Group consensus processes on cognitive bias tasks: A social decision scheme approach

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Ninety-six university students (66 males and 30 females) responded to four short problems associated with one of the following three cognitive biases: Representativeness, availability, and inappropriate diagnostic reasoning. The subjects either worked on the problems individually or as members of four-person groups, discussing the problems in order to reach group judgments. Social Decision Scheme Theory (Davis, 1973) was used to test six hypothesized group consensus processes. Results showed that the best fitting Social Decision Schemes varied across tasks, ranging from "truth-supported wins" (a process that leads groups to increased performance) to "bias wins" (a process that leads groups to a higher proportion of biased decisions).

Key words: social decision scheme (SDS), cognitive biases, group decision making, availability heuristic, representativeness heuristic, diagnostic reasoning.

Research on human judgment and decision making has shown that people often fail to reach normatively optimal standards (e.g. Edwards, 1968). When a judgment or decision involves uncertainty, Tversky and Kahneman (1973, 1980; Kahneman & Tversky, 1972; Kahneman, Slovic, & Tversky, 1982) have outlined several judgmental heuristics and inferential processes that people tend to use to reduce the complexity or amount of uncertainty involved in such judgments; processes that in some circumstances can lead to biased or sub-optimal decisions. These heuristics can be thought of as information processing "rules of thumb" or shortcuts that serve to make decisions easier—such as the tendency to focus on one type of information more than another. Despite the surprising pervasiveness of the heuristics that characterize certain task situations, the use of these mechanisms is far from universal (Ajzen, 1977; Ginosar & Trope, 1980) and does not always lead to biased judgments.

Research on these biasing heuristics has, to date, almost exclusively addressed *individual* decision makers. Little work has been done to investigate what social con-

sensus processes groups might use in similar situations, and to see whether such processes in turn alter the biasing of judgments at the group level. This focus is surprising because many organizations and institutions have recognized that individuals often lack the relevant information or expertise for a decision, and thus may assign the task to a panel or committee. The use of small groups for complex decision tasks is typically justified by the assumption that groups will use a decision process that will increase the probability of an optimal or unbiased decision, a process that results in the individual errors and biases "canceling each other out." However the validity of this assumption has not yet been thoroughly tested with regard to the judgmental heuristics noted above. Although there is considerable evidence (see Davis, 1969; Laughlin, Kerr, Davis, Half, & Marciniak, 1975; Davis, Laughlin, & Komorita, 1976) that groups often use consensus processes that lead to a high proportion of correct or optimal group decisions, and that in direct comparison groups can outperform individuals on a large variety of tasks, this superiority is not true for all tasks; and,

when the comparison takes into account the input effort, time per person, or other criteria, group performance may be inferior to individuals.

Individual-level factors such as ignoring important information, attending disproportionately to irrelevant information, and lacking sufficient information processing capacity are often cited as the sources of bias in personal judgments. On the other hand, groups, containing several members, may expand these limitations or may use a decision process that places more emphasis on the relevant or important information needed for an optimal solution. However, in view of interpersonal coordination demands and other social factors, it is not at all clear which consensus processes groups will use on these tasks, or how groups will perform on these decision tasks relative to the same normative standards used to judge individuals. Although little work has been done on judgmental heuristics in groups, research on other kinds of group task performance situations (e.g. Davis, 1969, 1982) suggests several plausible decision processes for consideration here. These possibilities can be summarized in several hypotheses about the process in which group members may combine and aggregate their information, and then decide on one alternative. These hypotheses or Social Decision Schemes can be verbally described, summarized mathematically to provide predictions of group performance, and then tested against observed group performance using Social Decision Scheme (SDS) Theory (Davis, 1973, 1982). The following section presents a brief summary of Social Decision Scheme Theory and several of the Social Decision Schemes applicable to the types of tasks under investigation here.

Social Decision Scheme Theory

Given a decision task with n mutually exclusive and exhaustive response alternatives, $A_1, A_2, \dots, A_n$, we assume that individual decisions are characterized by the

probability distribution, $p = (p_1, p_2, \dots, p_n)$. Similarly, the probability distribution over these n response alternatives for r -person groups can be characterized as $P = (P_1, P_2, \dots, P_n)$.

At the beginning of a discussion, individual group members may have different response preferences and the group members may disagree on the response alternative for the group. The r group members may array themselves over the n response alternatives in $m = (C(n+r-1; r) = (n+r-1)!/r!(n-1)!)!$ different ways. Each of these m arrays is referred to as a distinguishable distribution since the alternatives are distinguishable, but the individuals are not. The probability of the i -th distinguishable distribution occurring, π_i , $i = 1, 2, \dots, m$, may in some research applications be estimated directly from the data. The π_i can be *estimated directly* when the preferences of the individual group members prior to the group discussion are known, by counting the relative frequency, π_i , of the i -th array. However, in many laboratory situations as well as in most applied settings, the individual preferences of group members prior to discussion are not known. In these situations, the π_i must be *estimated indirectly* from the responses of a separate sample of individuals, using the estimates $p = (p_1, p_2, \dots, p_n)$ which are appropriately substituted in the multinomial,

$$\pi_i = \binom{r}{r_1, r_2, \dots, r_n} p_1^{r_1} p_2^{r_2} \dots p_n^{r_n}. \quad (1)$$

Assume that the social interaction in a group affects the group decision (selection of some A_j) and that this decision is a joint function of the initial member preferences and the social decision scheme (implicit aggregation rule) which translates these preferences into the group decision. Each social decision scheme is defined as an $m \times n$ stochastic matrix, D , with the entries being the conditional probabilities, $[d_{ij}]$, which give the probability of a group choosing the j -th response alternative given the i -th distinguishable distribution of ini-

Table 1
D matrices corresponding to social decision schemes for two decision alternatives
 (correct and biased or incorrect) and group size of four

Member preference distribution (Corr, Bias)	Social decision scheme											
	Proportional- ity		Equiprobability		Truth-wins		Truth-sup- wins, pro- portionality otherwise		Bias-wins		Bias-support wins, pro- portionality otherwise	
	Corr	Bias	Corr	Bias	Corr	Bias	Corr	Bias	Corr	Bias	Corr	Bias
(4, 0)	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
(3, 1)	0.75	0.25	0.50	0.50	1.00	0.00	1.00	0.00	0.00	1.00	0.75	0.25
(2, 2)	0.50	0.50	0.50	0.50	1.00	0.00	1.00	0.00	0.00	1.00	0.00	1.00
(1, 3)	0.25	0.75	0.50	0.50	1.00	0.00	0.25	0.75	0.00	1.00	0.00	1.00
(0, 4)	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00

tial member preferences. Thus each row of this matrix *D* is a statement of the probability of the group selecting each of the *n* alternatives for the *m* distinguishable distributions. As a final step, the individual probability distribution, *p*, may be related to the group probability distribution, *P*, by the expression

$$(P_1, P_2, \dots, P_n) = \pi \cdot D$$

$$= (\pi_1, \pi_2, \dots, \pi_m) \cdot \begin{bmatrix} d_{11} & d_{12} & \dots & d_{1n} \\ d_{21} & d_{22} & \dots & d_{2n} \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ d_{m1} & d_{m2} & \dots & d_{mn} \end{bmatrix}. \quad (2)$$

Several examples of social decision scheme matrices that are relevant to the group size and task under investigation here are given in Table 1. For examples of social decision schemes (or just simply referred to as schemes) that apply to other tasks, see Davis (1973, 1982). The *D* matrices shown in Table 1 are described below.

Proportionality (PROP)

This social decision scheme (SDS) hypothesizes that the probability of a group decision is the proportion of members advocating that alternative. This model does not consider any characteristics of the alternatives (like correctness), but only the

internal distribution of group members. If all group members advocate the same alternative, that alternative is adopted with probability *very near* 1.00. The rationale for this scheme is that the number of persuasive arguments supplied for an alternative should depend on the number of people advocating the alternative, so that an alternative with more advocates is more likely to be adopted by the group. This SDS ultimately predicts that the proportion of groups deciding on each alternative will be very close to the proportion of individuals choosing the alternative. This SDS may predict group decisions on judgmental heuristic tasks where neither the correct nor incorrect (biased) alternative is more compelling.

Equiprobability (EQUI)

Under this SDS, any alternative that is proposed has an equal chance of being adopted, as long as one group member advocates it. This type of social process arises when the problem is not clear, where each alternative proposed is considered equally. This is not a "random" process, because an alternative must be proposed by at least one member before it receives consideration. This model predicts overall probabilities of group decisions close but slightly less extreme than the probabilities observed among individ-

uals. If in fact these heuristic tasks do involve great uncertainty, this decision scheme should predict group outcomes.

Truth-Wins (TWIN)

The title of this social decision scheme (SDS) is taken from Steiner (1972) who described it in his discussion of disjunctive tasks. This SDS assumes that a correct answer is so persuasive and intuitively compelling that the group will adopt the correct alternative if (and only if) at least group member proposes it. The prediction of group outcomes from the truth-wins SDS produces an exaggeration of the correct alternative relative to the proportion of correct individuals. This hypothesis has been formalized in other models (Lorge & Solomon, 1955; Davis, 1969) and is often considered as an extreme "positive" upper bound of group performance. It is unlikely that this SDS will adequately describe the process for these heuristically-biased tasks since "truth" is not immediately obvious, and even professionals have been found to make errors on these types of tasks (Slovic, Fischhoff, & Lichtenstein, 1977).

Truth-Supported Wins, Proportionality Otherwise (TSWIN/PROP)

This is a variation of the truth-wins model presented above. This SDS hypothesizes that the correct answer is adopted by the group if a member advocates it and he or she is supported by at least one other group member. However, if less than two people advocate the correct alternative, this model hypothesizes that there is still some probability proportional to the number of members proposing the correct alternative that this correct alternative will be the group decision. This SDS hypothesizes that a Proportionality (see above) *subscheme* applies to the groups where truth is not supported, so that truth only sometimes wins (a subscheme is a rule that guides group decision when the primary scheme does not apply). A ra-

tionale for the truth-supported scheme is that the persuasive arguments for correctness may be insufficient in number or quality if only a single person proposes the answer, but that a second correct advocate is a sufficient increment to convince the group of the correct answer. This SDS also produces an exaggeration of the probability of groups being correct relative to individuals, but less so than the Truth-wins model. This model has been successful in predicting group outcomes on certain types of problem solving tasks (e.g., Laughlin et al., 1975), and could provide good predictions for the heuristic tasks under investigation here because two correct members compose half of the four member group used in this study, and on a task with a great deal of uncertainty (like these heuristics) those who are incorrect may be easily swayed to the correct alternative.

Bias-Wins (BWIN)

This SDS assumes that if at least one group member proposes a biased or sub-optimal alternative, the group will adopt it with probability near 1.00. This scheme is the logical counterpart of truth-wins, and in the case of heuristic biases, it assumes that the bias is so convincing that it will be adopted by the group unless all group members favor an unbiased decision. This SDS predicts the extreme "negative" lower bound of group performance. It is unlikely that these heuristic biases are so pervasive as this model predicts.

Bias-Supported Wins, Proportionality Otherwise (BSWIN/PROP)

This SDS is similar (but opposite) to the truth-supported, proportionality scheme. This scheme predicts that the group chooses the sub-optimal alternative if at least two members advocate it. A proportionality sub-scheme is applied when less than two group members favor a sub-optimal or biased alternative, so bias some-

times wins. This scheme predicts a higher proportion of biased group decisions relative to the proportion of individual biased decisions. Considering the group size of four, this SDS may characterize tasks where the correct alternative is highly counter-intuitive or difficult to defend.

The research presented here investigates several hypothesized group consensus processes (Social Decision Schemes) on several tasks previously associated with individual level judgmental biases to investigate whether the group discussion and consensus processes used on these tasks are the type which may either compensate, exaggerate, or leave unchanged those biases observed among individuals. This study used four different judgment problems that previous research had demonstrated were susceptible to one of three different heuristics or judgmental biases: 1) the *representativeness* heuristic (Kahneman & Tversky, 1972), where the probability of an uncertain event is evaluated by the degree to which it (a) is similar in essential properties to its parent population and (b) reflects the salient features of the process by which it is generated; 2) *inappropriate diagnostic reasoning* (Tversky & Kahneman, 1980), where people assign greater impact to causal than to diagnostic data of equal informativeness, because it is easier to follow the normal sequence in reasoning from cause to consequence than it is to invert this sequence and reason from consequence to cause; and 3) the *availability* heuristic (Tversky & Kahneman, 1973), where the relative frequencies of events are estimated by how easily specific examples of the event are retrieved from or available in memory. The main focus of this study was to test several social consensus hypotheses in the form of Social Decision Scheme models, to see if the best fitting consensus models are the types of processes which may lead groups to fall prey to or overcome the now familiar faulty decision processes observed at the individual level.

Method

Subjects

The 96 subjects (66 males and 30 females) were students in introductory psychology courses at the University of Illinois who received course credit in return for their participation.

Stimulus Materials

Four problems were selected which had previously shown decision and judgment biases at the individual level apparently due to heuristics associated with: *representativeness*, (inappropriate) *diagnostic reasoning*, and *availability*. These three areas and the problems used for each are given below.

Representativeness. 1. All families of six children in a city were surveyed. In 72 families the exact order of births of boys and girls was G B G B B G. What is your estimate of the number of families surveyed in which the exact order of births was B G B B B B?

— families.

(Kahneman & Tversky, 1972)

2. There are two programs in a high school. Boys are a majority (65%) in program A, and a minority (45%) in program B. There is an equal number of classes in each of the two programs. You enter a class at random, and observe that 55% of the students are boys. What is your best guess? Does the class belong to:

— program A or

— program B

(Kahneman & Tversky, 1972)

Inappropriate Diagnostic Reasoning. Which of the following events is more probable?

1. That a girl has blue eyes if her mother has blue eyes.
2. That the mother has blue eyes, if her daughter has blue eyes.
3. The two events are equally probable.

(Tversky & Kahneman, 1980)

Availability. The frequency of appearance of letters in the English language was studied. A typical text was selected, and

the relative frequency with which various letters of the alphabet appeared in the first and third positions was recorded. Words of less than three letters were excluded from the count.

Consider the letter R.

Is R more likely to appear in

—— the first position?

—— the third position?

(Tversky & Kahneman, 1973)

Procedure

Half of the subjects were randomly assigned to the individual condition to work on the problems alone, while the other half of the subjects were assigned to the group condition to work on the problems as members of a four-person mixed-sex group. Group members responded individually to each problem just prior to their group's discussion of the problem, and the groups were given enough time to discuss each problem until all members agreed on a single alternative. The order in which the problems were discussed was counter-balanced in a Latin square design, and following discussion of all the problems, group members again responded individually to each of the problems. The subjects working alone in the individual condition responded to each problem twice, with a short period of time between responses provided so that they could think over each problem. Following completion of all the tasks, the subjects were thanked and debriefed.

Results and Discussion

Due to small sample sizes, especially the small number of groups available for the Social Decision Scheme (SDS) analysis, responses to each task have been coded as correct or incorrect (biased or sub-optimal). The SDS analysis will be presented first, then the individual versus group comparison on each task is discussed in relation to the best fitting Social Decision Scheme for that task.

The SDS analysis was carried out as described above (Equation 2) using the six social decision schemes in Table 1, and indirect estimates of the π_i (Equation 1) using the appropriate relative frequencies observed in the individual condition.

The model testing approach of SDS theory tests the predicted values from each of the six models against the obtained group results to see which models adequately fit the data. Unlike null-hypothesis testing, we are here looking for models that fit well (i.e., low chi-square values and high p -values), and thus to be properly cautious, we will disregard any models with $p < .25$ as providing a significantly poor fit.

The (inappropriate) diagnostic reasoning task (Eye Color problem) has three as the correct alternative because there is an equal proportion of blue eyes in each generation. Here the causal information in alternative 1 and the diagnostic information in alternative 2 are equally informative in reaching the correct solution. However the individual subjects in previous research have given more weight to the causal information than to the diagnostic information, even though the causality in this relation is irrelevant for the given task. With regard to the groups in our study, we can see that the PROP and EQUI (abbreviations given earlier in the text) models provide the best fit to the obtained results for the Eye Color problem (see Table 2), with PROP slightly under-predicting and EQUI slightly over-predicting the results. As we mentioned earlier, these two Social Decision Schemes are characteristic of tasks on which there is great uncertainty, so it appears as though groups and the process they may be using do not lend any great insight to this particular task (inappropriate diagnostic reasoning). These two processes predict that group performance will be quite similar to that of individuals, although the EQUI model predicts slightly less extreme proportions of group deci-

Table 2
Observed proportions of correct group decisions, predicted proportions of correct group decisions under six different social decision scheme models, and chi-square goodness of fit statistics for each model on each problem

SDS model / (Data)	Problem			
	Eye Color (.417)	Birth Order (.167)	Class (.000)	Letter R (.667)
PROP				
Predicted prop. corr.	.396	.104	.104	.458
Chi-square (1 <i>df</i>)	0.021 ^{a)}	0.506 ^{a)}	1.393	2.105
EQUI				
Predicted prop. corr.	.446	.178	.178	.479
Chi-square (1 <i>df</i>)	0.041 ^{a)}	0.010 ^{a)}	2.595	1.696
TWIN				
Predicted prop. corr.	.867	.355	.355	.914
Chi-square (1 <i>df</i>)	21.084	1.876	6.619	9.228
TSWIN/PROP				
Predicted prop. corr.	.605	.131	.131	.695
Chi-square (1 <i>df</i>)	1.784	0.134 ^{a)}	1.810	0.045 ^{a)}
BWIN				
Predicted prop. corr.	.025	.000 ^{b)}	.000 ^{b)}	.044
Chi-square (1 <i>df</i>)	76.905	2 845.682	0.001 ^{a)}	110.604
BSWIN/PROP				
Predicted prop. corr.	.137	.003	.003	.200
Chi-square (1 <i>df</i>)	7.926	102.496	0.038 ^{a)}	16.305

^{a)} Indicates an *acceptable* fit between observed and predicted at $\alpha = .25$.

^{b)} Values are actually *very near* 0.000.

sions, which in this case implies that groups will produce slightly fewer biased decisions (since a biased decision is the extreme in this case).

For the Birth Order problem, the probability of a boy or girl at any time in the sequence is essentially equal, meaning that each series is considered to be equally likely, so the correct answer is 72. However, previous research shows that this answer is greatly underestimated due to the fact that among families of six children, a family of five boys and one girl *appears* to be very rare and a family of three boys and three girls appears to be highly "representative" of six child families. It is assumed that individual subjects ignore or do not understand the information regarding the exact order of the births. There are three models that fit the obtained

group results for this task (see Table 2), PROP, EQUI, and TSWIN/PROP. Once again the EQUI and PROP models fit, but the fact that the TSWIN/PROP model fits the data so closely seems to indicate that some groups may in fact detect their individual biased decisions and take some corrective measures. The use of a TSWIN/PROP Social Decision Scheme implies that groups tend to come up with a higher proportion of unbiased decisions as compared to individuals, however it is important to note that other processes such as the simple aggregating techniques of PROP or EQUI may be taking place. In this instance the size of χ^2 provides an index of closeness of fit in those cases where two models predict successfully since the sample sizes and degrees of freedom are constant for all χ^2 values involved in

the comparison. This comparison shows that the EQUI model (a process predicting groups to be only slightly better than individuals) fits the data closest, with TSWIN/PROP (predicting groups more optimal) second closest, and PROP (predicting groups and individuals equally biased) appears to be the least accurate of the three, although all three models describe the process well.

The other representativeness task (the Class problem) asked whether a high school class with 55% male students is more likely to be part of a program where 65% of the students are boys (program A) or a program where 45% of the students are boys (program B). Although 55% is 10% away from both 45% and 65%, the 55% is actually more likely to come from program B because there is a greater variance around 45% than around 65%. Prior research has shown that individual subjects tend to pick program A, because this program, like the randomly chosen class, has a majority of boys, hence the selected class is more representative of program A. The SDS analysis shows the best fitting models to be BWIN and BSWIN/PROP, two models that imply that the bias resulting from this task is especially pervasive and that this biased alternative is convincing when discussed in a group. The use of either of these group consensus processes will result in groups having a higher proportion of biased decisions than people working individually.

Previous research on the availability problem (Letter R) has indicated that individual subjects feel that there are more words beginning with R than words that have R as the third letter. However, an actual word count showed that the letter R appears more in the third position than in the first position (Mayzner & Tresselt, 1965). The reason advanced to explain why subjects tend to respond incorrectly states that people search their memories for specific examples of words that have R in either the first or third position, and

Table 3
Relative frequency of correct and incorrect responses to problems associated with diagnostic reasoning, representativeness, and availability heuristics for groups and individuals

Task		Cor- rect	Incor- rect	N
Birth order				
(Representa- tiveness)	Individuals	.10	.90	48
	Groups	.17	.83	12
Class				
(Representa- tiveness)	Individuals	.10	.90	48
	Groups	.00	1.00	12
Letter "R"				
(Avail- ability)	Individuals	.46	.54	48
	Groups	.67	.33	12
Eye color				
(Diagnostic reasoning)	Individuals	.40	.60	48
	Groups	.42	.58	12

then find that it easier to recall words beginning with R, indicating that these types of words must be more frequent. The Letter R problem can only be characterized by the TSWIN/PROP social decision scheme. Use of a truth-supported wins/proportionality Social Decision Scheme usually results in a higher proportion of unbiased group decisions (relative to the proportion of unbiased individual decisions). Since this is the only Social Decision Scheme that fits the data well, it seems as though groups use an effective social consensus process on this particular task, and given that there is more than one person to advocate the optimal position groups may outperform individuals working alone.

Direct comparisons between group and individual solutions on the tasks are similar to the predictions made by the Social Decision Schemes for each respective task. Our results on the Eye Color task show that both groups (58%) and individuals (60%) (see Table 3) tend to show the bias of incorrectly weighting one type of information more heavily than the other, and the individual-group difference is not

significant, $Z=0.13$, $p=.449$ (one-tail), just as anticipated since the PROP and EQUI models so closely predict the group decisions that characterize the task. Individuals on the Birth Order problem showed a strong bias (90% were incorrect, see Table 3) and group performance was a little better (83% incorrect), but not significantly better, $Z=0.68$, $p=.248$ (one-tail), a result consistent with the EQUI predictions. The Class problem also showed that individuals often response incorrectly (90% were incorrect) and groups were incorrect even more often (100% incorrect). The individual-group difference is not significant, $Z=1.14$, $p=.127$ (one-tail), as we would expect since the BWIN and BSWIN consensus models had best predicted task performance. Subjects showed better performance on the Letter R problem, but there were still 54% of the individuals and 33% of the groups reaching biased decisions. The lower proportion of errors by groups approaches significance, $Z=1.30$, $p=.097$ (one-tail), as anticipated, since the only good-fitting Social Decision Scheme model was TSWIN/PROP.

The results from this study indicate that in situations where heuristic biases are prevalent, the group consensus process varies with the task—at least as summarized by the best fitting Social Decision Scheme. Sometimes groups seemed to perform according to the “performance-enhancing” TSWIN/PROP decision scheme (Letter R and to some extent the Birth Order tasks), and at other times appeared to perform according to the sub-optimal BWIN or BSWIN/PROP decision scheme (Class problem). It is interesting to note that this difference was observed on two different tasks (Birth Order and Class) that have in the past been associated with the same heuristic (representativeness). Our findings provide some evidence that on these heuristic tasks, groups sometimes use processes that may lead to decisions of a higher quality than individual decisions, although at other times the processes may

lead to lower quality decisions. Further research could profitably focus on groups of larger size to test other social decision processes applicable to larger groups, and of course, use larger samples to obtain better parameter estimates and more powerful statistical tests.

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