# The effects of groups' variety and disparity on groups' cognitive complexity

Curseu, P.L.; Schruijer, S.G.L.; Boros, S.

*Published in:*
Group Dynamics: Theory, Research and Practice

*Publication date:*
2007

Group Dynamics: Theory, Research, and Practice
2007, Vol. 11, No. 3, 187–206

1089-2699/07/$12.00 DOI: 10.1037/1089-2699.11.3.187

# The Effects of Groups' Variety and Disparity on Groups' Cognitive Complexity

Petru Lucian Curşeu
Tilburg University

Sandra Schruijer
University of Utrecht

Smaranda Boroş
"Babeş-Bolyai" University Cluj-Napoca

This study examined the influence of group diversity conceptualized as disparity and as variety on group cognitive complexity. Data on individual cognitive complexity and group cognitive complexity were collected in 44 groups using a conceptual mapping technique. Also data on the quality of teamwork processes and satisfaction were collected using an individual questionnaire. The results indicate that (a) gender variety has a positive impact on group cognitive complexity, (b) cognitive disparity has a negative impact on group cognitive complexity, and (c) groups with a high average individual cognitive complexity have the highest cognitive complexity as a group only if the quality of their interactions is high.

*Keywords:* cognitive mapping, cognitive complexity, group dynamics

In modern organizations, complex cognitive tasks ranging from decision making to strategy development are generally given to groups rather than individuals (Cooke, Kiekel, Salas, Stout, Bowers, & Cannon Bowers, 2003; Devine, 2002; Weber & Donahue, 2001). It is believed that groups can use a greater pool of knowledge to tackle complex information-processing tasks and be more effective than individuals. Therefore, the diversity in knowledge resources is a strategic advantage. However, whether "n" different heads are always better than "n" similar ones is still a matter of debate. This issue has been extensively investigated in the group diversity literature. It is argued that in order for a team to be effective it has to successfully integrate the individual knowledge of its members. This process was labeled as *knowledge integration* by Okhuysen and Eisenhardt (2002), as *the elaboration of task information* by Van Knippenberg, De Dreu, and Homan (2004), or as *group cognitive complexity* by Curşeu (2006).

In this article, we will further on use the term *group cognitive complexity* to define the richness of the collective knowledge structures that emerge as a team-level phenomenon from the integration of individual specialized knowledge through interpersonal interactions (Curşeu, 2006). Group cognitive complexity is an essential characteristic of group cognition. Although most of group cognition scholars agree that group cognition is a group-level phenomenon that emerges from the interplay between the individual cognitions of group members and their interactions (Rentsch & Woehr, 2004; Salas & Fiore, 2004), there is little emphasis in the literature on the emergence of group cognition as a group-level phenomenon (Curşeu, 2006).

Also, in the diversity literature questions concerning what types of attributes are more likely to be beneficial for group cognitive complexity or under which conditions a diverse group can effectively use the variety of knowledge and expertise of its members, remain largely unan-

Petru Lucian Curşeu, Department of Organisation Studies, Tilburg University; Sandra Schruijer, Utrecht School of Governance, University of Utrecht; and Smaranda Boroş, Department of Psychology, "Babeş-Bolyai" University Cluj-Napoca.

Correspondence concerning this article should be addressed to Petru Lucian Curşeu, Department of Organization Studies, Tilburg University, Room S161, Warandelaan 2, P.O. Box 90153, 5000 LE Tilburg, The Netherlands. E-mail: p.l.curseu@uvt.nl

swered (Milliken & Martins, 1996; Williams & O'Reilly, 1998). Several taxonomic approaches have been used to make sense of the puzzling effects of group diversity on group performance (Pelled, 1996; Harrison & Klein, 2007) starting from the assumption that different types of diversity yield different effects on performance. Harrison and Klein (2007) argue that group diversity can be operationalized as separation (e.g., differences in opinions among the group members), variety (e.g., differences in types of knowledge or experience among the group members), or disparity (e.g., differences in assets or resources among the group members), and only variety will foster a higher pool of knowledge within a group. This taxonomic approach has good potential for explaining the mixed effects of group diversity on group performance because on the one hand it accommodates for other existing taxonomies (e.g., Pelled, 1996; Milliken & Martins, 1996) and on the other hand it connects each diversity type with the underlying mechanisms of group performance (Harrison & Klein, 2007).

The first aim of this article is to explore the role of group interaction processes on groups' cognitive complexity. We argue that the quality of interpersonal interactions in a group is central for the integration of individual knowledge structures (individual cognition) into a group knowledge structure (group cognition) and that the quality of teamwork moderates the relation between the average individual cognitive complexity and group cognitive complexity. The second aim is to use the taxonomy introduced by Harrison and Klein (2007) to explore the differential impact of group disparity and variety on group cognitive complexity.

We extend existing research in several ways. First, the article contributes to the group diversity debates and provides an empirical test for the theoretical propositions raised by the distinction between disparity and variety as types of group diversity. According to these propositions, cognitive disparity is illustrative for the vertical differentiation within groups and is expected to have a negative impact, while variety is illustrative for a horizontal differentiation within groups and has a positive impact on group cognitive complexity. Second, the article adds to the group cognition literature by exploring the role of interpersonal interactions within a group on the emergence of group cognition (operationalized as a group's cognitive complexity). Finally, the article sheds some light on the impact of group disparity on group members' satisfaction. We will start by shortly reviewing the literature on group cognitive complexity as well as on group diversity with an emphasis on cognitive diversity.

## Cognitive Complexity in Groups and the Meaning of Collaboration

The concept of cognitive complexity (CC) has initially been introduced by Bieri (1955) as a personality trait and has subsequently been researched within the framework of personal construct theories (Kelly, 1955). Later it has been redefined as a characteristic of information processing in cognitive systems (Schroder, Driver, & Streufert, 1967). CC refers to the complexity of the knowledge structures in a cognitive system, and it describes the sophistication of those cognitive structures that are used for organizing and storing cognitive contents (Kelly, 1955; Goodwin, Wofford, & Harrison, 1990; Curşeu & Rus, 2005). High CC reflects a flexible and adaptive orientation in information processing (Schroder et al., 1967).

Groups are sociocognitive systems (Curşeu, 2003; Hinsz, Tindale, & Vollrath, 1997; Hollan, Hutchins, & Kirsch, 2000; Hutchins, 1995). They develop, store, and use cognitive representations (Curşeu, 2003). Because cognitive systems can vary in complexity on a continuum ranging from cognitive simplicity to cognitive complexity (Schroder et al., 1967), the concept of cognitive complexity can also be applied to groups as a characteristic of group cognition. According to the group cognition approaches (Curşeu, 2003; Hinsz, Tindale, & Vollrath, 1997; Hollan et al., 2000; Hutchins, 1995; Mohammed, Klimoski, & Rentsch, 2000; Rentsch & Woehr, 2004; Weick & Roberts, 1993), group cognition depends on the knowledge of individual group members as well as on their interaction processes.

One empirical study (Hendrick, 1979) suggests that the individual cognitive complexity of group members has a positive effect on group processes and performance. He found that groups composed of cognitively complex individuals used information cues more efficiently, interacted more easily, and came up with correct solutions for a puzzle faster than groups whose members were low on cognitive complexity. Nonetheless, Hendrick (1979) did not investigate the cognitive complexity of the group as a whole and did not take into account the interactions among group members. The cognitive complexity was measured only at the individual level, not at the group level. Only his inferences regarding performance pertain to the group level. By ignoring the interactions between group members, Hendrick (1979) did not conceptualize the group as a social system but rather as an addition of individuals varying in cognitive complexity. In real groups interpersonal interactions play a crucial role in the development of group cognition, and to date there is little empirical evidence for the interplay between teamwork processes and the cognitive complexity of the group members in generating group cognition (Curşeu & Rus, 2005).

Although group cognitive complexity was previously discussed in relation to group performance—as the elaboration of task relevant information (Van Knippenberg et al., 2004) or knowledge integration (Okhuysen & Eisenhardt, 2002)—no clear operationalization and measurement of the these concepts as a group-level phenomenon was developed. In the present study, group cognitive complexity is operationalized as *the number of independent concepts used by the group to define (represent) a particular situation or knowledge domain and the number and variety of connections among these concepts* (Curşeu & Rus, 2005). This operationalization is consistent with the definition of cognitive complexity in cognitive systems in general. In a cognitive system characterized by high cognitive complexity, information processing is defined by the use of many constructs with many relations among them (Schroder et al., 1967). The cognitive complexity of the group is domain specific: groups can be cognitively complex in some areas and cognitively simple in others. Therefore, group cognitive complexity describes the richness of the knowledge representations held by the group for a particular knowledge domain.

One possibility for groups to represent declarative knowledge is through natural language. Conceptual networks are therefore central representation forms. A conceptual network is a graphical representation, which consists of several interconnected concepts that the group uses to make sense of a task. Although various approaches have been used to represent group cognition, the most frequently reported technique has been cognitive mapping (Axelrod, 1976; Bougon, 1983; Huff, 1990). The complexity of the group's cognitive map is illustrative for the cognitive complexity of the group.

Most of the studies use aggregation methods to combine individual cognitions into shared mental models (Cooke, Salas, Cannon-Bowers, & Stout, 2000; Cooke et al., 2004; Lagan-Fox, Code, & Langfield-Smith, 2000; Mohammed, Klimoski, & Rentsch, 2000). However, as argued, group cognition is a group-level phenomenon, and any evaluation method must (1) address the group as a whole, (2) demonstrate group members' agreement with regard to the evaluated construct, (3) demonstrate that the results discriminate across groups, and (4) reflect group interaction processes (see for more details Bar-Tal, 1990). A simple aggregation of individual mental models does not satisfy all four criteria. However, cognitive mapping can be adapted to meet the four criteria. A card-sorting technique is suitable for such a purpose. Relevant concepts for the knowledge domain of the group (to be elicited by interview, document analysis, verbal protocol analysis—see for details Carley, 1993, 1997; Mohammed et al., 2000) are to be written on independent cards, and then the group members are instructed to organize them in a way that makes sense to the group as a whole. This method can be used to study the structure of the conceptual networks developed by groups at the group level of analysis.

In this study we use such a modified cognitive mapping technique to understand how individuals and groups make sense of the concept of "collaboration." Thus, we elicit conceptual networks about the phenomenon of collaboration. When it is used as a group task, the group members have to reach consensus on the structure of the conceptual network that best represents the group as a whole (Curşeu, 2003; Curşeu & Rus, 2005). Although this consensus based method reflects the group as a whole (it satisfies all the requirements stated by Bar-Tal, 1990, for valid holistic evaluation methods), we have to acknowledge, in line with Sundstrom, Busby, and Bobrow (1997), the fact that reaching consensus in this particular task does not necessarily mean complete unanimity (the technique might involve compromises among the group members). We will further address the issue of computing the complexity of cognitive maps in the section on procedure.

## Group Diversity

Group diversity refers to the degree of differentiation that exists among the group members with respect to a particular attribute (Harrison & Klein, 2007). Although during the last decades, group diversity received a considerable amount of interest (Weber & Donahue, 2001; van Knippenberg et al., 2004), scholars still disagree if group diversity is beneficial or not for group performance (Milliken & Martins, 1996; Williams & O'Reilly, 1998). It is generally believed that heterogeneous groups are more creative and reach better decisions, yet experience more difficult group interaction processes (suboptimal communication, conflict, stereotyping) than homogeneous groups. However, homogeneous groups solve problems more quickly, are more cohesive, and group members are more satisfied with their cooperation (Milliken & Martins, 1996; Williams & O'Reilly, 1998; Weber & Donahue, 2001).

Research on group diversity addressed a large variety of attributes, from demographic (e.g., age, gender) to cognitive ones (e.g., attitudes, values), and currently several diversity attributes taxonomies exist. The most used ones distinguish between visible versus less visible attributes (Milliken & Martins, 1996) and between highly job-related versus less job-related attributes (Pelled, 1996). The first taxonomy (visible vs. less visible attributes) emerged from reviews of the group diversity literature, and it does not describe the mechanisms that connect group diversity with performance, while the second was developed starting from mechanisms that could explain the differential impact of diversity on performance, yet it received little to no empirical support (Weber & Donahue, 2001).

More recently, Harrison and Klein (2007) introduced a new distinction. They differentiate between group diversity as *separation* (differences in beliefs, attitudes, and values), *variety* (differences in functional background and type of expertise) and *disparity* (inequalities in status, power, and resource availability). Of all these types, only variety is expected to have a positive influence on group effectiveness (Harrison & Klein, 2007). Separation refers to differences in the lateral disposition of the group members on a continuum defined by a certain diversity trait. Separation reflects a bimodal distribution, with half of group members at the highest (e.g., they have strong similar religious beliefs), the other at lowest endpoints of the considered variable's continuum (e.g., they have no religious beliefs). Variety refers to the composition of differences in kind, source or category of relevant knowledge or experience among group members. It reflects a uniform distribution with an even spread of members across all possible categories of a variable (e.g., a group high on variety is a group composed of psychologists, sociologists and anthropologists). Disparity refers to the composition of (vertical) differences in proportion of socially valued assets or resources held among group members, pointing to an inequality or relative concentration. Disparity reflects a positively skewed distribution with one member at the highest point on the continuum (one member that has access to a particular form of resource, like money, knowledge, or expertise) of the considered variable, others at the lowest (most of the members have no access to the previously mentioned resources) (Harrison & Klein, 2007). The taxonomy introduced by Harrison and Klein (2007) opens new ways of looking at group diversity. The same attribute, gender for example can be understood as variety (e.g., if group members have different task related knowledge structures emerging from qualitatively different gender-specific life experiences), disparity (e.g., if the most powerful person in a group of several women and one man is the man), or separation (e.g., if all women in a group are feminist and all men are misogynists).

The complexity of group cognition (group's cognitive complexity or elaboration of task relevant information) is the linking pin between group diversity and group performance, or as Cooke et al. (2003) stated, the cognitive underpinnings of group performance. From the types of diversity described by Harrison and Klein (2007) only variety has a positive impact on the elaboration of task relevant information, while disparity has disruptive effects.

Group variety is associated with a larger knowledge repertoire which will ultimately be reflected in the complexity of the cognitive map produced by the group. There is, however, the requirement that the variety of knowledge group members have should be relevant for the task (Schruijer & Vansina, 1997). This requirement is also supported by the meta-analysis by Bower, Pharmer, and Salas (2000) who showed that the advantages of group heterogeneity are strictly dependent on the task. The specific task used in this study is to elicit cognitive maps about the concept of collaboration. Gender diversity is certainly related to this particular task and can be conceptualized as variety. The decision quality is higher in gender mixed groups due to the qualitatively different contributions to teamwork men and women have (Rogelberg & Rumery, 1996); therefore, it is expected that when mapping collaboration men and women will contribute with different knowledge structures rooted in different life experiences with collaboration.

Group disparity on the other hand is more likely to trigger misunderstandings and conflicts and will have a negative impact on the complexity of the cognitive map of the group. Few attempts have been made to study the diversity of the groups in terms of the content and structure of the cognitive representations held by individual members. Knowledge and expertise is certainly a relevant resource for groups, especially when they have to perform cognitive tasks. Therefore, the complexity of members' understanding of the issue at hand is a key aspect of group disparity. The disparity attribute we consider in this study is the complexity of the individual cognitive map group members have about collaboration.

## Hypotheses

The efficiency of groups (operationalized as the time needed to complete a cognitive-mapping task) is generally less than that of individuals. However, we expect that when making decisions or discussing a relevant issue (e.g., the meaning of collaboration), people with similar cognitive structures reach consensus faster than groups consisting of people with different cognitive structures. Based on this, it is predicted that both group variety and disparity will have a positive impact on the time needed to reach consensus within the group. However, under the conditions of high cognitive disparity (one group member with a complex knowledge structure and the others with simple cognitive structures), the conversion theory of minority influence (Moscovici, 1980) suggests that most probably the informed or expert minority (in this case the member with a complex knowledge structure) will lead the group toward a deeper information processing of the issue at hand and a greater cognitive activity in the group. To reconcile the different perspectives, the group needs time and, as argued by Harrison and Klein (2007), disparity is also likely to be associated with process losses. Because of that, it is expected that group diversity as disparity will have a stronger impact on the length of group discussions (time to reach consensus) than group diversity as variety.

*Hypothesis 1:* Both disparity and variety will have a positive impact on the length of time needed to reach consensus in groups with disparity having the strongest effect.

However, the criterion for effectiveness is not the time needed to reach consensus, but the volume of knowledge pooled during group discussions. Groups of people with different backgrounds (high group variety) are expected to construct more complex conceptual networks or cognitive maps than homogeneous groups (Curşeu, 2003; Harrison & Klein, 2007). As argued in the previous section, group diversity as variety is expected to have a positive impact on the cognitive complexity of groups, in the sense that the pool of knowledge within the group will be higher in groups composed of members with different types of experiences and expertise (cognitively diverse groups), while group diversity as disparity will have the opposite effect on group cognitive complexity. Therefore, it is anticipated that group diversity will only be beneficial for group cognitive complexity if it is reflected by the variety in perspectives that are highly relevant for the task.

The attributes that ensure greater information richness and variety within groups may differ. Members with different educational backgrounds or with different types of expertise are likely to use their differences in perspectives, ensuring a higher cognitive complexity of the group. Most of the studies concerning the effects of demographic diversity dealt with individual level consequences (low satisfaction, high turnover; see for details, Sacco & Schmitt, 2005). However, demographic diversity is sometimes an accurate proxy for less visible differences (e.g., knowledge, experiences) that are in fact relevant for the task. In a policy development group for racial issues, for example, racial diversity will be closely associated with group variety, and due to a greater informational richness, it will ultimately be beneficial for the group outcomes. A diverse group with respect to gender will also have a higher cognitive complexity if the task requires a variety of knowledge that emerges from gender specific experiences. A similar argument holds for collaboration. Gender is a task-relevant diversity attribute because men and women have different experiences with and attitudes toward collaboration (see, e.g., the results concerning gender differences in negotiations, Stuhlmacher & Walters, 1999). In this respect, gender diversity can be conceptualized as variety and expected to have a positive impact on a group's cognitive complexity.

Further, there is evidence showing that mixed gender groups generate a higher number of alternatives and that they discuss a higher number of ideas (Schruijer & Mostert, 1997), and they are more creative (Hoffman & Maier, 1961) as compared to homogeneous groups. Also in mixed gender groups the quality of decisions is higher than in homogeneous gender groups due to the qualitatively different contributions to teamwork men and women have (Rogelberg & Rumery, 1996). Because the cognitive complexity of groups also depends on the number of issues discussed, as well as on the quality of teamwork, these results support the prediction that gender diversity will be beneficial for the cognitive complexity of groups (in this case the conceptual network of collaboration). To summarize, according to previous research, gender diversity (1) can be understood as variety, and (2) it is beneficial for group creativity; therefore, our prediction is that in tasks that require a variety of informational resources that are one way or another associated to gender-specific traits, gender variety has a positive impact on a group's cognitive complexity.

*Hypothesis 2:* Gender variety has a positive impact on the cognitive complexity of groups.

Group disparity, however, is expected to have a different impact on a group's cognitive complexity. Group diversity conceptualized as disparity involves an asymmetry within a group concerning the distribution of valued assets, with few group members having a particular asset and the majority of group members not possessing it (Harrison & Klein, 2007). If few members within a group have a high level of expertise or, in a more general sense, a high level of cognitive complexity, while the majority of the group members have a low level of cognitive complexity (high disparity), the cognitive complexity of the group will be also low. A similar argument holds for the diversity in individual cognitive complexity (further referred to as cognitive disparity). If only one member in a group has a highly complex conceptual network for collaboration, it is very likely that he or she will try to persuade the others to accept his or her perspective on the issue (see, e.g., the research on minority influence, Moscovici, 1980; Wood et al., 1994). Therefore, it is expected that the general complexity of the conceptual network developed by the group will be rather low, reflecting mostly one perspective on collaboration.

*Hypothesis 3:* Group cognitive disparity has a negative impact on group cognitive complexity.

Cognitive disparity will most probably influence the individual group members as well. It seems reasonable to argue that such asymmetry in cognitive complexity will frustrate the members with a higher cognitive complexity; they will perceive the individual contributions to the group task as unequal, and they will be less satisfied with group processes and outcomes than members with a low cognitive complexity.

*Hypothesis 4:* Group members with a higher CC than the group's CC will be less satisfied about the quality of teamwork as compared with members with a lower individual CC than the group's CC.

*Hypothesis 5:* Participation on the task will be perceived as less equal by group members with a higher individual CC than the group's CC as compared with members with a lower individual CC than the group's CC.

The individual cognitive complexity of the group members is expected to have a positive influence on a group's cognitive complexity. In line with the empirical results reported by Hendrick (1979), we argue here for a direct and positive impact of average individual cognitive complexity on group's cognitive complexity. The higher the cognitive complexity of individual group members, the higher the group's cognitive complexity will be. However, group cognitive complexity is more than just an aggregation of individual cognitive complexities. Group interactions (debates, negotiations, discussions) can shape and reshape the content and structure of the group's conceptual network (or cognitive map), and new patterns of connections among concepts might emerge (which cannot be captured through a simple aggregation of individual cognitive maps; Curşeu, 2003; Curşeu & Rus, 2005). It is therefore reasonable to argue that groups with a high quality of interpersonal interactions (further on referred to as high *teamwork quality*—see for details Hoegl & Gemuenden, 2001) will benefit the most from their members' level of cognitive complexity. In conclusion, we predict that teamwork quality will have a moderating effect on the relation between the average individual cognitive complexity within a group and the group's cognitive complexity.

*Hypothesis 6:* The teamwork quality moderates the relation between the average individual cognitive complexity and the group cognitive complexity, in the sense that the positive effect of average individual cognitive complexity on group cognitive complexity will be accentuated in groups that experience a higher teamwork quality.

## Method

### *Sample*

A sample of 132 students (with an average age of 20.16 years; 74 women and 58 men) participated in a cognitive mapping session in exchange for extra credits for a social psychology course. Only students with previous groupwork experience were used as respondents in our sample. First individually and then in groups of two, three, or four, the students were asked to select from 40 concepts those that according to them are related to collaboration and subsequently to organize them in a way that makes sense to them. Students were grouped in homogeneous (14 male groups and 15 female groups) and heterogeneous (15) groups. After realizing the group maps, the participants were asked to fill in a questionnaire evaluating satisfaction, equal participation to the group outcome, and teamwork quality (communication, collaboration, planning, organizing, conflict, and process efficiency).

### *Procedure*

We used a card-sorting variant of a conceptual mapping technique to explore the way in which individuals and groups represent collaboration. Collaboration is a concept that suits the context of this study because the task content requires a variety of knowledge that is associated with demographic attributes (e.g., gender-specific experiences with collaboration are a relevant source of variety for this particular task). Another conjecture behind the use of this concept is that the concept of collaboration and its links to other relevant concepts can be represented as a network. Students build a conceptual network, in which the relevant concepts are represented as nodes and the relations among them are represented as lines (Bougon, 1983; Calori, Johnson, & Sarnin, 1994). This conceptual mapping technique is particularly relevant for our research because of its vast potential to encompass complex relations and interdependencies in a conceptual domain.

In order to obtain the concepts to be used in the conceptual mapping, we first interviewed five students about their experiences with collaboration. We then used a free association technique to elicit the main concepts related to collaboration from an independent sample of 80 students. In this way we made sure that we found the most relevant concepts used by this particular group (students) to define collaboration. From the interview and from the free association task, the 40 most important concepts were selected. A list of the concepts ranked according to their frequency in the free association task is presented in Appendix A. Given the fact that the respondents had to map the concepts twice and fill in two questionnaires, the time span of the study was of critical importance. Forty concepts can be mapped in a reasonable amount of time (around 40 minutes), and in the same time they give a sufficient richness of the conceptual domain to be mapped. Every concept was written on a different card. The respondents received an envelope with the 40 concepts and an A3 blank sheet of paper and glue. Their task was to distribute the concepts on the sheet in such a manner that their spatial proximity would reflect the extent to which they were related. Afterwards, they were instructed to draw the connections they see among the concepts and to specify the nature of the relations between concepts. The respondents were instructed to use only the concepts that according to them describe or are related to collaboration; therefore, the decision on how many concepts are relevant for collaboration and need to be included in the cognitive map was made by each individual or group.

The complexity of 132 individual and 44 group cognitive maps was investigated using three indicators: (1) map connectivity, a count of the number of connections established between the concepts, (2) map diversity, a count of the number of distinct types of relations established between the concepts (a list and description of possible types of relations among concepts is presented in Appendix B—see for details also Gómez, Moreno, Pazos, & Sierra-Alonso, 2000), and (3) the number of concepts used in the map. We computed the map complexity index based on the following formula: complexity = (connectivity*diversity)/number of concepts (for details, see Curşeu & Rus, 2005). For an illustration on how cognitive map complexity was computed see Appendix C. This formula reflects the embeddedness of the concepts in the conceptual network at hand; therefore, it illustrates the richness of the conceptual knowledge structure developed by groups about collaboration (as it is specified in the definition of cognitive complexity). Previous empirical research shows that the cognitive complexity of student groups (evaluated by this formula) positively and significantly correlates with the general performance of the group (the group grade for the project from which the concepts to be mapped were extracted), with the number of ideas exchanged during group discussions, with the perceived effectiveness of the group as well as with the quality of teamwork (Curşeu, 2003). Finally, as argued before, the cognitive mapping method meets the validity criteria discussed by Bar-Tal (1990) for holistic evaluation methods in group research.

### *Questionnaire*

Group members' satisfaction with the group, perceived equal participation to the group outcome, and teamwork quality (collaboration, organizing, conflict, and process efficiency) were evaluated with an individual questionnaire completed after the group cognitive mapping session.

Satisfaction was evaluated using two items ("How satisfied are you with the group process?" and "How satisfied are you with the outcome of the group?"), rated on a 5-point Likert scale (from 1 to 5). Cronbach's alpha for this scale is 0.83.

Equal participation to the group map was evaluated with four items designed specially for the cognitive mapping session (e.g., "The final map reflects the ideas expressed by all group members," "All group members participated equally in creating the group cognitive map," "My ideas are reflected in the final product of the group," and "The ideas of all group members were incorporated into the final group map"), rated on a 5-point Likert scale (from 1 to 5). Cronbach's alpha for this scale is 0.79.

The quality of teamwork processes was evaluated using four items (rated on a 5-point Likert scale, from 1 to 5) related to collaboration, organizing, conflict, and process efficiency. Previous research emphasized the unitary factor structure of the scales evaluating different facets of teamwork (Curşeu, 2003; Eby, Meade, Parisi, & Douthitt, 1999; Hoegl & Gemuenden, 2001). The content of the items was developed using examples from Eby, Meade, Parisi, and Douthitt (1999) and Hoegl and Gemuenden (2001). Consequently, the four items were used together to evaluate teamwork quality. Cronbach's alpha for this scale is 0.82, with the item evaluating conflict being reverse coded.

A principal components analysis of the scale revealed a unitary factor structure (similar to previous research Curşeu, 2003; Eby, Meade, Parisi, & Douthitt, 1999; Hoegl & Gemuenden, 2001), explaining 70% of the variance with the following factor loadings: Conflict .70 ("How often did members of your group disagree or expressed different opinions in the group?"—reverse coding), Collaboration .83 ("Group members collaborated well and worked together interdependently to achieve the task"), Organizing .90 ("Group activities were well organized"), and Process efficiency .86 ("The group used effective processes to achieve the task").

In order to justify aggregation of individual scores into group scores, we used the procedure introduced by James, Demaree, and Wolf (1984) to estimate the interrater reliability (the index of agreement within groups). The within group agreement index (*Rwg*) can take values between 0 and 1, and generally, a value of 0.70

or higher is considered to reflect a reasonable amount of agreement within a group (James, Demaree, & Wolf, 1984). Table 1 summarizes the *Rwg* for each variable, with the maximum, minimum, mean, and the standard deviation of the *Rwg* scores.

After the within-group agreement was computed and verified, the individual scores of the group members were aggregated into group scores by computing the group mean.

## Group Diversity

The diversity index for gender was computed using a formula proposed by Teachman (1980) and widely used in group diversity literature (Williams & Meân, 2004). The formula is:

$$H = -\sum_{i=1}^{s} P_i(\ln P_i)$$

where $i$ represents a particular category, $s$ is the total number of categories, and $P_i$ is the proportion of the members belonging to the $i$ category. If a group consists of members belonging to $s$ categories, and $P_i$ probability is assigned to a given category, then the $H$ index is a measure of group heterogeneity (structural diversity). The higher the value of the index, the higher is the variety of the group. The theoretical maximum for $H$ depends on the total number of categories ($s$; Williams & Meân, 2004). Since gender is a dichotomous variable, we only had two categories in our formula. For groups consisting of only one category, $H = 0$. This way of computing group diversity is consistent with the conceptualization of group diversity as variety (see for details, Harrison & Klein, 2007).

Cognitive disparity within groups was computed using the coefficient of variation. According to Harrison and Klein (2007) the coefficient of variation is a suitable method for computing group disparity. It is computed by dividing the standard deviation with the group average cognitive complexity. It reaches a maximum when *n-1* group members are at the lower end of the scale, and one of the group members is at the higher end of the scale (Harrison & Klein, 2007). In addition, a heuristic method based on the conceptualization of disparity by Harrison and Klein (2007) was used to compare the results. The groups were divided in three categories: minimum, medium, and maximum disparity. Four groups had minimum disparity (groups in which the majority of the group members had a high cognitive complexity and groups in which all group members had approximately the same level of cognitive complexity). Twenty-seven groups had medium cognitive disparity (groups in which the individual cognitive complexity ranged from low to high and the differences were compressed). Thirteen groups had maximum cognitive disparity (groups in which only one of the members had a very high cognitive complexity); see also Harrison & Klein, 2007, Figure 1).

Table 1
*Within Group Agreement Indices (Rwg)*

| | *N* | Min. | Max. | *M* | *SD* |
|---|---|---|---|---|---|
| *Rwg* equal participation within groups | 44 | .75 | 1.00 | .86 | .06 |
| *Rwg* quality of teamwork processes | 44 | .75 | 1.00 | .84 | .07 |
| *Rwg* satisfaction | 44 | .75 | 1.00 | .85 | .08 |

# Results

The results of this study are reported at two levels of analysis. Hypotheses 1, 2, 3, and 6 concerned the group level of analysis, while Hypotheses 4 and 5 concerned variables evaluated at the individual level of analysis (satisfaction and equal participation). Table 2 shows the means, standard deviations, and correlations for the aggregated variables (group level of analysis), while Table 3 shows the means, standard deviations, and correlations for the individual level of analysis.

To test Hypothesis 1, a stepwise regression analysis was performed, with gender variety introduced in the first step and cognitive disparity introduced in the second step as predictors for the time needed to reach consensus in the cognitive mapping. The results of this regression analysis are presented in Table 4. In Model 2, the standardized beta coefficient for cognitive disparity is positive and significant, while the standardized beta coefficient for gender variety is positive, but not significant. The $F$ change when disparity is introduced in the model is significant [$F(1, 41) = 13.49$, $p <$ .001]; therefore, we can conclude that Hypoth-

Table 2
*Means, Standard Deviations, and Correlations for the Group Level of Analysis*

| | *M* | *SD* | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| 1. Gender variety | .21 | .26 | | | | | | | |
| 2. Cognitive disparity | .35 | .15 | .02 | | | | | | |
| 3. Average ICC | 2.88 | .74 | .22 | | −.21 | | | | |
| 4. Group CC | 2.64 | 1.11 | .21 | −.25 | .56** | | | | |
| 5. Equal participation within groups | 3.88 | .51 | −.13 | −.28 | −.11 | .31* | | | |
| 6. Quality of teamwork processes | 3.92 | .59 | −.10 | −.32* | −.01 | .42** | .83** | | |
| 7. Satisfaction | 3.85 | .55 | .12 | −.18 | .04 | .39** | .79** | .72** | |
| 8. Time to reach consensus | 23.36 | 6.39 | .21 | .49** | .21 | .17 | −.01 | −.10 | .05 |

*Note.* ICC = individual cognitive complexity; CC = cognitive complexity; *N* = 44 groups.
* $p < .05$. ** $p < .01$.

esis 1 which predicts that both group disparity and variety will have a positive impact on the time needed to reach consensus, and the effect of disparity will be the stronger of the two is supported.

A second regression analysis was conducted to test Hypotheses 2 and 3, and the results are presented in Table 5. In this regression analysis, the dependent variable was the complexity of the group cognitive map, while the independent ones are gender variety and cognitive disparity. Hypothesis 2 states that gender variety has a positive impact on group's cognitive complexity, and as shown by the positive standardized beta coefficient, it is marginally supported. Hypothesis 3 states that cognitive disparity has a negative impact on group's cognitive complexity. This hypothesis also received only marginal support since the standardized beta coefficient is indeed negative, but only marginally significant.

In the operationalization of disparity, Harrison and Klein (2007) argue that the use of a coefficient of variation to compute disparity induces the effect of a particular moderating structure of within-group data and therefore they recommend to use a modified regression equation in which the hidden effect of the mean

Table 3
*Means, Standard Deviations, and Correlations for the Individual Level of Analysis*

| | *M* | *SD* | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| 1. Age | 20.16 | 1.95 | | | | | | | |
| 2. Gender | 1.56 | .49 | .10 | | | | | | |
| 3. Equal participation within groups | 3.86 | .64 | −.01 | .08 | | | | | |
| 4. Quality of teamwork processes | 3.90 | .72 | .01 | .05 | .71** | | | | |
| 5. Satisfaction | 3.84 | .76 | −.04 | .16 | .63** | .64** | | | |
| 6. Time to make the individual cognitive map | 33.94 | 7.58 | −.06 | .03 | −.13 | −.18* | −.24** | | |
| 7. ICC | 2.89 | 1.17 | −.03 | .04 | −.02 | .07 | .03 | .02 | |
| 8. Difference between individual and group CC | .25 | 1.29 | −.01 | −.01 | −.24** | −.24** | −.21* | .14 | .59** |

*Note.* ICC = individual cognitive complexity; CC = cognitive complexity; *N* = 132 respondents.
* $p < .05$. ** $p < .01$.

Table 4
*Results of the Regression Analysis for Time to Reach Consensus*

| | Model 1 | Model 2 |
|---|---|---|
| 1. Gender variety | .21 | .20 |
| 2. Cognitive disparity | | $.49^{***}$ |
| $R$ | .21 | $.53^{**}$ |
| Adj. $R$ square | .05 | .25 |
| $F$ change | 1.95 | $13.49^{***}$ |

$^{*}p < .10.$ $^{**}p < .05.$ $^{***}p < .01$

is controlled for. In line with this reasoning, we rearranged the regression equation used to test Hypothesis 3 as:

$$Y = b_0 + b_1(SD_{AICC}) + b_2(\frac{1}{Mean_{AICC}}) + b_3CV_{AICC} + c$$

where AICC is average cognitive complexity within groups. A similar strategy was used for the time to reach consensus. The value for $b_3$ reflects the "clean" effect of cognitive disparity on the cognitive complexity of the groups. The results of the two rearranged regression equations are presented in Table 6 (only the standardized beta coefficients from Model 3 with all the predictors included in the equation are presented in the table). The results of the rearranged regression equations show support for Hypothesis 3 in the sense that the effect of cognitive disparity (corrected for the effect of the mean AICC) on GCC is positive and significant. However, the results for the time to reach consensus were not fully supported and the "clean" effect of disparity on the time groups need to reach agreement on the structure of the cognitive map is positive, but not statistically significant. A possible explanation is the hidden effect of within unit moderating factors (e.g., AICC interacts with cognitive disparity in the sense that the groups that need the most time to reach consensus are the groups with high AICC scores and high scores on cognitive disparity).

Table 5
*Results of the Regression Analysis for Group Cognitive Complexity*

| | Group cognitive complexity |
|---|---|
| 1. Gender variety | $.23^{*}$ |
| 2. Cognitive disparity | $-.26^{*}$ |
| $R$ | $.34^{*}$ |
| Adj. $R$ square | .08 |

$^{*}p < .10.$ $^{**}p < .05.$ $^{***}p < .01$

Table 6
*Results of the Rearranged Regression Equations for Time to Reach Consensus (TC) and Group Cognitive Complexity*

| | TC (Model 3) | GCC (Model 3) |
|---|---|---|
| 1. *SD* AICC | −.05 | .79 |
| 2. 1/Mean AICC | −.28 | .10 |
| 3. CV AICC | .60 | $-.92^{*}$ |
| $R$ | $.54^{***}$ | $.47^{***}$ |
| Adj. $R$ square | .24 | .16 |

*Note.* *SD* AICC = standard deviation average individual cognitive complexity; CV AICC = coefficient of variation for AICC (cognitive disparity).
$^{*}p < .10.$ $^{**}p < .05.$ $^{***}p < .01.$

To further check the operationalization of disparity, we conducted an additional set of analyses. Starting from the alternative conceptualization of group disparity, we heuristically divided our sample in three subgroups based on the distribution of individual cognitive complexities within each group. In order to check if the relationship between cognitive disparity and group cognitive complexity is indeed linear, we plotted the scores of group cognitive complexity based on this distinction. The results are presented in Figure 1.

The results using the second form of operationalization show a reversed U-shaped relation between groups' cognitive disparity and groups' cognitive complexity, with the highest level of complexity for groups with moderate levels of cognitive disparity (see Figure 2). When the coefficient of variation was used as operationalization of disparity, the relation between the groups' cognitive disparity and groups' cognitive complexity is negative and linear. These differences raise the question whether the second operationalization of disparity as presented in Harrison and Klein (2007) is accurate.

Hypotheses 4 and 5 were the only hypotheses for which the data were analyzed at the individual level. In order to test these hypotheses, we artificially split the sample based on the difference between the ICC and GCC. We used the

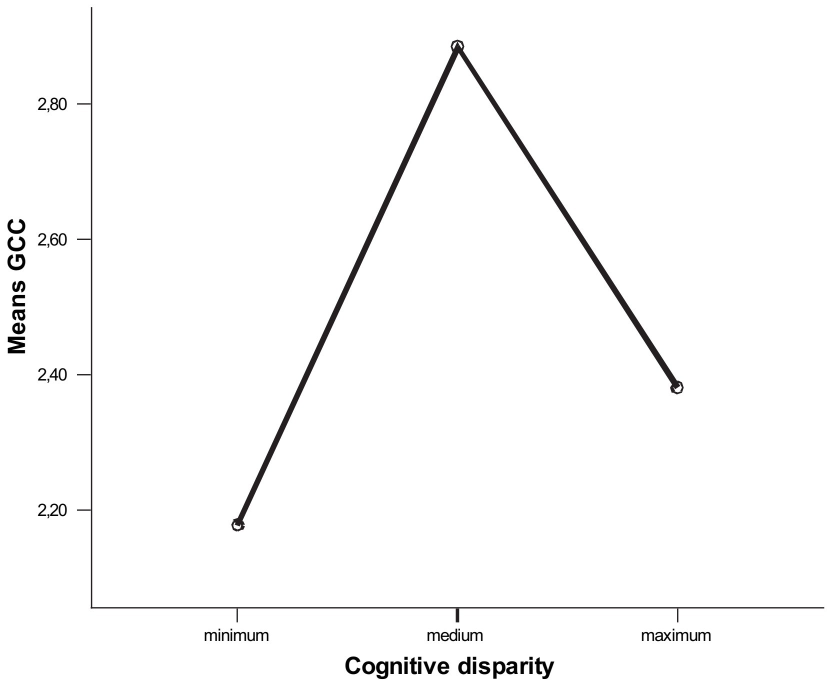


*Figure 1.* Group cognitive complexity as a function of cognitive disparity operationalized as minimum, medium, and high.

mean and standard deviation of the differences between GCC and ICC to obtain three subgroups: the first with an ICC lower than the GCC (lower than the mean minus a standard deviation, $N = 22$), the second with an ICC approximately equal to the GCC (one standard deviation around the mean, $N = 88$), and the third with an ICC higher than the GCC (higher than the mean plus a standard deviation, $N = 22$). Hypothesis 4 stated that group members with a higher CC than the group's CC will be less satisfied about teamwork quality as compared with members with a lower individual CC than the group's CC. A $t$ test for independent samples was computed in order to test it. Group members with a CC lower than the Group CC report a higher satisfaction ($M = 3.84$, $SD = .64$) than the members with a CC higher than the group CC ($M = 3.43$, $SD = 1.18$). The difference, however, is not statistically significant $t(42) = 1.42$ ($p < .16$); therefore, Hypothesis 4 is not supported. Hypothesis 5 stated that the participation to the task will be perceived as being less equal by group members with an ICC higher than the GCC as compared with members with a lower ICC than the GCC. It was tested using a similar procedure as for satisfaction. The results support this hypothesis, showing that group members with a higher ICC than the GCC are less satisfied ($M = 3.50$, $SD = 1.03$) and perceive the individual contributions to the group task as less equal than the group members with an ICC lower than GCC ($M = 4.04$, $SD = .53$), $t(42) = 2.19$ ($p < .03$).

In order to test Hypothesis 6, a hierarchical regression was conducted. In the first step, group cognitive complexity was regressed to both average individual cognitive complexity and quality of teamwork processes. The cross-product term was introduced in the second step of the regression. Multicollinearity can be a problem especially in small samples; therefore, in order to facilitate the interpretation of the results and reduce the multicollinearity (see for details Aiken & West, 1991), the cross-product term was computed based on the centered values for teamwork quality and average ICC. The centered scores were computed by subtracting the sample mean from the original values for teamwork quality and average ICC. The results are presented in Table 7.

The average individual cognitive complexity has a positive effect on group cognitive complexity, a result which is consistent with the results reported by Hendrick (1979). Further, as expected, the quality of teamwork processes has also a positive impact on group cognitive complexity. The cross-product term introduced in the second step also has a significant effect. Therefore, the impact of the interaction between average ICC and teamwork quality on GCC is significant. As shown in Figure 2, the groups with the highest cognitive complexity are those whose members have highly complex maps and experienced effective teamwork processes while working as a group. In addition, we performed a $t$ test for simple slopes to check for the difference in the impact of average ICC depending on the quality of teamwork. The $t$ test for simple slopes was computed by rearranging the regression equations into simple regressions of group cognitive complexity on average ICC for conditional values of teamwork quality (see for details, Aiken & West, 1991). When the teamwork quality is high (higher than the mean for the entire sample), the impact of average ICC on GCC was positive and significant ($b$ = .72, $t$ = 4.55, $p < .0001$). When teamwork quality is low (lower than the mean for the entire sample), the impact is still positive and significant, but much lower than in the first case ($b$ = .45, $t$ = 2.33, $p < .03$). Based on the results from the $t$ test for simple slopes, it can be concluded that the positive impact of average ICC on GCC is significantly accentuated under high teamwork quality conditions. Therefore, Hypothesis 6 is fully supported.

Table 7
*Results of the Regression Analysis for the Interaction of Teamwork Processes and Individual Cognitive Complexity on Group Cognitive Complexity*

| Step and variable | Group CC 1 | Group CC 2 |
|---|---|---|
| 1. Quality of teamwork processes | $.43^{***}$ | $.45^{***}$ |
| Average ICC | $.57^{***}$ | $.56^{***}$ |
| 2. Teamwork quality × Average ICC | | $.23^{**}$ |
| $R$ | $.71^{***}$ | $.74^{***}$ |
| Adj. $R$ square | .50 | .54 |
| $F$ change | $20.91^{***}$ | $3.74^{**}$ |

*Note.* ICC = individual cognitive complexity; CC = cognitive complexity, the cross-product term was computed based on the centered values of quality of teamwork processes and average ICC.
$^{*} p < .10$. $^{**} p < .05$. $^{***} p < .01$.

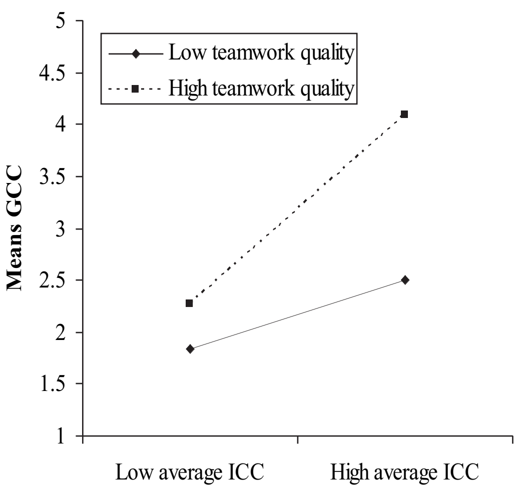


*Figure 2.* The regression slopes for the interaction effect of teamwork processes quality and average individual cognitive complexity (CC) on group cognitive complexity. ICC = individual cognitive complexity; GCC = group cognitive complexity.

## Discussion

In this study we set out to explore the implications of group diversity and teamwork processes on the cognitive complexity of groups. More specifically, we examined to what extent group diversity (as variety and disparity), teamwork processes, and the average ICC within groups explain the complexity of the conceptual networks for collaboration developed by groups. Concerning group diversity, we started from a taxonomy introduced by Harrison and Klein (2007) and argued that group diversity as variety (gender variety) is beneficial, while group diversity as disparity is detrimental for GCC. We also argued that group disparity has negative implications for the individual group members because it is associated with dissatisfaction and perception of unequal participation to the group task. With respect to GCC, we argued in line with other group cognition scholars that it is explained both by ICC and teamwork processes. To examine these contentions, we collected data from 44 groups using multiple methods. Unlike most of the previous research on group cognition, we evaluated GCC as a group-level variable and used a cognitive mapping technique to elicit and represent the conceptual networks for collaboration. Prior, the same method was used to investigate the way in which individual group members make sense of collaboration. A questionnaire was used afterward to investigate the quality of teamwork processes, group members' satisfaction, and their perceptions of individual participation to the group's task.

As predicted by Hypothesis 1, we found that highly diverse groups need more time to reach consensus in a cognitive mapping session and that the strongest impact is obtained for group diversity as disparity. When asked to create a map for collaboration, groups in which only one individual had a highly complex representation about collaboration needed more time to reach consensus than groups in which the cognitive complexity was evenly distributed. The asymmetrical distribution of a highly valued asset for groups (individual cognitive complexity) leads to long debates. This result is in line with the predictions of conversion theory of minority influence (Moscovici, 1980), which states that the presence of an informed (in the terms of our article—highly complex) minority in a group leads to a greater cognitive activity in the group, with the minority trying to persuade the other group members.

Groups high on disparity ended up with group cognitive maps that were less complex than groups low on disparity. When looking at the individual level, the group members with an ICC higher than the GCC were less satisfied and perceived the contribution of the individual group members to the task as more unequal than did those group members with an ICC lower than the GCC. At the systemic level, these results suggest that group disparity is detrimental to group effectiveness, both in terms of performance (GCC) and satisfaction. As theoretically stated by Harrison and Klein (2007) group disparity is indeed associated with process losses (the correlation between the quality of teamwork processes and cognitive disparity is $-.32$), with unequal participation to the task ($r = -.28$), and it creates frustration and dissatisfaction among those individuals that have a high ICC. Although the grouping of individuals according to their ICC relative to the GCC ignores the impact of the within group interpersonal interactions and interdependencies, these results can be used to argue that (1) the cognitive disparity was negatively perceived among group members (see the lower scores on satisfaction and perception of equal participation) and (2) the conversion theory of minority influence yields valid predictions concerning the implications of cognitive disparity on groups' cognitive complexity. Therefore, future theoretical developments should connect these two previously disparate research traditions: group diversity and minority influence, in order to further explore the implications of cognitive disparity on groups' cognitive complexity. Also, in a more practical vein, future research should explore the ways in which the negative effects of disparity can be controlled for in real groups. Previous research shows that the negative effects of expertise disparity on group performance in problem-solving tasks can be counterbalanced if the group members with a low expertise will value the contribution of the member(s) with the highest expertise (see for details, Bonner, 2004). In conclusion, if cognitive disparity is acknowledged by the group members and the most knowledgeable member is allowed to take the lead, the negative impact of disparity can be attenuated.

Group variety has the opposite effects on GCC as compared to group disparity. In this study gender diversity was used as a proxy for group variety in collaboration experiences and attitudes, with the assumption that men and women have qualitatively different experiences with collaboration and so gender can be used as a variety-relevant attribute. Our results indeed show that gender variety has a positive influence on GCC. However, according to most group diversity scholars (Milliken & Martins, 1996; Pelled, 1996; Van Knippenberg et al., 2004; William & O'Reilly, 1998), gender is also likely to trigger social categorization process and the use of stereotypes in interpersonal interactions. Therefore, it is expected that gender diversity will ultimately impede group processes. The small and negative correlation between gender variety and quality of teamwork processes offers partial support for this proposition. It can therefore be concluded that gender diversity has a positive impact on GCC because (1) gender is in this instance an attribute highly relevant for the task and (2) associated with variety. Gender diversity, however, may have disruptive effects for teamwork processes because it triggers social categorization processes and therefore is also associated with separation. One attribute can at the same time stand more than one type of diversity as described by Harrison and Klein (2007). Therefore, the most important challenge for management is how to highlight the positive effects of knowledge variety and to reduce the negative effects of disparity or separation associated with a particular attribute (e.g., gender or race).

The core result of this article refers to the moderator role of teamwork quality in the relationship between average ICC and GCC. Therefore, it puts a key claim of group cognition research to test. Previous research started from the assumption that the elaboration of task relevant information is increased if group members have complex knowledge structures (e.g., Hendrick, 1979). Our study confirms these results showing that the average ICC within groups has a positive impact on GCC. However, the average ICC interacts with the quality of teamwork processes in determining GCC, in the sense that groups with a high average ICC have the highest GCC if they experience high quality teamwork processes. The group members that have complex representations about collaboration construct the most complex group conceptual network for collaboration if they interact in an effective way and if they experience as few process losses as possible.

Group cognition scholars argue that teamwork processes are relevant for the development of team cognition (Rentsch & Woehr, 2004; Salas & Fiore, 2004). Group cognition emerges as a group-level phenomenon from the interplay between the knowledge structures of the group members and the interaction processes that take place within groups (Curşeu, 2006). Although group cognition has been theoretically described as a group-level phenomenon, it was rarely investigated as such. Most of the research focused on aggregating group members' cognitions in order to predict group performance and ignored the interaction processes altogether. The present study went a step further and captured group interactions both in the method to elicit and evaluate GCC and in the role of teamwork processes in GCC. Therefore, GCC was explored in the present study as a characteristic of group cognition that emerges from the interplay between the individual knowledge structures and the quality of interpersonal interactions inside the group.

### *Theoretical, Methodological, and Practical Implications*

Based on our results it can be argued that group disparity influences the group outcomes through teamwork processes, an argument that is also in line with the open system models of group effectiveness (Gladstein, 1984; Hackman, 1987; McGrath, 1984). However, the mediation models of group effectiveness are as important as the open system models because other factors (e.g., emergent states like cohesion, trust, potency) seem to mediate the impact of group diversity on group effectiveness (Ilgen, Hollenbeck, Johnson, & Jundt, 2005; Jung & Sosik, 1999; Marks, Mathieu, & Zaccaro, 2001). Therefore, an interesting research direction will be to test the extent to which teamwork processes and emergent states mediate the impact of group disparity on group effectiveness and how group disparity impacts on specific teamwork processes (see, e.g., the distinction between transition phase processes and action phase processes Marks et al., 2001), as well as the emergent states.

As mentioned before, our study argues that a diversity attribute can be related to more than only one diversity type as described by Harrison and Klein (2007). This raises the question of how to interpret an attribute exclusively in terms of variety, disparity, or separation. The practical implication is that in order to increase the GCC group leaders or managers should focus on increasing variety as much as possible and decreasing separation and disparity within their groups. Moreover, because a single attribute can be related to more than one type of diversity, it is important to note that group variety should not be increased in a way that increases disparity or separation simultaneously.

Another issue concerns the alternative operationalization of group disparity suggested by Harrison and Klein (2007). They suggest that the coefficient of variation is a good indicator of disparity because high values for the coefficient of variation are obtained if a single member in a group has a high score on a certain scale, while others have low scores. The same arguments were provided by Bedeian and Mossholder (2000), who showed that the theoretical maximum for the coefficient of variation is obtained when all cases in a group have zero values except one. On the other hand, Harrison and Klein (2007) suggest another operationalization for disparity (maximum disparity if one group member is situated at the top of the scale, while the others are situated at the lower levels, medium disparity if all group members are equally distributed along the scale and minimum disparity if the majority of the members are situated at the top of the scale, or all members are situated at the same level of the scale—low, medium or high). When we divided our sample according to this second operationalization of disparity, the pattern of results changed dramatically (see Figure 1). The results show that the relationship between disparity and GCC using this operationalization of disparity has an inverted U shape. The small number of groups in the extreme groups (for low disparity, $N = 4$, and for high disparity, $N = 13$) suggests that these results should be interpreted with caution. We conclude that the operationalization of disparity is not yet completely clear and future research is needed in order to extensively test the two operationalizations in parallel.

Our study shows that GCC is a group-level phenomenon that emerges from the interaction between the group members, and as a consequence, it depends both on the ICC of the group members as well as on their interaction while performing the task. Any attempt to explore the cognitive complexity of groups should therefore satisfy the criteria proposed by Bar-Tal (1990) for the evaluation of group-level phenomena. First, they should address the group as a whole. Second, group members' agreement with regard to the construct must be demonstrated. Third, the construct must discriminate between groups and finally the origin of the construct must reflect group interaction processes (Bar-Tal, 1990). The cognitive-mapping technique that was used to investigate GCC in the present article satisfies all these essential criteria for group-level evaluations. In order to investigate GCC further, the use of this technique, as well as other methods that satisfy the above mentioned criteria, is welcomed.

The effect of the interaction between teamwork processes and average ICC on GCC also has straightforward practical implications. It is obvious that in order to get the best out of a group it is necessary, but not sufficient, to bring together the most knowledgeable members. It is also highly relevant to make sure that interaction processes that occur while working at the task are highly effective. Process facilitation interventions and measures might enhance the extent to which the group as a whole uses the cognitive resources of its members in order to get the best possible outcomes.

## References


Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions.* Newbury Park, CA: Sage.

Axelrod, R. (1976). *The nature of decision.* Princeton, NJ: Princeton University Press.

Bar-Tal, D. (1990). *Group beliefs. A conception for analyzing group structure, processes and behavior.* New York: Springer-Verlag.

Bedeian, A. G., & Mossholder, K. W. (2000). On the use of coefficient of variation as a measure of diversity. *Organizational Research Methods,* 3, 3, 285–297.

Bieri, J. (1955). Cognitive complexity-simplicity and predictive behavior. *Journal of Abnormal and Social Psychology, 51,* 263–268.

Bonner, B. L. (2004). Expertise in group problem solving: Recognition, social combination, and performance. *Group Dynamics,* 8, 4, 277–290.

Bougon, M. (1983). Uncovering cognitive maps: The "Self Q" technique. In G. Morgan (Ed.), *Beyond method: A study of organizational research strategies* (pp. 173–188). New York: Sage.

Bower, C. A., Pharmer, J. A., & Salas, E. (2000). When member homogeneity is needed in work teams. A meta-analysis. *Small Group Research, 31,* 305–327.

Calori, R., Johnson, G., & Sarnin, P. (1994). CEO's cognitive maps and the scope of the organization. *Strategic Management Journal, 15,* 437–457.

Carley, K. M. (1993). *Coding choices for textual analysis: A comparison of content analysis and map analysis.* In P. V. Marsden (Ed.), *Sociological methodology* (Vol. 23, pp. 75–126). Oxford, UK: Blackwell.

Carley, K. M. (1997). Extracting team mental models through textual analysis. *Journal of Organizational Behavior, 18,* 533–558.

Cooke, N. J., Kiekel, P. A., Salas, E., Stout, R., Bowers, C., & Cannon-Bowers, J. (2003). Measuring team knowledge: A window to the cognitive underpinnings of team performance. *Group Dynamics, 7,* 179–199.

Cooke, N. J., Salas, E., Cannon-Bowers, J. A., & Stout, R. J. (2000). Measuring team knowledge. *Human Factors, 42,* 151–173.

Cooke, N. J., Salas, E., Kiekel, P. A., & Bell, B. (2004). Advances in measuring team cognition. In E. Salas & S. M. Fiore (Eds.), *Team cognition. Understanding the factors that drive process and performance* (83–106). Washington, DC: American Psychological Association.

Curşeu, P. L. (2003). *Formal group decision-making. A social cognitive approach.* Cluj-Napoca, Romania: ASCR Press.

Curşeu, P. L. (2006). Emergent states in virtual teams. A complex adaptive systems perspective. *Journal of Information Technology, 21,* 249–261.

Curşeu, P. L., & Rus, D. (2005). The cognitive complexity of groups. A critical look at team cognition research. *Cognitie, Creier, Comportament (Cognition, Brain, Behavior) 9,* 681–710.

Devine, D. J. (2002). A review and integration of classification systems relevant to teams in organizations. *Group Dynamics, 6,* 291–310.

Eby, L. T., Meade, A. W., Parisi, A. G., & Douthitt, S. S. (1999). The development of an individual level groupwork expectations measure and the application of a within-group agreement statistic to assess shared expectations for groupwork. *Organizational Research Methods, 2,* 366–394.

Gladstein, D. L. (1984). Groups in context: A model of task group effectiveness. *Administrative Science Quarterly, 29,* 499–517.

Gómez, A., Moreno, A., Pazos, J., & Sierra-Alonso, A. (2000). Knowledge maps: An essential technique for conceptualisation. *Data & Knowledge Engineering, 33,* 169–190.

Goodwin, V. L., Wofford, J. C., & Harrison, D. (1990). Measuring cognitive complexity in the organizational domain. Paper presented at the annual meeting of the Academy of Management. San Francisco, CA.

Hackman, J. R. (1987). The design of work teams. In J. W. Lorsch (Ed.), *Handbook of Organizational Behavior* (pp. 315–342). Englewood Cliffs, NJ: Prentice Hall.

Harrison, D. A., & Klein, K. J (2007). What's the difference? Diversity constructs as separation, variety, or disparity in organizations. *Academy of Management Review, 32*(4).

Hendrick, H. W. (1979). Differences in group problem solving behavior and effectiveness as a function of abstractness. *Journal of Applied Psychology, 64,* 518–525.

Hinsz, V. B., Tindale, R. S., & Vollrath, D. A. (1997). The emerging conceptualization of groups as information processors. *Psychological Bulletin, 121,* 43–64.

Hoegl, M., & Gemuenden, G. H. (2001). Teamwork quality and the success of innovative projects: A theoretical concept and empirical evidence. *Organization Science, 12,* 435–449.

Hoffman, L. R., & Maier, N. R. F. (1961). Quality and acceptance of problem solutions by members of homogeneous and heterogeneous groups. *Journal of Abnormal and Social Psychology, 62,* 401–407.

Hollan, J., Hutchins, E., & Kirsch, D. (2000). Distributed cognition: Toward a new foundation for human-computer interaction research. *ACM Transactions on Computer – Human Interaction, 7,* 174–196.

Huff, A. S. (1990). *Mapping strategic thought.* Chichester, UK: Wiley.

Hutchins, E. (1995). *Cognition in the wild.* Cambridge, MA: MIT Press.

Ilgen, D. R., Hollenbeck, J. R., Johnson, M., & Jundt, D. (2005). Teams in organizations: From Input-Process-Output models to IMOI models. *Annual Review of Psychology, 56,* 517–543.

James, L. R., Demaree, R. R. G., & Wolf, G. (1984). Estimating within-groups interrater reliability with and without response bias. *Journal of Applied Psychology, 69,* 85–98.

Jung, D. I., & Sosik, J. J. (1999). Effects of group characteristics on work group performance: A longitudinal investigation. *Group Dynamics, 3,* 279–290.

Kelly, G. A. (1955). *The psychology of personal constructs.* New York: Norton.

Lagan-Fox, J., Code, S., & Langfield-Smith, K. (2000). Team mental models: Techniques, methods, and analytic approaches. *Human Factors, 42,* 242–271.

Marks, M. A., Mathieu, J. E., & Zaccaro, S. J. (2001). A temporally based framework and taxonomy of team processes. *Academy of Management Review, 26,* 356–376.

McGrath, J. E. (1984). *Groups: Interaction and performance.* Englewood Cliffs, NJ: Prentice Hall.

Milliken, F. J., & Martins, L. L. (1996). Searching for common threads: Understanding the multiple effects of diversity in organizational groups. *Academy of Management Review, 21,* 402–433.

Mohammed, S., Klimoski, R., & Rentsch, J. R. (2000). The measurement of team mental models: We have no shared schema. *Organizational Research Methods, 3,* 123–165.

Moscovici, S. (1980). Toward a theory of conversion behavior. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 13, pp. 209–239). New York, NY: Academic Press.

Okhuyzen, G. A., & Eisenhardt, K. M. (2002). Integrating knowledge in groups. *Organization Science, 13,* 370–386.

Pelled, L. H. (1996). Demographic diversity, conflict, and work group outcomes: An intervening process theory. *Organization Science, 7,* 615–631.

Rentsch, J. R., & Woehr, D. J. (2004). Quantifying congruence in cognitions: Social relations modeling and team member schema similarity. In E. Salas & S. M. Fiore (Eds.), *Team cognition. Understanding the factors that drive process and performance* (pp. 11–31). Washington, DC: American Psychological Association.

Rogelberg, S. G., & Rumery, S. M. (1996). Gender diversity, team decision quality, time on task, and interpersonal cohesion. *Small Group Research, 27,* 79–90.

Sacco, J. M., & Schmitt, N. (2005). A dynamic multilevel model of demographic diversity and misfit effects. *Journal of Applied Psychology, 89,* 1–29.

Salas, E., & Fiore, S. M. (2004). Why team cognition? An overview. In E. Salas & S. M. Fiore (Eds.), *Team cognition. Understanding the factors that drive process and performance* (pp. 3–8). Washington, DC: American Psychological Association.

Schroder, H., Driver, M., & Streufert, S. (1967). *Human information processing.* New York: Holt, Rinehart, & Winston.

Schruijer, S. G. L., & Mostert, I. (1997). Creativity and sex composition: An experimental illustration. *European Journal of Work and Organizational Psychology, 6,* 175–182.

Schruijer, S. G. L., & Vansina, L. (1997). An introduction to group diversity. *European Journal of Work and Organizational Psychology, 6,* 129–138.

Stuhlmacher, A. F., & Walters, A. E. (1999). Gender differences in negotiation outcome: A meta-analysis. *Personnel Psychology, 52,* 653–677.

Sundstrom, E., Busby, P. L., & Bobrow, W. S. (1997). Group processes and performance: Interpersonal behaviors and decision quality in group problem solving by consensus. *Group Dynamics, 1,* 241–253.

Teachman, J. (1980). Analysis of population diversity. *Sociological Methods and Research, 5,* 341–362.

Van Knippenberg, D. van, De Dreu, C. K. W., & Homan, A. C. (2004). Work group diversity and group performance: An integrative model and research agenda. *Journal of Applied Psychology, 89,* 1008–1022.

Weber, S. S., & Donahue, L. M. (2001). Impact of highly and less job-related diversity on work group cohesion and performance: A meta-analysis. *Journal of Management, 27,* 141–162.

Weick, K. E., & Roberts, K. (1993). Collective mind in organizations: Heedful interrelating on flight decks. *Administrative Science Quarterly, 38,* 357–381.

Williams, H. M., & Meân, L. J. (2004). Measuring gender composition in work groups: A comparison of existing methods. *Organizational Research Methods, 7,* 456–474.

Williams, K. Y., & O'Reilly, C. A. (1998). Demography and diversity in organizations: A review of 40 years of research. *Research in Organizational Behavior, 20,* 77–140.

Wood, W., Lundgren, S., Ouellette, J. A., Busceme, S., & Blackstone, T. (1994). Minority influence: A meta-analytic review of social influence processes. *Psychological Bulletin, 115,* 323–345.

Received June 8, 2006
Revision received January 30, 2007
Accepted February 13, 2007 ■

# Appendix A

Table 8
*A List of Concepts Related to Collaboration Ranked on the Basis of Their Frequency in the Free Association Technique*

| Rank | Concept | Frequency |
|---|---|---|
| 1. | Teamwork | 30 |
| 2. | Understanding | 22 |
| 3. | Friendship | 18 |
| 4. | Communication | 18 |
| 5. | Support | 16 |
| 6. | Stress | 14 |
| 7. | Debates | 13 |
| 8. | Time spent together | 11 |
| 9. | Divergences | 10 |
| 10. | Tolerance | 9 |
| 11. | Satisfaction | 9 |
| 12. | Being informed (knowledgeable) | 7 |
| 13. | Frustration | 7 |
| 14. | Group | 6 |
| 15. | Unity | 6 |
| 16. | Influence | 6 |
| 17. | Cooperation | 6 |
| 18. | Meetings | 6 |
| 19. | Involvement | 6 |
| 20. | Interaction | 6 |
| 21. | Knowledge | 5 |
| 22. | Shared ideas | 6 |
| 23. | Effort | 6 |
| 24. | Seriousness | 5 |
| 25. | Achievement | 5 |
| 26. | Compromise | 5 |
| 27. | Patience | 5 |
| 28. | Roles | 4 |
| 29. | Cohesion | 4 |
| 30. | Rules | 4 |
| 31. | Trust | 4 |
| 32. | Consensus | 4 |
| 33. | Arguments | 4 |
| 34. | Innovation | 4 |
| 35. | Punctuality | 4 |
| 36. | Interdependence | 3 |
| 37. | Respect | 3 |
| 38. | Defensive reactions | 3 |
| 39. | Inflexibility | 3 |
| 40. | Conflict | 3 |

# Appendix B

## *A Taxonomy of Types of Relations Identified in the Cognitive Maps (adapted from Gómez, Moreno, Pazos, & Sierra-Alonso, 2000)*

Gómez et al. (2000) discussed the process of conceptualization as a critical element in every problem-solving activity. The authors presented a framework for conceptual modeling in which they described several types of possible relations between concepts (relations are interconnections between concepts in a conceptual network). Seven types of connections are particularly relevant for the case of cognitive maps (for a detailed discussion, see Gómez et al., 2000, p. 174).

Causal relations (CA) describe how a given action or phenomenon induces (determines) another state, action, or event (e.g., A is the cause of B, A needs B, A fires B, if A than B) or describe the conditions or actions are followed by consequences or reactions (e.g., A enables B, A needs B).

Association (ASO) describes how two or more concepts are correlated (e.g., A is related or associated to B, A is connected to B, A is in contact with B) or describes combination of concepts (e.g., A and B are combined to. . .).

Equivalence (EQ) establishes the equality between two or more apparently different concepts, including similarity (establishes which concepts are similar or analogue and to what extent; e.g., A = B + C, A is similar to B).

Topological (TOP) relations describe the spatial distribution of concepts representing physical items (e.g., A is above B, A is to the right of B, A is inside B).

Structural (STR) relations describe how a concept or a group of concepts can be decomposed into parts (also inclusion/exclusion relations, A is a part of B, A and B are parts of C), or describe how several concepts share a common trait or are united by a common element (A, B, and C share common elements).

Chronological (CHR) relations describe the way two or more concepts are related in a time sequence (e.g., A occurs before B, A and B occur simultaneously, A occurs during B, A starts before B ends).

Hierarchical (HIE) relations describe the categorical relation between concepts (one or several elements are subordinated to one or several others) (e.g., A is subordinated to B; A, B and C are subordinated to D), or describe taxonomic relations (e.g., A can be classified as B, C, and D).

(*Appendix continues*)

# Appendix C

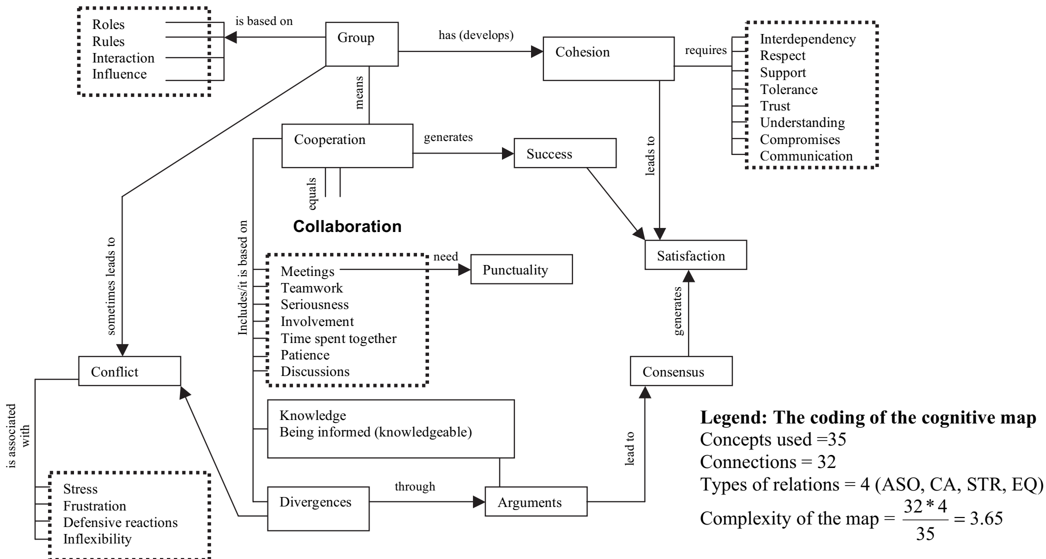


*Figure 3.* Example of a group cognitive map, the coding scheme, and the formula to compute cognitive complexity.