any of the participants was able to see and analyze the whole matrix of data. Individual differences with respect to short-time memory were randomized. Finally, each participant presented his/her choice(s) according to the given voting method. The average time of a session with one subject was 15 minutes and was similar for all the voting methods tested. The coordinator calculated the results of group decision making under each method and analyzed the sequences of openings to find specific properties of individual decision making under each method. In particular, hypothesis **H1** was investigated.

The results of the votes are presented in the following tables. In Table 2 the number of votes for each candidate is given. The categorization method is presented in

three columns: positive evaluation (Yes – approvable, 1 point for a vote), negative evaluation (No – not approvable, –1 point for a vote), and final evaluation (Yes – No, the difference between the numbers of positive and negative evaluations).

Table 2. Number of votes received by candidates under the majority, approval and categorization methods*

Candidate	MAJ	APP	CAT		
			YES votes	NO votes	Difference YES – NO
1	0	1	0	1	–1
2	0	0	1	5	–4
3	0	0	0	8	–8
4	1	0	0	3	–3
5	0	3	5	2	3
6	0	2	0	5	–5
7	4	4	7	0	7
8	2	4	2	2	0
9	2	5	6	0	6
10	0	1	4	0	4
11	1	3	6	0	6
12	1	3	4	1	3
13	0	2	1	4	–3
Mean	1	2.154	2.769	2.385	0.384

*MAJ – majority rule, APP – approval voting, CAT – categorization method.

Table 3. Order of candidates (from the best to the worst) under majority, approval and categorization voting

Order of candidates	Majority voting	Approval voting	Categorization method
1	Candidate 7	Candidate 9	Candidate 7
2	Candidates 8 and 9	Candidates 7 and 8	Candidates 9, 11
3	Candidates 4,11,12	Candidates 5, 11, 12	Candidates 10
4	Candidates 1, 2, 3, 5, 6, 10, 13	Candidates 6, 13	Candidates 5, 12
5		Candidates 1, 10	Candidates 8
6		Candidates 2, 3, 4	Candidate 1
7			Candidates 4, 13
8			Candidate 2
9			Candidate 6
10			Candidate 3

The ranking of the candidates, constructed on the basis of the results from Table 2, is presented in Table 3. In the first row, the candidate who won first place is indicated

(separately for each voting method), in the second row – the second placed candidates, etc. The ranking of the candidates varies according to voting rule. This is not a surprising result, but it may suggest that the respondents' decision processes were different and influenced by the voting rule.

Table 4. Number of candidates selected by individual voters under approval voting and the categorization method

Number of selected candidates	Number of voters		
	Approval voting	Categorization YES	Categorization NO
1	2	0	1
2	5	4	2
3	4	0	3
4	1	1	1
5		1	1
6		2	0
7		1	0
8			1
Mean	2.33	1.92	2.44

Under voting with multiple choices, the average number of choices significantly differed from 1. In Table, 4 the number of voters choosing a given number of candidates is presented. Most voters chose more than 1 candidate, thus they made use of the specific properties of voting with multiple choices.

3. Results

We use two simple and natural measures of the cognitive effort of a participant:

- M1 – the total number of moves (clicks); M1 = NK + NC + NR
- M2: the total number of cells seen; M2 = NK + 14NR + 13NC,

where NK, NR and NC denote the numbers of openings of cells, rows and columns, respectively. The number of opened rows and number of opened columns are also considered. Recall that when a row was opened, the respondents obtained all the information on a specific candidate, and when a column was opened, they obtained all the information on a specific attribute.

Both measures (M1 and M2) include repetitions, i.e. openings of the same row (column, cell) more than once or opening the row or column containing a cell which had been opened before. This does not influence the values of M1 and M2 drastically – such openings constitute about a tenth of the total number of moves. More importantly, we are strongly convinced that coming back to information already viewed also contributes to cognitive effort (see also the discussion in section 2).

The average levels of cognitive effort in each group are presented in Table 5, together with some extra data.

Table 5. Cognitive effort under majority rule (MAJ), approval voting (APP) and the categorization method (CAT)

Group	MAJ	APP	CAT
Number of subjects	11	12	9
Average number (pro subject)			
Openings (M1)	23.55	17.36	28.85
Cells seen (M2)	264.09	216	385.91
Rows opened	12.36	8.33	21.67
Columns opened	7.09	7.50	8.22

The means presented in Table 5 suggest some notable differences between the groups, both in absolute and relative terms. In particular, it is clearly visible that all the averages take their lowest values in the APP group (except for the number of columns opened) and the highest in the CAT group. To state whether some significant differences are indeed present and, in particular, to eliminate the possible effect of individual differences between subjects (like those of two subjects in the CAT group with 61 and 46 openings, no other subject exceeded 40), we apply non-parametric tests based on ranks. Recall also that such tests are particularly useful for dealing with small independent samples, as is the usual situation in experiments in cognitive psychology (see e.g. [10]). The independence of our samples follows from the construction of the experiment (disjoint groups of students, constructed randomly).

The Kruskal–Wallis test, applied to check whether the three groups MAJ, APP and CAT differ in their levels of cognitive effort **(H1),** supports this conjecture. When cognitive effort is measured by M1, i.e. the number of moves, the null hypothesis that the measures for all three groups come from the same distribution can be rejected at the 5% significance level ($\chi^2 = 6.23$, df = 2). For the M2 measure, we cannot definitely reject the null hypothesis ($\chi^2 = 4.90$, $p < 0.09$) but this result still offers some moderate support for the claim that the three groups also differ in this respect. A similar result is obtained for the number of rows opened $\chi^2 = 4.91$, $p < 0.09$), whereas for the numbers of columns, as suggested by the averages in Table 5, no significant differences are observed.

For pairwise comparisons between groups, the Mann–Whitney U test is applied. When the MAJ and APP groups are compared, the hypothesis that M1(MAJ) = M1(APP) can be rejected at the 5% significance level in favour of the hypothesis **H2**: M1(APP) < M1(MAJ) ($U = 34$, $p < 0.035$); other differences between these two groups are not significant ($U > 45$). Thus, the overall (M1) level of cognitive effort is significantly higher under majority voting than under approval voting, but its particu-

lar components (numbers of columns and rows opened) and the M2 measure of effort do not differ.

On the other hand, the observed differences in behaviour – in particular in the level of cognitive effort – between the APP and CAT groups are clearly statistically significant. The null hypotheses of no differences of parameters of M1, M2 and the number of rows opened between APP and CAT voters are rejected in favour of:

M1 (APP) < M1 (CAT) ($U = 26$, $p < 0.025$),
M2 (APP) < M2 (CAT) ($U = 24$, $p < 0.025$),
# of rows (APP) < # of rows (CAT) ($U = 25$, $p < 0.025$).

This means that subjects participating via the method of categorization voting clearly display significantly higher cognitive effort – both measured by the numbers of openings and of cells potentially seen – than those participating via the method of approval voting. In particular, those voting via the categorization method open significantly more rows – that is, view more full profiles of alternatives (candidates) than their counterparts using approval voting do*.

4. Conclusions

We hypothesized that the differences between various voting methods (even those as similar as approval voting and categorization) lead to different cognitive effort understood as the psychological process of collecting the information about alternatives needed to make a decision.

Our experimental data clearly confirm that voting methods do differ with respect to the mental operations performed by voters (**H1**). The cognitive effort of subjects voting under approval voting turns out to be significantly lower than that of subjects voting using categorization voting, regardless of the measure of effort used. More surprisingly, it was also lower than that of subjects voting under majority rule, and for the simplest measure this difference was statistically significant. We are strongly convinced that these differences should be studied more extensively and taken into account when choosing voting rules for particular purposes.

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*In fact, this effect is so strong that it is easy to observe without using any statistical inference. It is easily seen in table 5 that subjects voting under the CAT rule look at each candidate (row) approximately 1.66 times on average and those voting under APP – less than once.

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