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Falsification cueing in collective reasoning: Example of the Wason selection task

MARIA AUGUSTINOVA[1,2]*
[1]*Miami University, Oxford, USA*
[2]*Blaise Pascal University, Clermont-Ferrand, France*

Abstract

This paper focuses on the effectiveness of groups, as opposed to individuals, in benefiting from falsification cueing in solving the Wason selection task. Consistent with the idea that groups use information that often individuals fail to use, Experiment 1 showed that groups (but not individuals) that received falsification cueing focused more on cue-consistent evidence in their reasoning. Experiments 2 and 3 showed that the increment in focus on cue-consistent evidence is moderated by the distribution of the falsification cue within a group. Finally, Experiment 3 demonstrated that the cue distribution affects collective focus on cue-consistent evidence through the content of the group discussion, namely through mentioning the cue during the discussion. Copyright © 2008 John Wiley & Sons, Ltd.

The comparison between individuals and groups in cognitive and behavioral performance has been a research tradition in both social and industrial-organizational psychology (see, e.g., Hill, 1982; Kerr, MacCoun, & Kramer, 1996 for reviews). Yet, such comparisons have been relatively inconclusive: sometimes groups outperform individuals, sometimes their performance is comparable, and sometimes individuals outperform groups. For instance, using the very same probability judgment paradigm, Argote, Seabright, and Dyer (1986) showed that group judgments are less affected by base-rate information than judgments made by individuals; whereas Argote, Devadas, and Melone (1990) showed that sometimes group judgments are more sensitive to base-rates than individual judgments. This not-isolated example of mixed findings points to the fact that the search for a single answer to the question of whether *N + 1 heads are* indeed *better than one* (see Hill, 1982) may be less productive, both socially and empirically, than the search for answers to the questions of *when* and *why* groups perform differently (i.e., better and worse) than individuals (see, e.g., Broadbeck & Greitemeyer, 2000; Kerr et al., 1996 for similar reasoning). In this spirit, the present paper examines *when* groups perform differently from individuals in the Wason selection task (Wason, 1966) and attempts to shed some light on *why* any such differences occur. Since the Wason task was devised to assess how people engage in hypothesis testing, specifically when the hypothesis under consideration is supported by confirming evidence (Wason, 1968b), the cognitive processes involved map on to those that jurors, board members, and other decision-makers employ everyday in individual and, even more frequently, in group settings.

In order to address the question of *why* groups perform differently from individuals, significant attention has recently been devoted to how groups process information (Hinsz, Tindale, & Vollrath, 1997; Larson & Christensen, 1993). Although largely modeled on individual models of information processing, resulting conceptualizations have identified many specificities of cognitive processes in interpersonal and group contexts. One key factor is that information processing at the group level involves a high degree of *social sharedness* (Tindale & Kameda, 2000; Tindale, Meisenhelder, Dykema-Engblade, & Hogg, 2001). Indeed, information processing in groups is often evaluated in terms of ''the degree to which information, ideas, or cognitive processes are shared, and are being shared, among the group

*Correspondence to: Maria Augustinova, LAPSCO and CNRS UMR 6024, Universite Blaise Pascal, 34 Avenue Carnot, 63037 Clermont-Ferrand, France. E-mail: maria.augustinova@univ-bpclermont.fr

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members. . .'' (Hinsz et al., 1997, p. 43). Consistent with this view, the more specific aim of this paper is to test the hypothesis that group can outperform individuals on the Wason selection task expressly because many specificities of information processing at group level enable them to use information that individuals do not use. In other words, the purpose of this paper is to examine how different aspects of social sharedness are implicated in the collective use of information and collective outcomes.

THE WASON SELECTION TASK

In the classic version of the Wason selection task, participants are given a conditional rule in the abstract form ''*if p then q*'' and a card-deck. Each of four cards represents a separate instance that may satisfy or violate the rule: one side says whether the instance has the property *p* and the other side tells whether it has the property *q*. Participants can only see one side of each card, and the side facing the participants displays, respectively, *p*, *non-p*, *q*, and *non-q* properties. The task is to decide which card or cards need to be turned over in order to determine whether the given rule is true.

Individuals usually have no difficulty deciding to turn over the card that displays the *p* property in order to see whether there is indeed a *q* property on the other side. However, they seldom (i.e., less than 10%, Klauer, Stahl, & Erdfelder, 2007) choose the *non-q* property card in order to verify that the false consequent is not paired with the true antecedent. Instead, individuals tend to choose the card displaying the *q* property (i.e., the instance that allows them to confirm but not falsify the rule), or else they choose the *p* property card alone (Wason, 1966).

Note that the idea of selecting the *p* and *non-q* cards as the rational choice is rooted in what Oaksford and Chater (1994, p. 608) have called the ''now outmoded falsificationist philosophy of science'' in their consideration of formal logic as an adequate normative theory for human reasoning. Indeed, applying Popper's (1959) criteria of an adequate scientific type of hypothesis testing to the reasoning of lay people is subject to many criticisms (see, e.g., Evans, 2002 for a review). In many theoretical views, choices other than strictly logical choices do not necessarily (if not at all) imply irrationality. For instance, Over and Evans (1994) argued that, from a Bayesian point of view, turning over a *p* property card to find a *q* on the other side confirms the conditional rule and thus increases the subjective probability of its being true. Thus, even selecting the *p* property card alone—the choice considered as incorrect within formal logic framework—has an indisputable epistemic utility.

In short, the correct or rational solution of the Wason selection task is still subject to scientific debate (see, e.g., Evans, 2002; Oaksford & Chater, 1994), and the aim of this paper is not to further it. Given that the distinction between correct and incorrect performance requires agreement about the underlying normative model of performance, the present research does not take a position on the rationality of specific solutions. Using so-called falsification indexes (FIs) (Oaksford & Stenning, 1992), the research instead examines how much falsification cueing influences focus on the cue-consistent *p* and *non-q* instances cards, without any attempt to justify the latter choice as the correct or rational one.

FALSIFICATION INSTRUCTIONS AND CUEING

A significant amount of research has been dedicated to pinpointing the conditions that enhance the use of falsification versus confirmation strategies in reasoning (see Evans, 2002 for a review). For example, in some versions of the Wason selection task, instead of being told to test whether the given rule is *true*, participants are invited to decide which card(s) need to be turned over in order to establish that the given rule is *false*. Alone, such *falsification instructions* usually fail to enhance individual's consideration of both *p* and *non-q* cards (Griggs, 1984; Yachanin, 1986; see Yachanin & Tweney, 1982 for exception).

However, falsification instructions may produce increments in the focus on *p* and *non-q* instances when coupled with other task features. Such a focus increases, for instance, when the content of the rule elicits suspicion about its validity, or through the addition of concrete or thematic content to the task (Fiedler & Hertel, 1994). Additionally, Augustinova, Oberlé, and Stasser (2005) introduced a technique of *falsification cueing* in which they reminded participants that in order to prove that a rule is true, they needed to demonstrate that there is no case in which it is false. Consistent with past research

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presented above, individuals' reasoning was not influenced by the falsification cue unless they were provided with an additional social cue such as having more relevant information than the other prospective group members.

Despite the accumulating evidence that individuals rarely respond to explicit falsification instructions and cues, the question of whether groups respond to such instructions has not been addressed. As mentioned above, the general hypothesis assessed in the studies reported below is that many specificities of information processing at the group level enable groups to use information that individuals do not use. The more specific aim is to test the prediction that groups (unlike individuals) benefit from falsification cueing, such as that used in Augustinova et al. (2005). I propose that providing all group members with the falsification cue significantly shifts collective focus toward the consideration of the *p* and *non-q* instances (i.e., cue-consistent evidence). The reasoning behind this argument is that both collective input (e.g., collective task representation); and group processes (e.g., discussion content) should be affected by the content of the falsification cue.

SHARED TASK REPRESENTATION

In conceptualizing information processing at the group level, Tindale, Smith, Thomas, Filkins, and Sheffey (1996, p. 84) coined the term ''shared representation,'' which is defined as ''any task/situation relevant concept, norm, perspective, or cognitive process that is shared by most or all of the group members.'' Applied to the present concerns, if a falsification cue is contained in a shared task representation it should have an influence on group processes and group outcomes. This is because, in theory, information that is consistent with a shared representation is easier to defend and more likely to influence group choice outcomes (Tindale & Kameda, 2000, p. 129). Thus, if a falsification cue is considered in collective reasoning, it will be easier to pick up on and its implications for a collective solution more likely to be elaborated. Likewise, if a cue-consistent alternative, such as the selection of the *non-q* property card, is suggested during the discussion, it will be more likely considered, easier to defend, and more likely to end up as a collective choice.

It is important to note that this effect on choice outcome does not necessarily imply increased explicit use of falsification as a strategy *per se*. For example, even when cued to and perhaps even having comprehended the principle of falsification, individuals still sometimes focus on confirming evidence as suggested by the simultaneous choice of the *q* property card (Johnson-Laird & Wason, 1970). Thus, this *partial insight pattern* suggests that an increase in the focus on cue-consistent *p* and *non-q* instances does not necessarily eliminate the consideration of confirming the *q* instance.

Moreover, in their work on demonstrability, Laughlin and Ellis (1986, see also Laughlin, 1980) argued that whenever a shared task representation exists in a group (and, e.g., it contains the falsification cue), a minority or even a single group member arguing for an alternative that is consistent with such the concept can win out over majorities. This implies that when a falsification cue is widely shared, a minority or even a single group member arguing for a cue-consistent alternative (e.g., selecting a *non-q* property card) can win out over majorities favoring the most frequent confirmation alternative (i.e., selecting *q* property card).

In sum, the implications of the group process constructs outlined above are rather simple: in groups, unlike in individuals, falsification cueing should enhance consideration of *p* and *non-q* property cards. Experiment 1 was designed to assess this hypothesis.

CUE DISTRIBUTION AMONG GROUP MEMBERS

Tindale and Kameda (2000, p. 124) also argued that ''things that are shared to a greater degree within groups will have greater influence on the relevant group outcomes/responses than those things shared to lesser degrees.'' According to their account, the extent to which the collective focus shifts toward the consideration of *p* and *non-q* cards should also be affected by the degree to which the falsification cue is shared among group members. Indeed, if the cue is given to only several group members, conflicting task representations might occur favoring majority/plurality-type processes (Tindale & Kameda, 2000; see also Tindale et al., 2001). Given the pervasiveness of confirmation as a strategy, majority/plurality-type processes in this case would be detrimental to a shift toward a cue-consistent alternative.

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In the same vein, Stasser and Titus (1987) have examined the conditions under which information is mentioned in group discussion (see also Stasser & Titus, 2003; Wittenbaum & Stasser, 1996 for reviews). They showed, first, that the likelihood of a piece of information being recalled by a group is a function of the number of members in possession of that information (see also Hinsz, 1990). Second, even with perfect recall, the probability that a piece of information is brought up and repeated (see also Larson, Christensen, Abbott, & Frantz, 1996) is also a function of the number of members who have it. The implications of such *biased information sampling* for the present research are rather straightforward: the more the falsification cue is shared among group members prior to group discussion, the more likely it will be mentioned during group discussion and influence its solution of a task. The latter idea is also consistent with work of Gigone and Hastie (1993, 1996) on the *common knowledge effect* showing that the importance of a given cue in predicting group performance increases linearly with the number of group members that received it. This hypothesis was examined in Experiment 2.

DISCUSSION CONTENT

Tindale and Kameda (2000; see also Tindale et al., 2001) have proposed that the distribution of information in a group influences group judgment only indirectly through member preferences prior to the group discussion. In other words, the (biased) distribution of information shapes individual preferences that determine the content of the current discussion and thus any collective outcome. This suggests that individual preferences prior to group discussion play a central role in influencing the collective outcome (see also Gigone & Hastie, 1993, 1996).

In terms of the reasoning task of interest here, this account implies that individuals will mention a falsification cue because it has already guided their preferred solution. However, findings from studies of individuals reasoning alone argue against the idea that individual preferences or individual card selections prior to the group discussion are positively facilitated by the presence of a falsification cue. As suggested above, the shared task representation should be influenced by the cue (in the sense that the focus on cue-consistent evidence will be induced). However, it was also proposed that an actual shift in this focus is more likely to occur at the group level. Such an argument implies that the collective consideration of *p* and *non-q* cards cannot be entirely explained by the shift in focus on these instances at the individual level prior to the group discussion. Said differently, the distribution of the falsification cue in the group will affect the collective outcome through the content of the group discussion and not only through individual solutions prior to the group discussion. This idea is consistent with Winquist and Larson (1998) who showed that both individual preferences and group discussion content shape collective outcomes. Thus, Experiment 3 was designed to examine the respective role of individual preferences and group discussion content, namely mentioning the cue, in collective focus on cue-consistent evidence.

OVERVIEW OF STUDIES

To sum up, the aim of this paper is to test the hypothesis that, when solving the Wason selection task (Wason, 1966), groups use information that individuals do not use. Recall that in the Wason selection task a falsification cue is generally disregarded by individuals working alone. This should be the case in a group context to a far lesser extent. Unlike individuals, a group should respond to the falsification cue and focus more on the cue-consistent *p* and *non-q* cards. This hypothesis was assessed in Experiment 1. Experiment 2 examined a moderating factor. More specifically, it assessed the hypothesis that increments in collective consideration of cue-consistent evidence (i.e., *p* and *non-q* cards) increase linearly with the number of group members provided with the cue. Finally, Experiment 3 investigated the idea that the distribution of the falsification cue affects collective focus on *p* and *non-q* cards through the content of the group discussion and not exclusively through individual solutions prior to the group discussion.

EXPERIMENT 1

Experiment 1 was designed to examine the extent to which groups, as opposed to individuals, focus on *p* and *non-q* cards as a function of falsification cue addition. The cue emphasized the advantages of choosing these instances in "*if p then q*" rule

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testing. Indeed, it reminded participants that in order to prove that a rule is true, they need to show that there is no case in which it is false (see Augustinova et al., 2005). I expected that groups would use information that individuals do not, and thus that only collective reasoning would reveal the use of a falsification cue.

Method

Participants and Design

Undergraduates (160) at the Ecole de Psychologues Praticiens of Paris (152 females and 8 males) volunteered to participate in the study. They were randomly assigned to one of four experimental conditions in a 2 (reasoning context: individual vs. in a group of three) $\times$ 2 (provision of falsification cue: yes vs. no) between-subjects factorial design. The main dependent variable was the FI computed as a function of selections of cards in the Wason selection task.

Procedure and Materials

Participants were recruited to participate in a study on problem solving. Three to four people attended each experimental session. Depending on the experimental condition, participants were told that they would solve the problem either individually or as a group. After these preliminary instructions, participants were seated individually and instructed to carefully read the problem presented in the booklet that was placed on the table in front of them. Additionally, they were asked to simply get familiar with the problem but not yet generate a solution. These instructions were also printed on the front page of the booklet.

The second page of the booklet presented the abstract version of the selection task (Wason, 1966). In short, four cards displayed, respectively, ''B,'' ''D,'' ''3,'' and ''7.'' Furthermore, printed instructions stated that each card had a letter on one side (either ''B'' or ''D'') and a number on the other side (either ''3'' or ''7'') and that their task was to decide what card(s) need(s) be turned over in order to prove that the rule ''if there is the letter B on one side of the card, there is the number 3 on the other side'' is true. Depending on the experimental condition (and similarly to Augustinova et al., 2005) this version was or was not accompanied by a falsification cue as follows: ''Don't forget that in order to prove that a rule is true, you need to show that there is no case in which it is false.''

After 5 minutes, the booklet was taken from participants. They then received another sheet of paper depicting the four cards, the given rule to test and a blank space for the solution. In group condition, only one sheet per group was provided and participants were asked to exchange as much information as possible before coming up with one collective solution with which every group member agreed. Participants were fully debriefed once they completed the problem.

Falsification Index (FI)

The main dependent variable was the FI (Oaksford & Stenning, 1992). Recall that four cards displayed *p* (true antecedent), *non-p* (false antecedent), *q* (true consequent), and *non-q* (false consequent) properties. Each selection of these different cards was scored 1 and each non-selection was scored 0. These scores served as a basis for computing the FI for each participant (or group of participants). This index reflects the degree to which people focus on cue-consistent instances in rule testing [i.e., instances where a true antecedent (ta) is paired with a false consequent (fa) since it is computed as follows $FI = (ta + fc) - (fa + tc)$]. Thus, $FI = 2$ if one's choice was to turn over *p* (ta) and *non-q* (fc) cards; $FI = 1$ if one's choice was to turn over *p* (ta) card only, $FI = 0$ if one's choice was to turn over *p* (ta) and *q* (tc) cards, etc. Moreover, unlike the classic binary coding of performance as correct versus incorrect, the FI can be considered and used as a continuous variable.

Results and Discussion

It was predicted that the presence of the falsification cue would affect collective, but not individual reasoning in the Wason selection task. In order to test this prediction, FIs were analyzed in a 2×2 ANOVA, with reasoning context and

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Table 1. Falsification indexes as a function of reasoning context and cue availability

	No cue	Additional falsification cue
Individuals		
M_{FI}	0.10	0.05
SD_{FI}	0.91	0.76
N	20	20
Groups		
M_{FI}	0.40	1.10
SD_{FI}	0.82	1.02
N	20	20

falsification cue as two between-subjects factors. This analysis revealed a significant main effect of reasoning context, $F(1,76) = 11.67$; $p = 0.001$, $\eta_p^2 = .133$, showing that the mean FI is higher in groups as compared to individuals. It also revealed a non-significant effect of the falsification cue, $F(1,76) = 2.71$; $p = .102$, *n.s.*, and a marginally significant interaction of these factors, $F(1,76) = 3.60$; $p = 0.062$, $\eta_p^2 = .045$.

More importantly, in accordance with our specific predictions, the addition of the falsification cue for individuals solving the problem alone did not reliably affect the consideration of *p* and *non-q* cards, $F(1,76) = 0.32$; $p = .858$, *n.s.* (means depicted in Table 1). However, the addition of this cue for individuals working in groups, significantly boosted the mean FI, $F(1,76) = 6.28$; $p = 0.014$, $\eta_p^2 = .076$, suggesting that the addition of the falsification cue shifted the focus toward *p* and *non-q* cards in rule testing.

These findings are consistent with past work suggesting that providing individuals with falsification instructions or a falsification cue does not significantly bolster their focus on *p* and *non-q* instances in syllogistic reasoning (Augustinova *et al*., 2005; Griggs, 1984; Yachanin, 1986). More importantly, they support the initial reasoning that the groups use information that individuals do not. Indeed, when group members were provided with the falsification cue, the collective focus shifted importantly toward cue-consistent *p* and *non-q* cards. However, processes underlying such focus still remain an open question. I argued previously that the cue influences both collective input and group processes. One possibility is that the cue influences the shared task representation such that group members are more inclined to seek cue-consistent evidence. Also, the fact that all members are provided the cue maximizes its chances to be mentioned during the group discussion and influence subsequent collective reasoning.

The framework of *social sharedness*, which is a key concept for understanding group information processing (Tindale & Kameda, 2000; Tindale et al. 2001, see also Hinsz et al., 1997), suggests that effects of both the shared task representation and cue mentioning are contingent on the level of sharedness of the falsification cue prior to group discussion. In order to examine such implications of different aspects of social sharedness, the second experiment examined the link between the level of cue distribution prior to the group discussion and collective focus on cue-consistent *p* and *non-q* instances.

EXPERIMENT 2

In addition to addressing the objectives mentioned above, the aim of the second experiment was to extend the findings of Experiment 1 by looking more directly at some of the group processes that might be responsible for the increment in collective focus on cue-consistent *p* and *non-q* instances in groups. If this increment is due at least partly to mentions of the falsification cue during group discussion, then this process should be sensitive to variation in the number of group members receiving the falsification cue. Indeed, a significant amount of literature converges on the idea that the more widely a piece of information is available to individual group members, the more likely it will be brought up and repeated during group discussion, and thus will influence collective outcome (Stasser & Titus, 2003).

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In order to assess the role of mentioning the falsification cue, Experiment 2 systematically varied the cue distribution in a group of four and included a measure of its mention during the group discussion. It was predicted that both mentioning the cue and a focus on cue-consistent *p* and *non-q* instances will augment linearly with the number of people in the group of four provided with that cue. Additionally, I also argued that collective focus on cue-consistent *p* and *non-q* instances is strongly influenced by the group processes. Thus, it was expected that the effect of cue distribution on collective focus on *p* and *non-q* cards would be at least partially mediated by group-process variables such as mentioning the cue during the group discussion.

Method

Participants and Design

Participants were 240 French senior high school students from Paris region (132 females and 108 males). Individuals were randomly assigned to groups of four. The experiment took place as part of a classroom exercise. Four to fourteen groups were run in one of seven experimental sessions. Groups were randomly assigned to one of three experimental conditions: 0 versus 2 versus 4 (all) group members were provided with the falsification cue. The main dependent variables were the FI computed as a function of selections of cards in the Wason selection task and recall of mentioning the falsification cue during the group discussion.

Procedure and Materials

Participants were divided into groups of four individuals and separate workspaces were provided for each group. From that point, the procedure was identical to that used in Experiment 1. Once participants solved the problem as a group, they individually completed the recall questionnaire designed to measure mentions of the falsification cue during the discussion. The cue was embedded in a list of several different statements. Participants were asked to check whether a given statement was mentioned during the group discussion.

The individual recall of mentioning the cue during the discussion was scored as 1 and 0 otherwise. These individual recall scores served as a basis for computing a collective recall index corresponding to the mean of individual recalls of all four members of a group. It was used as a proxy for assessing mentions of the cue during the group discussion (see, e.g., Galinsky & Kray, 2004 for similar measure of group discussion content). Values of the collective recall index ranged from 0 (corresponding to the recall of the all four group members that the cue was not mentioned) to 1 (corresponding to all four group members recalling that the cue was mentioned).

Results

Collective Focus on the Cue-consistent Instances

It was predicted that the mean FIs will be affected by the cue distribution such that the increment in mean FI would increase linearly with the number of group members provided with the cue. Results of the one-way ANOVA suggest that the cue distribution indeed affected FIs as expected, $F(2, 59) = 5.88$, $p = .005$, $\eta_p^2 = .171$ (means depicted in Table 2). Moreover, a test for trends across the *a priori* ordering of cue distribution on mean FIs yielded a significant linear trend, $F(1, 59) = 9.37$, $p = .003$, and a nonsignificant quadratic trend, $F(1, 59) = 2.39$, $p = .128$, *n.s.*

Falsification Cue Mentioning

It was also predicted that the mean indexes of collective recall would be affected by cue distribution such that the increment in recall would increase linearly as a function of number of group members provided with the cue. Results of the

DOI: 10.1002/ejsp

Table 2. Falsification and collective recall indexes as a function of cue availability among four group members

	0/4 Cue unavailable	2/4 Cue partially shared	4/4 Cue widely shared
M_{FI}	0.40	0.45	1.20
SD_{FI}	0.75	0.76	0.95
N	20	20	20
M_{recall}	0.23	0.48	0.69
SD_{recall}	0.36	0.38	0.41
N	20	20	20

one-way ANOVA suggest that the cue distribution affected collective recall of its mentioning, $F(2, 59) = 7.33$, $p = .001$, $\eta_p^2 = .205$ (means depicted in Table 2). Moreover, a test for trends across the *a priori* ordering of cue distribution on mean FIs yielded a significant linear trend, $F(1, 59) = 14.33$, $p < .001$, and a nonsignificant quadratic trend, $F(1, 59) = 0.32$, $p = .859$, *n.s.*

Relationship between Cue Mentioning and Collective Focus on the Cue-consistent Instances

Since the two dependant variables were correlated ($r = .452$, $p < .001$) and were similarly affected by the cue distribution, I examined whether, as predicted, mentioning the cue mediates the relationship between the effect of cue distribution and collective outcome. Consistent with previous analyses, the cue distribution in a group significantly predicted both the collective focus on cue-consistent instances as indicated by FIs ($\beta = 0.37$, $p = .004$) and mentioning the cue during the group discussion as indicated by collective recall indexes ($\beta = 0.45$, $p < .001$) In accordance with remaining conditions of mediation (Baron & Kenny, 1986), mentioning the cue during the group discussion predicted the collective focus on *p* and *non-q* instances while effect of cue distribution was controlled ($\beta = 0.36$, $p = .008$); and crucially, the direct path from cue distribution to the focus on *p* and *non-q* instances did not reach significance when the effect of cue mentioning was controlled ($\beta = 0.21$, $p = .12$, *n.s.*) (Figure 1). A significant Sobel test (Preacher & Leonardelli, 2001) for the indirect effect, $z = 2.27$, $p = .02$, bolsters the idea that the effect of cue distribution on collective focus on cue-consistent evidence is mediated by cue mentioning during the group discussion.

Discussion

As in Experiment 1, the present results are consistent with the idea that providing group members with a falsification cue enhances collective focus on cue-consistent *p* and *non-q* property cards. More specifically, the increment in such focus increases linearly with the number of people in a group provided with the cue. Additionally, the increment in mentioning of the cue during group discussion also increases linearly as a function of cue distribution. Finally, the mediational analysis

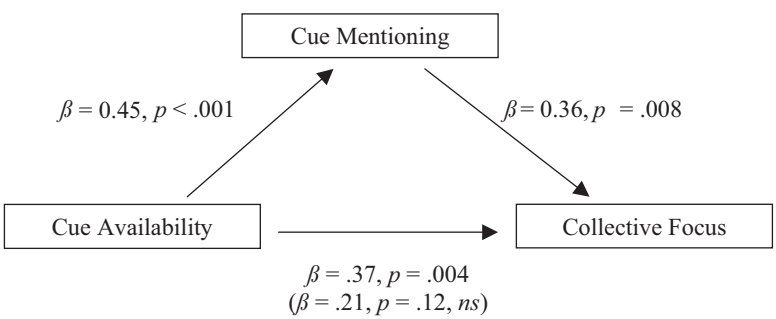

Figure 1. Mediational analysis of the relationship between cue distribution, cue mentioning, and collective focus on cue-consistent evidence (Experiment 2)

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bolsters the initial reasoning that the relationship between cue distribution and collective focus on cue-consistent instances might be mediated by group-process variables such as mentioning the cue during the group discussion.

These findings suggest that the cue distribution affects group processes, namely the content of the discussion, and that such processes are closely implicated in group outcomes. In other words, collective focus on *p* and *non-q* instances is greatly influenced by what is brought up during the discussion, namely whether the falsification cue is mentioned. Of course, this strong conclusion is still speculative. Recall that in both experiments, participants were instructed prior to the group discussion to simply get familiar with the problem but not generate a solution. Given this instruction, it is not clear whether participants still tried to solve the problem and to what degree these possible prior preferences for solution influence both the process variable (i.e., mentioning the cue during the group discussion); and the outcome variable (i.e., collective focus on cue-consistent evidence). This implies that the effect of both cue distribution and cue mentioning presented above might be potentially confounded with the effects of prior preferences.

Recall, however, that the individual condition findings of Experiment 1 still suggest that providing individuals with the falsification cue does not affect their performance prior to group discussion. Nevertheless, it seems important to ascertain whether mentions of the falsification cue affects collective focus on cue-consistent instances only indirectly through member preferences for such instances prior to the group discussion (Tindale & Kameda, 2000; Tindale et al., 2001) or whether both preferences and discussion content shape such focus (Winquist and Larson, 1998). The last experiment was designed to assess those possibilities.

EXPERIMENT 3

This experiment was designed to replicate findings of Experiment 2 while controlling for individual preferences prior to group discussion. It was predicted that both mentioning the cue during the discussion and increments in collective focus on cue-consistent instances would increase linearly with the number of group members provided the cue. Another prediction assessed in this experiment derives from the idea that collective focus on cue-consistent evidence is greatly influenced by what is brought up during the discussion. Specifically, it was expected that mentions of the cue should be a significant mediator of cue distribution effects on collective focus on *p* and *non-q* instances even when controlling for the effect of individual focus on these instances prior to the group discussion. This idea is also based on empirical considerations. Indeed, the findings of Experiment 1 suggest that providing individuals with the falsification cue does not affect their individual preference prior to the group discussion (see also Augustinova *et al*., 2005; Griggs, 1984; Yachanin, 1986) but, as suggested by results observed in Experiment 2, such intervention affect their reasoning at group level.

Method

Participants and Design

Undergraduates (192) at the University of Clermont-Ferrand (172 females and 20 males) volunteered to participate in the study. The experiment took place as part of a classroom exercise. Four to 12 groups were run in one of six experimental sessions. Individual were randomly assigned to groups and groups were randomly assigned to one of four experimental conditions: 0 versus 1 versus 2 versus 3 (all) group members were provided with the falsification cue. The main dependent variables were the individual FI prior to the group discussion, the collective FI, and recall of mentioning the falsification cue during the group discussion.

Procedure and Materials

Participants were randomly assigned to one of the four group conditions. In order to control for individual focus on cue-consistent evidence prior to the group discussion, participants first solved the Wason selection task alone, before having met other members of their group. For this part of the experiment, the procedure was identical to the one used for

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individuals in Experiment 1. After participants finished solving the problem individually, their questionnaires containing individual solutions of the Wason task were taken from them. Next, the groups of three were formed and were provided with a separate workspace. From that point, the procedure was identical to that used for groups in Experiments 1 and 2. Recall that all groups then received another sheet of paper depicting only the four cards, the given rule to test and a blank space for the solution, and were instructed to exchange as much information as possible before coming up with one collective solution with which every group member agreed. As in Experiment 2, participants individually completed the recall questionnaire once they had solved the problem as a group. Remember that the recall of mentioning the cue was used as a proxy for assessing its mentions during the group discussion. After completing the latter questionnaire, participants were thanked and fully debriefed.

Results

Focus of Individuals on Cue-consistent Instances

Experiment 1 showed that the falsification cue did not affect individual reasoning in the Wason task. Despite the obvious problem of null hypothesis assessment, all individual FIs prior to the group discussion (i.e., regardless of the group condition) were analyzed in a one-way ANOVA as a function of the cue (yes vs. no). Somewhat contrary to what was expected, this analysis revealed a marginally significant effect of the falsification cue, $F(1,190) = 3.73$; $p = 0.055$, $\eta_p^2 = .019$ suggesting that individuals with the additional falsification cue tended to focus more on cue-consistent instances ($M = 0.40$, SD $= 0.93$) as compared to the individuals reasoning without the cue ($M = 0.17$, SD $= 0.69$).

Focus of Individual Group Members Prior to the Group Discussion

It was critical to examine the performance of individual members as a function of the cue prior to the group discussion (and group problem solving). To this end, the averages of the individual FIs of the three prospective group members were computed. This nominal group performance was consequently analyzed as a function of the number of group members possessing the falsification cue (i.e., 0 vs. 1 vs. 2 vs. 3 (all)) in a one-way ANOVA. In spite of the marginal effect of cue addition presented above, results of this analysis suggest that cue distribution did not reliably affect nominal group FIs prior to the group discussion, $F(3, 60) = 0.80$, $p = .50$, *n.s.* (means depicted in Table 3). This was also the case in a test for trends across the *a priori* ordering: the linear trend of cue distribution on nominal group FIs did not reach significance, $F(1, 63) = 1.66$, $p = .20$, *n.s.*, nor did quadratic and cubic trends $F_s < 1$, $p_s > .40$. However, as the pattern of results suggests (see Table 3), along with the marginally significant effect of the cue addition on individual focus on cue-consistent instances, these preferences of individual group members prior to the group discussion and collective focus on cue-consistent instances might not be independent. This is indeed the case since the nominal group and actual group FIs were correlated ($r = .60$, $p < .001$).

Table 3. Collective falsification indexes as a function of reasoning context and cue availability among three group members

	0/3	1/3	2/3	3/3
Prior to the group discussion (nominal group FI)				
M_{FI}	0.10	0.25	0.38	0.31
SD_{FI}	0.48	0.55	0.44	0.59
N	16	16	16	16
After the group discussion				
M_{FI}	0.13	0.63	0.63	1.25
SD_{FI}	1.09	0.89	0.89	1.00
$M_{FI,adj}$[a]	0.30	0.64	0.49	1.19
N	16	16	16	16

[a]Means adjusted for nominal group falsification indexes.

DOI: 10.1002/ejsp

Focus of Groups on Cue-consistent Instances

It was predicted that the group FIs would be affected by the cue distribution such that the collective FIs would increase linearly with the number of group members provided with the cue. Because of the aforementioned correlation, I examined this hypothesis while controlling for the effect of individual preferences prior to the group discussion (i.e., nominal group FIs). Results of the one-way ANCOVA suggest that when the effect of nominal group FIs, $F(1, 59) = 34.54$, $p < .001$, $\eta_p^2 = .369$, was controlled, the cue distribution still reliably affected the collective focus on cue-consistent evidence, $F(3, 59) = 3.86$, $p = .014$, $\eta_p^2 = .164$ (means depicted in Table 3). Moreover, a test for trends across the *a priori* ordering of cue distribution on mean collective FIs while controlling for the effect of nominal group FIs, $F(1, 59) = 34.54$, $p < .001$, yielded a significant linear trend, $F(1, 59) = 8.27$, $p = .006$, and nonsignificant quadratic, $F(1, 59) = 0.867$, $p = .36$, *n.s.*, and cubic trends, $F(1, 59) = 2.30$, $p = .14$, *n.s*. These results suggest that the falsification cue influences collective focus on cue-consistent instances increasingly with the number of group members provided with such cue.

Falsification Cue Mentioning

It was predicted that the mean scores of collective recall will be affected by cue distribution such that increment in recall would increase linearly with the number of group members supplemented by the cue. Since the nominal group FIs (i.e., individual preference or performance of group members prior to the group discussion) and cue mentioning were correlated ($r = .51$, $p < .001$), I examined the latter hypothesis while controlling for the effect of nominal group FIs. Results of the one-way ANCOVA suggest that cue distribution still affected collective recall of mentioning of the falsification cue during group discussion, $F(3, 59) = 3.36$, $p = .025$, $\eta_p^2 = .146$ (means depicted in Table 4) even though the effect of nominal group FIs, $F(1, 59) = 18.76$, $p < .001$, $\eta_p^2 = .241$, was controlled for. Moreover, a test for trends across the *a priori* ordering of cue distribution on mean FIs yielded a significant linear trend, $F(1, 59) = 9.83$, $p = .003$, and nonsignificant quadratic and cubic trends, $F_s < 1$, *n.s.*

Relationship between Cue Mentioning and Collective Focus on Cue-consistent Instances

It was predicted that mentioning the falsification cue mediates the relationship between the effect of cue distribution and performance. Consistent with previous analyses and while adjusting for individual performance of group members prior to the group discussion, the cue distribution significantly predicted both the collective focus on cue-consistent instances as indicated by group FIs ($\beta = 0.26$, $p = .012$), and mentioning the cue during the group discussion as indicated by collective recall indexes ($\beta = 0.33$, $p = .002$). Additionally, mentioning the cue during the group discussion predicted the collective focus cue-consistent evidence when the effect of cue distribution was controlled ($\beta = 0.61$, $p < .001$); and the direct path from cue distribution to the focus on cue-consistent instances was removed when the effect of cue mentioning was controlled ($\beta = 0.06$, $p = .50$, *n.s.*). Again, the latter conditions of mediation (Baron & Kenny, 1986) were assessed while entering the individual performance of group members prior to the group discussion as a covariate ($\beta = 0.28$, $p = .002$) (Figure 2).

A significant Sobel test (Preacher & Leonardelli, 2001) for indirect effect of cue distribution on collective focus on cue-consistent instances, $z = 2.80$, $p = .002$, bolsters the idea that taking cue mentions into account significantly weakened the effects of cue distribution on collective focus on cue-consistent *p* and *non-q* property cards. Thus, these results support

Table 4. Collective recall of the falsification cue during group discussion as a function of cue availability among three group members

	0/3	1/3	2/3	3/3
M	0.15	0.29	0.48	0.63
SD	0.34	0.40	0.47	0.47
M_{adj}[a]	0.21	0.30	0.43	0.60
N	16	16	16	16

[a]Means adjusted for nominal group falsification indexes.

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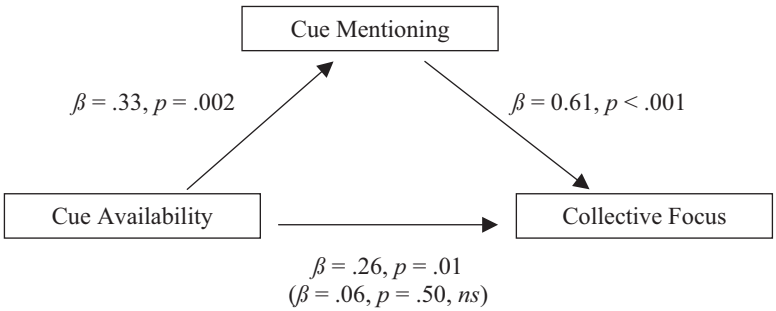

Figure 2. Mediational analysis of the relationship between cue distribution, cue mentioning, and collective focus on cue-consistent evidence (Experiment 3)

the idea that mentioning the cue mediates the relationship between the effect of cue distribution and the collective focus on cue-consistent evidence, and this is the case independent of the effect of individual focus on this cue-consistent evidence prior to the group discussion.

GENERAL DISCUSSION

The first objective of the present research was to assess the hypothesis that, in solving the Wason selection task (Wason, 1966), groups use information that individuals do not use. Our results showed that groups benefited from a falsification cue whereas individuals did not (Experiment 1) or did so to a far lesser degree then groups (Experiment 3). The slight differences in the findings of those two experiments in this regard are worth mentioning. Significant differences in sample size across two experiments could account for the difference in individual performance. However, it is also noteworthy that the reasoning contexts were not identical. In Experiment 3, while solving the Wason selection task individually, participants also anticipated solving it subsequently as a group. An expectation of impending group membership usually leads to more extensive elaboration and use of information (see, e.g., Levine, Bogart, & Zdaniuk, 1996; Levine, Resnick, & Higgins, 1993 for reviews). Indeed, Roch (2006) recently found that the anticipation of group discussion on a cognitive task bolstered initial accuracy as compared to non-anticipation. Further, Augustinova et al. (2005) argued that for the falsification cue to have an effect on individual performance on the Wason selection task, individuals have to anticipate transmitting information to, rather than receiving information from, other prospective group members. Thus, both the individual performance differences from group performance observed in both Experiments 1 and 3 are interpretable within the present account.

The second aim of the research reported here was to examine the idea that the effect of the cue on collective focus on cue-consistent evidence demonstrated in Experiment 1 is moderated by the distribution of the cue within the group. Consistent with this expectation of the moderating role of cue distribution, collective focus on cue-consistent evidence increased linearly with the number of group members provided the cue prior to the group discussion in both Experiments 2 and 3.

Still at issue is the question of the processes implicated in these effects. As suggested earlier, the extent to which the cue was shared prior to group discussion was expected to influence several components of collective information processing (Tindale & Kameda, 2000; Tindale et al., 2001). One possibility is that the cue influences collective focus on cue-consistent evidence through changes in shared task representations. More specifically, I speculated that this shared task representation becomes more cue-consistent as the number of group members provided with the falsification cue increases. Groups in which the cue is widely available might be more inclined to engage in seeking cue-consistent evidence and thus focus more on *p* and *non-q* instances cards that can show that the "if *p* than *q*" rule under consideration is false. Collective performance data from the three experiments are consistent with such reasoning.

However, the question of *when* the cue-consistent task representation arises is still open. The individual preference data from Experiment 3, along with the data from individuals in Experiment 1 (see also Augustinova *et al*., 2005; Griggs, 1984;

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Yachanin, 1986), suggest that it does not emerge prior to group discussion. This proposal should be addressed more directly in future research with, for example, the use of reasoning aloud protocols. In addition, the direct assessment of the content of group discussion might support better understanding of the role of the shared task representation. Such an approach might also clarify the extent to which information processing at individual and group levels are required, and also the degree to which it is a part of an explicit or implicit style of group coordination.

Another possible process implicated in the influence of cue distribution on collective focus on cue-consistent evidence is in changes in group discussion content. I proposed that the cue distribution prior to the group discussion would influence mentions of the cue in group discussion. Consistent with work of Stasser (Stasser & Titus, 1987; see Stasser & Titus, 2003; Wittenbaum & Stasser, 1996 for reviews), in both Experiments 2 and 3, the degree to which groups mentioned the cue increased as a function of the number of group members possessing the cue. Even more relevant to the question of underlying processes is the fact that mentioning the falsification cue mediated the relationship between the cue distribution and collective focus on cue-consistent instances across studies. This was the case even when the effect of initial individual solutions was removed (Experiment 3). This mediation points to the fact that a collective focus on cue-consistent evidence is greatly influenced by what is brought up in the discussion, namely whether the falsification cue is being mentioned.

This finding has implications for understanding the processes involved in group problem-solving performance. Indeed, contrary to the idea that the distribution of information in the group usually influences group outcomes indirectly through member preferences prior to the group discussion (Tindale & Kameda, 2000; Tindale et al., 2001; see Winquist & Larson, 1998 for an exception), the findings of Experiment 3 suggest that the influence of cue mentioning is statistically independent of the effect of individual solutions prior to the group discussion. Given the null effect of cue distribution on individual solutions prior to the group discussion, it can be argued that, in the present work, discussion content shaped collective focus on cue-consistent evidence more than did individual solutions that were generated prior to the group discussion.

The influences of information and individual solutions (or preferences) in collective outcomes may thus appear to vary as a function of the type of task. In decision-making tasks, the distribution of information in the group usually influences group judgment indirectly through member preferences, while the influence seems to be more direct in problem-solving or reasoning tasks such as the task used in the present study. This conclusion is consistent with the findings of Kelly, Jackson, and Hutson-Comeaux (1997) that showed that amount of informational, as opposed to normative, influence was more important in groups working on reasoning as opposed to the judgmental tasks, and that the accuracy of group performance in the reasoning task was related to the amount of information influence.

Of course, in the present research, mentions of the falsification cue were measured indirectly in post-task recall questionnaires. Thus, the present conclusions are subject to the usual limitations of correlation data. It is unclear whether group members recalled mentions of the cue during the discussion because they previously used it as a basis for their collective reasoning or they used it as a basis for collective reasoning precisely because it was mentioned and elaborated during the discussion as assumed in the underlying causal model. Thus, it is essential to replicate these findings with procedures in which mentions of the cue in group discussion are measured explicitly. Such a procedure would also distinguish between simple mentioning and elaboration of the cue, which might not always occur in concert. This distinction would also be useful for identifying the processes involved in the increase in focus on cue-consistent evidence.

Indeed, mentions of the cue could raise its salience, leading to cue-consistent card choices simply because group members heard about the cue often and repeatedly in discussion (Larson et al., 1996; Stasser, Taylor, & Hanna, 1989). Another possibility is that mentions of the cue altered its perceived importance. Widely shared information is often viewed as more credible and important (Kameda, Ohtsubo, & Takezawa, 1997; Postmes, Spears, & Cihangir, 2001; Wittenbaum, Hubbell, & Zuckerman, 1999). Either way, the falsification cue and mentions of it in discussion could have influenced the group outcome through typical group biases such as biased information sampling and/or focus on salient or frequently mentioned information.

On the other hand, elaboration of the cue implies some kind of reasoning activity with the cue used as an additional premise, and a subjective attribution of relevance to it (Sperber & Wilson, 1989; Sperber, Cara, & Girotto, 1995) at both intra- and inter-individual levels. This might (but not necessarily) result in considering falsification as the more sensible or rational option. Indeed, it can also result in an increase in the so-called partial insight pattern (Johnson-Laird & Wason, 1970) ensuing in the selection of cards displaying *p*, *q*, and *non-q* properties. Thus, even if elaboration of the cue leads to some understanding of the principle of falsification, it does not necessarily eliminate the use of confirmation. It is however thought to promote more reasoning-oriented type of group processes as compared to the superficial use of the most

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available or salient information described earlier. As can be seen, these qualitatively different processes can potentially lead to the very same outcome. Thus, it seems crucial for further research to address the interplay of seemingly rational and irrational tendencies in group interactions.

The latter considerations are also related to a discussion of the implications of the present findings for the literature on reasoning. As suggested earlier, despite the increase in focus on cue-consistent evidence by groups, the exact effect of the cue on reasoning *per se* is still not clear. The falsification cue may produce genuine changes from a confirmation to a falsification strategy, or increase *partial insight* (Johnson-Laird & Wason, 1970) reflecting the use of both confirmation and falsification. Another possibility is that the cue may lead to a superficial reframing of the rule from ''if *p* then *q*'' to ''if *p* then *non-q*'' that triggers focus-based responding. That is, consistent with the idea of the matching bias (Evans, 1972, see also Evans, 1998) individuals might simply focus on instances contained in the newly reframed rule without any explicit intention to falsify a rule. Future research should examine whether the collective focus on cue-consistent instances results in a transfer of performance to new problems that call for falsification. Transfer would suggest that falsification instructions and or cueing produce authentic changes in reasoning strategies.

In conclusion, the present research highlights the importance of examining the same cognitive phenomena in both individual and group contexts. Whereas falsification instructions or cueing usually fail to influence individual performance (Augustinova et al., 2005; Griggs, 1984; Yachanin, 1986), the present research demonstrates that the same instructions substantially modify group performance, specifically when the additional falsification cue is widely shared. Note that such conclusion also provides one answer to the opening question of *when* groups perform differently from individuals—better, in the present case—in the Wason selection task (Wason, 1966). The answer to the question of *why* this is the case seems to be linked to the specificities of the processing of the falsification cue at the group level. For instance, when the cue is widely shared among group members it is likely to be mentioned, repeated, and viewed as credible (see Stasser & Titus, 2003 for a review). The present research supports the idea that processing the cue at the group level amplifies its likelihood of being used, as compared to its processing at the individual level. This also suggests that the influence of a piece of information (e.g., a falsification cue) is not solely linked to its informational content but also to the context in which it is used. When it has a status of shared knowledge, information processing at group level renders it more influential than unique or partially shared knowledge in a group (see Stasser & Titus, 2003). Again, albeit identical in its informational content, information processing at the group level seems to render it more influential for the individual than does its processing at the individual level. Thus, the presented research provides substantial evidence for the complementarities of individual and group levels of analysis even in the domain of thinking and reasoning—cognitive actions that are often viewed and studied as individual.

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