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Development of a Model of Group Cognitive Complexity: A Combined View of a Group Compositional and a Group-as-a-Whole Perspectives*

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Abstract

Drawing on the *input-process-output* model (Hackman 1987), this study attempts to integrate two different perspectives on group-level cognition: a compositional and a group-as-a-whole perspective. A compositional perspective focuses on individual member cognitions and then examines how cognitions of group members combine to produce group-level cognition. In contrast, a group-as-a-whole perspective views group cognition as an emergent quality resulting from group interactions. Using the concept of cognitive complexity, this study explores some aspects of group compositions as a cause for an emergent property of group cognitive complexity, which in turn affects group decision-making effectiveness. This study introduces a causal mapping combined with a group discussion method as a useful tool to measure group cognitive complexity as a collective phenomenon.

Keywords: Group Cognitive Complexity, Group Composition, Causal Maps

INTRODUCTION

Increased competitive pressures and technology advancements have led current organizations to use work groups or teams widely

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in their functions (Sundstrom et al. 2000). Modern tasks are no longer simple and repetitive as in the past. Many tasks are often complicated and complex so that an individual alone cannot manage them successfully. The use of work groups has become popular as a solution to the growing complexity of tasks. However, many group works still involve a variety of cognitive tasks (e.g., problem solving, judgment, inference, and decision-making) and additionally entail new forms of cognitive requirement such as pooling and coordinating resources or inputs of individual members (Cooke et al. 2003). Therefore, the understanding of group-level cognition has gained importance to better understand group behaviors. In particular, scholars of managerial and organization cognition direct their interests toward analysis of collective information processing to explain performance differences between work groups.

In general, in a given decision-making context, effective decision-making cannot be made without an adequate amount of information (Kiesler and Spoull 1982). Therefore, the particular way in which a group searches for and handles information is of great importance in developing a model for effective group decision-making. To be effective decision-makers (both individuals and groups), some scholars have acknowledged the importance of "complicated understanding" (or cognitive complexity), in which organizational problems are seen from multiple perspectives (Bartunek, Gordon, and Weathersby 1983; Weick 1979). The concept of cognitive complexity was originally developed to describe the information-processing characteristics of individuals (Driver 1987). By applying this concept to the group level, this study developed a theoretical model of group cognitive complexity. In developing the model, the present study combines two different approaches on group-level cognitive complexity: A compositional and a group-as-a-whole approach. These two approaches have been applied to understand group-level cognition in general (e.g., group efficacy, group cognitive ability, and so on).

The compositional approach basically focuses on individual cognition and then examines how cognitions of individual group members combine to produce group-level cognition. This approach views that a human is a mental entity capable of thought but that groups do not literally think. Therefore, group cognition can only be characterized meaningfully by studying the attributes of individual members (Gioia and Sims 1986). Herein, one important assumption is that individual members are the fundamental element of a group. The cognitive resources of individual members can, in aggregate, influence the group (Walsh and Ungson 1991). Based on this idea, composition researchers have largely studied individual characteristics of group members as major factors that explain performance differences across groups (Bantel and Jackson 1989; Tziner and Eden 1985).

In contrast, some of the more recent authors subscribing to the group-as-a-whole approach begin to claim "the existence of collective mind" (Neck and Manz 1994; Weick and Roberts 1993); that is, a group can be regarded as a social entity capable of thought, much like an individual. This perspective maintains that group cognition is more than a simple collection of individual member cognitions, and that it cannot be characterized by studying individual members alone. Instead, the group-as-a-whole perspective views group cognition as an emergent product of social interactions.

While both approaches presume that group cognition is an important determinant of group effectiveness, they differ in conceptualizing the group cognition constructs by focusing on a different target. Specifically, while the compositional approach targets the cognitions of individual group members, the group-as-a-whole approach focuses on an emergent product of collective cognition resulting from social interactions. Conceptually, the group-as-a-whole approach is more compelling compared with the compositional approach. The main reason for this is that the former approach is able to approximate the interactive processes that are important during group task performance. However, the compositional approach underestimates the interactional processes among group members who possess different (or similar) attributes.

Although these two approaches differ in terms of conceptualization of group cognition, it does not necessarily mean that the two approaches are competitive in nature. Rather, the two approaches can be used together as a means to understand the phenomena of group cognition better. The *input-process-output* model (Hackman 1987) can serve as the basis for linking the two approaches and their relations to group outcomes. This *input-process-output* model posits that various inputs (e.g., member attributes, task characteristics, and structural characteristics) combine to affect group processes, which in turn influence group outputs.

Following the input-process-output model, this study builds and proposes a theoretical framework for the model of group cognitive complexity. The proposed model incorporates the compositional (*input*) and the group-as-a-whole (*process*) approaches to explain group decision-making effectiveness (*output*). The model specifies how group compositions, in terms of cognitive complexities of members, affect emergent properties of group cognitive complexity, which in turn affect group decision-making effectiveness.

The present study includes several composition methods (e.g., the mean, the variance, and the dominant member) as causes for emergent group cognitive complexity. Before presenting the theoretical model on group cognitive complexity, the literature on cognitive complexity is first reviewed, after which a discussion on group conceptualization of cognitive complexity is provided.

LITERATURE REVIEW

Cognitive Complexity

Different individuals have different ways of looking at the social world. To understand how individuals construct their social events, psychologists have developed the concepts of schemata (Minsky 1975), frames of reference (Shrivastava and Mitroff 1983), and mindscapes (Maruyama 1993). Despite different terminologies, these concepts refer to a cognitive structure that represents an organized and pre-existing knowledge system that guides in information processing (Fiske and Taylor 1991).

Cognitive complexity represents the complexity in the cognitive structure of an individual. Cognitive complexity is defined by two primary structural components: differentiation and integration. Differentiation refers to the ability to perceive several dimensions in a stimulus rather than a single dimension alone, while integration refers to the ability to identify multiple relationships among the differentiated characteristics (Schroder, Driver, and Streufert 1967).

Cognitive complexity has been studied as a predictor of human functioning in a wide range of areas: predictive accuracy (Bieri 1955; Crockett 1965), attribution (Streufert and Nogami 1984), interpersonal attraction and sociability (Adama-Webber 2001), communication (Burleson and Samter 1990), creativity (Quinn 1980), leadership (Zaccaro 2001), negotiation (Pruitt and Lewis

1975), and decision making (Gruenfeld 1995). In particular, with the increasing focus on the information-processing and decision-making perspectives, many researchers have extensively applied the concept of cognitive complexity to understand human information-processing behavior. The concept proposes that people differ in their tendency (or ability) to process information according to their level of cognitive complexity. Empirical evidence supports this theoretical argument. For example, cognitively complex individuals tend to search for a broader range of information and use more information to reach a conclusion, whereas less complex individuals tend to use relatively less information to make a decision (Driver 1987). Other studies have further demonstrated that cognitively complex people, in contrast to less complex people, interpret information in a multi-dimensional manner and integrate information more efficiently (Schroder, Driver, and Streufert 1967).

Cognitive complexity is more concerned with the structure of cognition than the content of cognition. Accordingly, research on cognitive complexity is more interested in the issues of how people think or how information is processed (i.e., structure) as opposed to what they think or what information is processed (i.e., content). This makes cognitive complexity different from other cognitive style measures, such as the Myers-Briggs Type Indicator (Myers and McCaulley 1985), the Kirton Adaption-Innovation inventory (Kirton 1976), and the Allinson-Hayes Cognitive Style Index (Allinson and Hayes 1996), all of which are content based. The content of what information is processed may vary from one activity to the other, whereas the structure-related issue of how information is processed is less sensitive to a particular activity. Thus, some authors have argued that cognitive complexity can be applied to a relatively wide range of human activities (Streufert and Swezey 1986).

Group Conceptualization of Cognitive Complexity

A traditional way of conceptualizing cognitive complexity at the group level is the compositional approach, which first targets the cognitive complexities of individuals and then assigns them to stratified groups according to their levels of cognitive complexity (Hendrick 1979; Stager 1967; Stone, Sivitanides, and Magro 1994). Although such a conceptualization was widely used, it could not reflect group interactive processes during the task performance. In contrast, other scholars supporting the "the existence of collective cognition" view group cognitive complexity as an emergent product of social interactions among group members (Greunfeld and Hollingshead 1993; Streufert and Nogami 1989). From this perspective, group cognitive complexity can be more (or less) than the sum of the cognitive complexities of the individual group members. More specifically, in the course of group interactions, although individual group members bring their own perspectives to a group, collectively, the group is likely to create something beyond the initial individual perspectives.

The two components of cognitive complexity at the individual level (i.e., differentiation and integration) can be applied to conceptualize the cognitive complexity construct of a whole group (Gruenfeld and Hollingshead 1993; Streufert and Swezey 1986). Although the cognition of individuals is not the same as group-based interactions among individual members who present ideas for group discussion, the concepts of differentiation and integration that characterize the information-processing behaviors by individuals can be applied to construe the overall group information-processing characteristics. These two primary components at the group level might be called as group differentiation and group integration. In the conceptualization of group cognitive complexity, the concepts of group differentiation and group integration can account for group interactions (group information processing). Paralleling the differentiation at the individual level, group differentiation could be defined as a function of the number of differentiated perspectives, ideas, or opinions presented by a group (or group members) during a group interaction. For example, in dealing with a problem, if a group approaches in a unidimentional manner or if group members hold a similar perspective, the level of group differentiation is low. In contrast, a group can be characterized as cognitively differentiated if diverse perspectives are presented by the group (or group members).

Likewise, paralleling the integration at the individual level, group integration could be defined as the extent of conceptual connections among the differentiated perspectives presented in a group (or among group members). If a group does not have any rules to connect the differentiated ideas of its members, or if a group relies repeatedly on a pre-established and fixed rule to connect the ideas at all times, the group can be described as having a low level of group integration. Group differentiation precedes group integration and can be precondition for group integration; however, group differentiation itself does not guarantee group integration. For example, even if a group holds a variety of perspectives, if the group lacks a rule to integrate it, the cognitive structure of the group is likely to be fragmented.

In sum, following the group-as-a-whole perspective, this study defines group cognitive complexity in terms of the two components of group differentiation and group integration, which reflects group interactions. This study also explores how the combinations of inputs by individual members (i.e., member cognitive complexities) influence group cognitive complexity. The interdependent nature of groups often poses interpersonal demands on group members. The patterns of group interaction may depend on the characteristics of individual members (i.e., what kinds of people in terms of demographics, personality, cognitive capability, and cognitive style) who belong to a group (Moreland, Levine, and Wingert 1996). In a similar vein, it would be reasonable to expect that the cognitive complexity of the whole group (i.e., that which *emerged* from group interactions) reflects the cognitive complexities of its individual members. To explore the linkages between individual member cognitive complexities and the emergent group cognitive complexity, this study draws on the analytical frameworks developed by the group composition studies: the mean, the variance, and the dominant member.

A THEORETICAL MODEL

The Mean Model

In group composition literature, individual member attributes are aggregated to represent a group-level attribute. Different researchers have adopted various aggregation methods in their investigations. In particular, Steiner's (1972) task typology provided theoretical guidance to group composition researchers for an appropriate choice of aggregation. He classified types of tasks according to how the contributions of individuals become related to group outcome; that is, in terms of additive, conjunctive, disjunctive, and discretionary tasks. In additive tasks, each individual member performs the same task (e.g., lifting a heavy object). The group outcome is a result of the summative combination of the contributions of all the group members, and the average score of member attributes is often used as a proper composition method. The use of the minimum score is regarded as a proper aggregation method if group tasks are conjunctive, particularly, if there is little redundancy in individual roles, and group performance is determined by the performance of the lowest member (e.g., a production assembly line). The use of the maximum score is considered most appropriate for disjunctive tasks, wherein group performance is dependent on the most competent member of a group (e.g., a math equation problem). Finally, in discretionary tasks, group members produce a single solution to an issue where the verifiable answer is unknown (e.g., forecasting stock prices). The average of the contributions of the individual members is suggested as the appropriate aggregation method (Steiner 1972). However, other methods have also been employed because discretionary tasks allow group members to decide how to combine members' contributions as they wish.

Overall, group composition researchers have commonly selected an aggregation method in their studies according to Steiner's task types: mean score for additive tasks, minimum score for conjunctive tasks, and maximum score for disjunctive tasks. If one intends to do a laboratory study that explicitly manipulates the task types, Steiner's typology provides a theoretical basis for the choice of aggregation methods. However, as several scholars have pointed out, real work groups perform various tasks associated with all the task typologies (Argote and McGrath 1993; Goodman 1986). Therefore, it is difficult to apply to the choice of aggregation method by Steiner's typology for actual work groups.

Empirical research investigating the relationships among the three aggregation methods has reported that mean score is substantially correlated to the minimum and maximum scores (Barrick et al. 1998; Williams and Sternberg 1988). This finding is reasonable because the computation of the mean includes both the minimum and the maximum. Moreover, a recent meta-analytic review by Devine and Philips (2001) demonstrated that the mean yields a higher predictive validity compared with the minimum and the maximum score. Day et al. (2004) reported similar findings. In their laboratory study, where Steiner's task types were manipulated, they found that the mean is the strongest predictor of group outcome for all task types: the mean is significantly stronger than the minimum and the maximum, even for conjunctive and disjunctive tasks, respectively. Based on the recent empirical findings, rather than the minimum and the maximum, the present study focuses on the mean score of member cognitive complexities as a cause for an emergent quality of group cognitive complexity.

The basic assumption of the aggregation by the mean is that as the amount of a particular characteristic possessed by individual group members increases, the collective pool of that characteristic in a group increases. That is, a simple linear relationship is postulated between an additive composition of individual member's characteristics and a group-level characteristic.

This simple linear model has guided early cognitive complexity researchers to assume that group-level cognitive complexity increases proportionately to the level of cognitive complexity of individual members in a group (e.g., Hendrick 1979; Stager 1967). Hendrick's (1979) study provided a typical example of the mean model. In his laboratory study, Hendrick measured the cognitive complexity of individual participants and classified them as high or low in cognitive complexity for group selection. Next, he operationalized group cognitive complexity by stratifying participants into two groups based on their scores on cognitive complexity: (1) high-cognitive complexity groups, to which individuals obtaining a high-cognitive complexity score were assigned and (2) low-cognitive complexity groups, to which individuals obtaining a low-cognitive complexity score were assigned. He found that less complex groups (composed of individuals with low cognitive complexity) took approximately twice as long as complex groups (composed of individuals with high cognitive complexity) to successfully complete an assigned task. He also found that, compared to less complex groups, complex group members demonstrated better cue utilization (e.g., more sensitivity to minimal cues and better ability to use them appropriately) and interacted at a faster pace.

The mean model assumes that group cognitive complexity is simply the sum of individual member cognitive complexities; however, this assumption might be wrong because group cognitive complexity is more (or less) than the sum. The group cognitive complexity phenomenon could be better understood if group interactions produced by group members who possess different (or similar) cognitive structure are taken into account. A certain group composition in terms of member cognitive complexities may, to some extent, explain the group cognitive complexity phenomenon; however, this is not sufficient to explain the phenomenon. Based on this argument, the two constructs (average of member cognitive complexities versus group cognitive complexity), which previous research has treated as the same construct, need to be distinguished, and the relationship between them should be investigated. To re-specify the relationships, the present study proposes the average of member cognitive complexities as a cause for the emergence of group cognitive complexity. For example, in a group composed of cognitively complex individuals, group members will be more likely to search for more alternatives and be able to integrate them. Thus, the group as a whole is likely to have a larger collective pool of generated alternatives and be able to synthesize them through extensive evaluations (i.e., high-group cognitive complexity). On the other hand, in a group composed of cognitively less complex individuals, the group as a whole is likely to have a smaller pool of divergent alternatives and show little integration of the alternatives (i.e., low-group cognitive complexity).

From the mean model discussed earlier, the following proposition is derived:

> **P1:** An average of the cognitive complexities of individual members in a group will be positively related to the cognitive complexity of a whole group

The Variance Model

Although the mean model represents a unique feature of group composition characteristics, at the same time, it provides limited information by simply combining group members' individual attributes in an additive manner. In cases wherein interpersonal demands in groups occur, a relatively notable characteristic of some members could be balanced out by the opposite characteristics of others (Barrick et al. 1998). In some cases, this difference may create a new group-level characteristic that is masked by the mean. As such, several composition researchers have shown interest in the issue of how certain distributions of a given characteristics within a group are related to group processes and outcomes (Haythorn 1968; Milliken and Martins 1996). The variance model is concerned with the degree of homogeneity (or heterogeneity) of the individual scores of group members for a particular characteristic, and then examines whether homogeneous groups behave differently compared with heterogeneous groups.

Intuitively, compared with the mean model, variance compositions may generate different patterns of group interactions and group cognitive structure. For a more complete understanding of the relationships between member cognitive complexities and emerging group cognitive complexity, the variance model seems an intriguing issue and worthy of investigation. However, there have been few studies on the variance compositions of member cognitive complexities. While there have been a few exceptions (i.e., Stager 1967; Tuckman 1967), even those studies did not directly address the question of how homogeneity (or heterogeneity) of member cognitive complexities leads to a certain shape of group cognitive structure.

In general, studies on group heterogeneity of a particular trait, based on different theoretical frameworks, have reported mixed findings (Milliken and Martins 1996; Williams and O'Reilly 1998). For example, the social categorization perspective proposes negative effects of group heterogeneity on group function (Berscheid and Walster 1978). According to the theory, interpersonal attraction and liking are determined by the extent to which a member perceives himself or herself to be similar or dissimilar to others. If a member feels dissimilar to others, he or she is less likely to interact and share experience with those dissimilar to him or her, thus resulting in unfavorable group function.

In contrast, the information-processing/decision-making perspective (Knippenberg, De Dreu, and Homan 2004) provides a theoretical foundation for the positive effects of group heterogeneity. According to this perspective, the positive effects of diversity are associated with differences in information (or viewpoints and ideas) among group members. Heterogeneous groups are more likely to process a broader range of information and examine more alternative ideas, thus resulting in effective group function.

Although the issues of whether group heterogeneity (diversity) has positive or negative effects on group processes and group outcomes are inconclusive and still challenge organizational scholars, a number of scholars have proposed different effects of diversity according to a composition variable (Milliken and Martins 1996; Williams and O'Reilly 1998). For example, readily observable attributes such as sex, age, and ethnicity are likely to evoke social categorization processes in groups and produce problematic relations between dissimilar members. Thus, group heterogeneity of such attributes is proposed to have a negative effect on group function. On the other hand, less-visible underlying attributes such as task-related knowledge, values, beliefs, and cognitive bases are linked often to differences in information, opinions, and viewpoints among group members, and this informational diversity is proposed to have beneficial effects on groups.

As cognitive complexity is not a visible attribute and is related to an individual difference variable in information processing, it is expected to be associated with informational diversity. Therefore, drawing on the information-processing/decision-making perspective, this study proposes that the heterogeneity of member cognitive complexities will increase group cognitive complexity. For example, in heterogeneous groups composed of individuals with varying levels of cognitive complexity, differences in ways of information processing among members may give rise to diverse information and perspectives in groups. Faced with diverse information and perspectives, a group as a whole creates a more differentiated cognitive structure. In addition, group members may engage in more elaborate information processing to reconcile the different perspectives than would be the case in the absence of diverse information.

However, it should be noted that too much diversity might disrupt group processes. Specifically, some researchers have suggested a curvilinear relationship between diversity and group effectiveness (i.e., an inverted U-shape) (Knippenberg, De Dreu, and Homan 2004; Williams and O'Reilly 1998). Diversity up to an optimal level may beneficial to groups; however, diversity beyond this level may be detrimental to groups. Following this line of reasoning, it is expected that a group composed entirely of members with high cognitive complexity may suffer from too much information because each highly complex member may bring a great amount of information to the group. Therefore, inclusion of some high-cognitive complexity members will be helpful, but too many high-cognitive complexity members will impair effective development of group cognitive complexity. Given the discussion above, the following proposition is derived:

P2: The variability in the individual cognitive complexity of group members will be positively related to the cognitive complexity of a whole group.

The Dominant Member Model

In the mean and the variance models, each member is assumed to contribute equally to the development of group cognitive structure, regardless of individual status differences in groups. However, group discussion is often dominated by high-status members (Earley 1999; Walsh, Henderson, and Deighton 1988). The consideration of status differences addresses not simply who is in the group but also how members function within the group (Ancona and Caldwell 1998).

Members in a group do not influence group works equally. In real work groups, some members could dominate group discussion, whereas other members may simply comply with the dominant member. Over the life of a group, differentiated status or prestige emerges among group members (Berger and Zelditch 1998). Members who are highly regarded relative to others are likely to acquire high status in a group. Research has reported several personal characteristics associated with status differences among group members: leadership, facilitation ability, assertiveness, knowledge competence, or activeness as members, among others (see Ancona and Caldwell 1998; Levin and Moreland 1990, for a review).

The social influence literature suggests that the patterns of inter-member relationships are formed by status systems (Levine and Moreland 1990). For example, members of high status are more likely to speak and be frequently spoken to, criticize, and interrupt others (Skvoretz 1988). Similarly, research on social cognition suggests that high-status members make larger contributions to the formation of group cognition compared with lower-status members (Earley 1999; Ginsberg 1990; Walsh and Fahey 1986). In his study on group efficacy, Earley (1999) found that a high-status member plays a significant role in the formation of group efficacy belief. In particular, a higher-status member is likely to set expectations for the groups, while lower-status group members are likely to follow the lead of the high-status member.

Other scholars have also noted that a high-status member can serve a crucial function in guiding group members to exchange and evaluate information during group discussion. Gersick (1988) suggested that high-status members often take greater initiative in facilitating information-gathering activities, interpreting information, and resolving disagreements or redirecting group members to process information. Moreover, status may serve a weighting function. Gibson (2003) argued that the information (opinions) suggested by high-status members is more likely to be emphasized during group discussion. Thus, during group interactions, the contributions of high-status members may be weighed more heavily compared with lower-status members.

Drawing on social influence literature, the present study proposes that the cognitive complexity of the dominant member who exerts the strongest influence on the other members in a group affects the development of the cognitive complexity of the whole group. For example, if one member dominates group decision making, the group cognitive structure may be highly influenced by the cognitive system of that member. In contrast, other members who simply endorse the opinions held by the dominant member may not contribute to the group cognitive structure, and their cognitive system may not exist in the group cognitive structure despite their presence during group discussions.

> **P3:** The level of cognitive complexity of the dominant member of a group will be positively related to the cognitive complexity of a whole group.

It should be noted that propositions 1, 2, and 3 are somewhat inconsistent with one another. Specifically, the mean model implies that the more highly complex the members in a group, the higher the group cognitive complexity (proposition 1), while the variance approach maintains that the greater the varying levels of cognitive complexity among members, the higher the group cognitive complexity (proposition 2). In addition, if a single dominant member determines the level of group cognitive complexity (proposition 3), either the mean or the variance model would not be feasible. In spite of the incompatible nature of the different composition methods, each method may account for an independent source of composition effects. Group compositions are multifaceted. There are many different patterns possible, even for a single composition variable (McGrath 1998). Thus, one single composition method is limited, covering only narrow aspects of composition. Although the mean, the variance, and the dominant models are somewhat incompatible, each has a different theoretical rationale. In addition, the use of multiple methods may provide a more complete understanding of how the cognitive complexities of members lead to emergent properties of group cognitive complexity.

Group Cognitive Complexity and Group Decision-Making Effectiveness

Effective decision making cannot be accomplished with insufficient information. Scholars have argued that the quality of a decision is a function of the number of alternatives available in decision-making contexts (e.g., Kiesler and Spoull 1982). The "Law of Requisite Variety" formulated by Ashby (1956) supports the argument. The law of requisite variety maintains that the requisite variety of a system must match the variety or complexity of its environment. In other words, in order to survive, a system (e.g., an individual or group) confronted with a complex decision-making situation must employ a corresponding variety in its responses. A system with inadequate requisite variety incorporates a limited set of responses. Thus, it is unable to react to a situation effectively.

Cognitive structure guides information-processing activities by filtering information from environmental stimuli, organizing and integrating certain aspects of stimuli, and adapting to situational constraints (Schneier 1977). Since the concept of cognitive complexity represents the complexity of cognitive structure, cognitive complexity is applied to understand how a system deals with information-processing behavior and its consequences (Streufert and Swezey 1986). Cognitive complexity has been found to relate to individual differences in information-processing style and resulting in the differences in task performance across individuals. The central idea in cognitive complexity theory is that individuals differ in information-seeking behaviors while performing cognitive activities (e.g., decision making, problem solving, and planning), which are primarily based on their levels of cognitive complexity (Driver 1987). As stated previously, the theory considers the two structural components (i.e., differentiation and integration) that underlie the flow, processing, and utilization of information. More specifically, in a given situation, cognitively complex decision-makers tend to approach an issue in a multi-dimensional way and employ considerably more information compared with less complex decision-makers. Complex decision-makers are also able to synthesize the relationship of diverse information. Furthermore, the concepts of differentiation and integration have been found to relate to effective decision making. Specifically, in addition to employing a wide range of information, complex decision-makers are more likely to make a more thorough and balanced consideration of the relevant information compared with less complex decision-makers, thus reducing the risk of bias, which in turn results in a better decision (Gruenfeld and Hollingshead 1993).

Most studies investigating the effects of cognitive complexity on task performance were conducted at the individual level (e.g., Hendrick 1979; Stager 1967; Stone, Sivitanidee, and Magro 1994). However, similar principles may work at the group-level. Based on the general system theory (Miller 1965), cognitive complexity researchers regard individuals, groups, and organizations as information-processing systems that possess certain general characteristics in common (Driver and Streufert 1969; Streufert and Swezey 1986). They view individuals and groups as having certain basic similarities in information processing (e.g., searching, analyzing, and organizing information) based on their levels of cognitive complexity. Therefore, both are expected to respond to their environments in a similar fashion. Extending the research at the individual level, the present study proposes the following:

> **P4:** The cognitive complexity of a whole group will be positively related to group decision-making effectiveness.

Figure 1 summarizes the proposed model of this study. Based on a system model of group, *input-process-output*, the present study elaborates the relationships between group compositions of member cognitive complexities, an emergent property of group cognitive complexity, and group decision-making effectiveness. Following a group-as-a-whole perspective, the present study defines group cognitive complexity as an emergent property resulting from social interactions among group members. The group compositions (i.e., the mean, the variance, and the dominant member) are derived from the compositional perspective and included as the input variables in the model. The proposed model also contains the relationship between the emergent group cognitive complexity and group decision-making effectiveness. Although some empirical works have

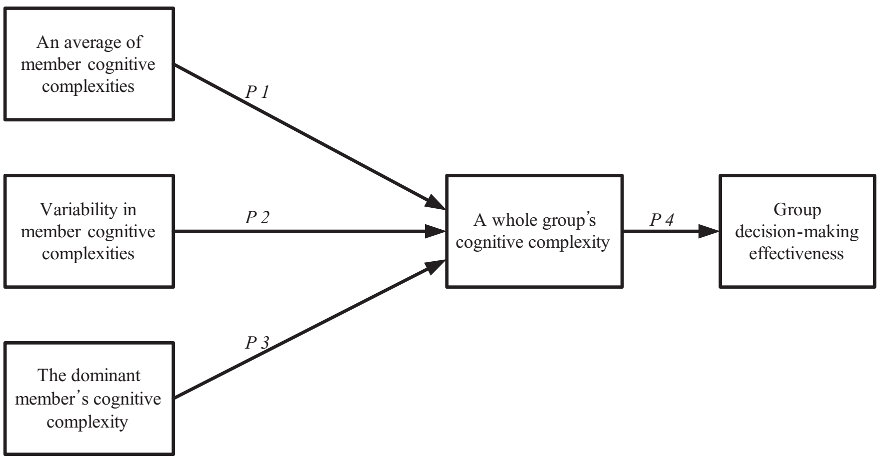

Figure 1. The Proposed Model of Group Cognitive Complexity

suggested the significant effects of group composition on group performance (Hendrick 1979; Stager 1967), they neglect a theoretical explanation for such effects. The inclusion of the emergent group cognitive complexity in the proposed model may provide an intervening mechanism between the composition characteristics and group decision-making effectiveness.

METHODOLOGICAL ISSUES

A critical step in empirically studying "collective cognition" in groups is to develop sound measures. The idea that individuals in groups interact with one another and produce a collective cognition that is qualitatively different from the sum of the individual cognitions is quite compelling. However, little empirical work has demonstrated group cognition as a property of working groups as whole. According to some scholars, the primary reason for this is that the conceptualization of collective cognition generally requires the invention of a new measure to capture cognitive and social interactions among group members (Greunfeld and Hollingshead 1993). This study therefore suggests a causal mapping combined with a group discussion method, which is a useful tool to measure group cognitive complexity as a collective phenomenon.

Causal Maps for Measuring Cognitive Complexity

Several researchers have developed different measurements of cognitive complexity (see Streufert and Swezey 1986, for a review of various cognitive complexity measures). Among the existing measurement methods, this study focuses on causal mapping techniques as appropriate ways to measure emergent qualities of group cognitive complexity, as well as individual cognitive complexity. First, causal maps reflect well the theoretical conceptualizations of cognitive complexity. While some cognitive complexity measures (e.g., Role Construct Repertory Test; Bieri 1955) focus on only differentiation, causal mapping is able to provide the measures of both differentiation and integration. Second, casual mapping enables to obtain cognitive complexity scores, both at the individual and group level (as an emergent group property) via the same procedure. Third, causal mapping provides highly structured elicitation procedures common to each individual. Therefore, it can facilitate, not only aggregation of individual cognitive complexities, but also comparisons between aggregated cognitive complexities and emergent group cognitive complexities.

Causal maps were developed to capture mental models for individuals with regard to a particular domain (Huff 1990; Eden and Ackermann 1992; Narayanan and Armstrong 2005). A causal map consists of concepts and causal relations (cause and effect) that an individual uses to understand a given issue (e.g., causal belief about important aspects of organizational success).

Causal maps are expressed in the form of a network of causal relations. In a graphical diagram, they involve nodes that indicate concepts (factors or variables) and arrows that indicate causal relationships between nodes. For example, if a person perceives that A is a cause of B, the relationship between the two concepts are represented as an arrow originating from A and pointing to B ($A \rightarrow B$).

Scholars in organizational cognition focus on the structural properties of causal maps to measure cognitive complexity (Calori, Johnson, and Sarnin 1994; Carley and Palmquist 1992); that is, the number of nodes and links reflects the complexity of a map. Comprehensiveness and density measures from the social network field are applied to measure the cognitive complexity of an individual (or a group). Comprehensiveness is a measure of the number of nodes in a causal map. This measure highlights the level of differentiation of a map; specifically, the more comprehensive the map (the more nodes in a map), the higher the differentiated cognitive structure of a cognitive system. On the other hand, density can be used for the measure of integration (i.e., how much the concepts in a map are connected). Density is calculated as the number of links between nodes divided by the number of nodes in a map.

On the assumption that the more comprehensive and denser the map, the higher is its level of cognitive complexity, researchers have combined comprehensiveness and density scores to measure cognitive complexity. There are at least two composite measures of cognitive complexity used in previous works on causal mapping: (1) a multiplication of the comprehensiveness score by density (i.e., the number of nodes x [the number of links/the number of node]) (Calori, Johnson, and Sarnin 1994), and (2) an average of the standardized scores of comprehensiveness and density (Nadkarni and Narayanan 2005).

Group Discussion Method

Group property, as a whole, does not emerge from the characteristics of individual members (Klein and Kozlowski 2000). Often, group researchers have difficulty obtaining an appropriate global measure of group-level constructs. In the past, many group researchers relied on aggregate measures of individual data to represent a group-level phenomenon. However, recent research suggests a promising avenue for measurement of a group property as a whole through a group discussion method.

Group discussion method has a unique advantage in satisfying the criteria outlined by Bar-tal (1990). Bar-tal suggested that a group-level construct must reflect the group as a whole, rather than individual members as separate units, and that the origin of the construct must reflect the processes of interaction within the group to best represent an attribute of the group. Several researchers have incorporated Bar-tal's recommendation in their studies (Gibson 1999; Gibson, Randel, and Early 2000). For example, in Gibson's (1999) study on group efficacy, a group was given one copy of a questionnaire and was asked to derive a single collective estimate of group efficacy through group discussion. However, as some scholars have pointed out, the group discussion method may be vulnerable to social desirability influence, and a group-level construct measured using the method is thus distorted (Earley 1999). For example, when a member has an inordinate power over other members, the estimate by the group eventually depends on that single member's personal judgment. Nonetheless, this distortion (resulting from status differences among members) may not be an actual distortion of reality because group interactions often result in disproportionate influence of one member over others (Earley 1999). Therefore, a group discussion method that allows group members to interact with one another, similar to what may really occur in their everyday tasks, may identify a more realistic nature of a group-level phenomenon.

The use of a group discussion method can be applied to elicit group causal maps. For example, when group members are asked to produce a single collective causal belief of their group (e.g., regarding important aspects of organizational success), the open discussion method allows interactions among members, and may capture how a collective cognitive structure arises, which is consistent with the group conceptualization of cognitive complexity in this study.

CONCLUSIONS

The present study attempts to integrate two different perspectives on group-level cognitive complexity based on the input-process-output model (Hackman 1987). The study explored several aspects of group composition as a cause for an emergent property of group cognitive complexity, which in turn affects group decision-making effectiveness. Although past studies have addressed the direct effects of a certain group composition on group effectiveness, they have largely neglected group interactions (e.g., what is going on with group members having similar or dissimilar attributes). The study includes group cognitive complexity, which is conceptualized as an emergent quality resulting from group interaction, in the linkage between group composition and group decision-making effectiveness. This inclusion may help more accurately theorize the underlying mechanism of how group composition affects group outcomes. For the conclusion, this paper discusses the future research directions of group cognitive complexity, including its managerial implications.

Future Research Directions

The first issue to confront in group cognitive complexity research stems from the infancy of this research area in organizational behavior. To progress, basic questions regarding the nature, causes, and consequences of group cognitive complexity need to be investigated empirically. The proposed model in this study may provide a theoretical basis for such studies. In particular, as discussed previously, the use of causal mapping combined with a group discussion method may help to capture group cognitive complexity reflecting group interactions and contribute to an empirical verification of the concept of “the collective mind.”

Several scholars in managerial and organizational cognition have paid increasing attention to group cognition from the group as a whole. However, little is known regarding the factors influencing the emergence of group cognition. In this study, in an attempt to link group compositions and emergent group cognition, the cognitive inputs from individual members are explored as causes of group cognitive complexity. Additionally, research is needed to investigate other possible antecedents for emergent qualities of group cognitive complexity. Although beyond the scope of this paper, some aspects of group processes can be a major cause of group cognitive complexity. For example, the degree of cognitive overlap (i.e., group cognitive diversity explained by Kilduff, Angelmar, and Mehra 2000) among individual members may affect the complexity of cognitive structure of a group as a whole. In addition, information sharing may affect the development of group cognitive complexity, independently of member cognitive complexities. Specifically, group differentiation and group integration (i.e., group cognitive complexity) may depend on the extent to which group members exchange information with one another. When they rarely do so, group processes reduce the amount of available information, and the group as a whole might not be able to utilize the potential available information fully during the group interaction. This may result in reduced group differentiation. Information sharing in groups also affects group integration. If group members fully share their ideas and perspectives, they are likely to maximize their potential to synthesize multiple perspectives. However, when group members do not share perspectives (or ideas) with one another, they are likely to reduce their potential to integrate different perspectives.

The present paper argues that the variability in member cognitive complexities is positively related to the cognitive complexity of a whole group. However, one important issue still remains to be addressed: how much variability is optimal? Research on variability in member abilities suggests inconclusive findings. One group of researchers suggested that large variations in group-member ability had detrimental effects on group performance because of the frustration it creates between members of different ability levels (Secord and Backman 1974). In contrast, another group of researchers offered a possible explanation for why variability in member abilities positively affects group function. According to the social compensation effects (Williams and Karau 1991), capable group members were likely to produce more ideas and exert more effort than they would have done individually to compensate for the weaker members of the group. Taken together, one may argue that the frustration effects may surpass the social compensation effects when group members are very dissimilar in their cognitive complexities. Thus, moderate variability in member cognitive complexities may lead to more effective group cognitive complexity. The issue of how much variability in member cognitive complexities is optimal for group cognitive complexity is intriguing and worthy of investigation.

The proposed relationships between group cognitive complexity and group decision-making effectiveness could be elaborated by considering a contextual factor. For example, the degree of complexity involved during group tasks may alter the strength of the relationships between group cognitive complexity and group decision-making effectiveness. Several theorists have proposed that task complexity play a moderating role in the effects of cognitive complexity on behavioral performance (Driver and Streufert 1969; Schroder, Driver, and Streufert 1967; Streufert and Swezey 1986). They found that when the tasks are simple (e.g., individuals rely on a standard operating procedure in performing their tasks) or extremely complex (e.g., turbulent environments exceed the cognitive capacity of individuals), the differences in performance between high and low cognitive complexities are not significant. In contrast, at the medium level of task complexity, the differences between high and low cognitive complexities are manifested. In this level, cognitively complex individuals perform much better compared with less complex individuals. Although the moderating effects of task complexity largely have been found on individual-level research, similar effects can be expected to the group-level. Thus, further studies on the moderating role of task complexity will extend understanding of the nature of the relationships between group cognitive complexity and group decision-making effectiveness.

Managerial Implications

If empirical studies demonstrate that a certain aspect of group compositions positively influences group cognitive complexity, which in turn positively affect group decision-making effectiveness, then team selection, team design, and team training can be developed. Group composition has frequently been studied as a team design variable. One pragmatic desire in this area is to create more effective work groups by selecting people with particular traits. However, past studies on group composition have largely focused on individual differences measure to predict group outcomes. The mismatch at the level of analysis might mislead the readers and practitioners. Team selection requires considering not only attributes of group members, but also team-level properties (Barry and Stewart 1997; Neuman and Wright 1999). Since the present study explores group decision-making effectiveness using both the individual-level and the emergent group-level attributes, it may be relevant to the practice of team design.

Another practical implication for managers concerns team training. Research suggests that mental modeling by individuals or groups can be taught and developed over time (Fiol 1994). In this sense, a team (group) as a whole is encouraged to utilize the concepts of cognitive complexity in decision-making contexts. The cognitive mapping technique may also offer relevant materials on team training processing, which could assist in team learning over time. For example, once group causal maps are identified, group members can review these with managers or other pertinent staff for possible growth.

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