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Decision Development in Work Groups: A Comparison of Contingency and Self-Organizing Systems Perspectives

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Strategic management teams make decisions that impact the members and profits of organizations; medical ethics boards decide life or death issues; committees composed of faculty members decide which applicants are admitted to graduate programs; government advisors meet to determine national policy. Groups that exist for the main purpose of making decisions impact all our lives (Poole, 1983a). Most groups do not operate in a vacuum; rather, they can be considered as component subsystems operating within larger organizational communication systems. This chapter examines the development of decisions within work groups that are embedded within larger organizational systems.

There has been substantial practical and theoretical interest in group decision making, and a large body of research focuses on group decision-making processes and the group's outcomes. Decision-making processes are typically characterized in terms of the content of the group's interactions. The group's outcomes include, for instance, the correctness of the decision, the group's satisfaction with the decision, the speed with which decisions were made, and the group's commitment to the decision. Several scholars have argued that the group's decision-making processes have a consistent impact on the group's outcomes. This argument has led scholars to closely examine the decision development in work groups. This chapter begins by critically reviewing the traditional and current models of decision development. The remainder of the chapter suggests an alternative intellectual and empirical approach-a self-organizing systems model-to study decision development in work groups,

TRADITIONAL AND CURRENT MODELS OF DECISION DEVELOPMENT

The traditional model of decision development (Bales & Strodtbeck, 1951; Tuckman, 1965) argued in favor of a single sequence model of decision making. This model suggested that in order for groups to be effective (i.e., have positive group outcomes), they should follow a single sequence of phases. Phases are defined as periods when the group focuses on a coherent and uniform communication activity. Some scholars (e.g., Tuckman, 1965) suggested that in order for groups to be effective they should sequentially progress through phases of forming (orientation), storming (conflict), norming, and performing. Others suggested that groups should begin with an orientation phase followed by phases of problem evaluation, solution suggestion, solution evaluation, and solution execution. For example, Bales and Strodtbeck (1951) presented a unitary three-phase pattern. They analyzed the communication interaction of 22 groups by dividing each group meeting into three time periods, and comparing the interaction levels at each of the three phases. Results showed groups begin with a relative emphasis on orientation, then move to a period of focus on problem evaluation, and conclude with an emphasis on control issues.

More recently, scholars (Gersick, 1988; Hirokawa, 1981; Poole, 1981, 1983a; Poole & Roth, 1989a, 1989b) have argued, and empirically demonstrated, that effective groups do not necessarily follow a prescribed sequence of decision development Instead, current models of decision development propose that groups may follow several alternative sequences depending on contingency factors such as task complexity, medium of communication, and group history. Poole (1981) first tested the unitary sequence approach's assumption by comparing the

sequences followed by two sets of groups. Five groups, composed of students, completed a ranking task, and five groups, composed of physicians, completed a program planning task. The 10 group meetings were coded, phases were identified, and the resulting patterns were compared. There were significant intergroup differences in both the number of phases and the order in which phases occurred, contradicting the unitary sequence model. Other empirical evidence supports this finding (Gersick, 1988; Hirokawa, 1981; Poole, 1983a; Poole & Roth, 1989a, 1989b; Scheidel & Crowell, 1964).

"The fault with the [unitary] phases hypotheses may well lie with the linear model so often used" (Scheidel, 1986, p. 117). As early as 1964, Scheidel and Crowell proposed an alternative spiral model, which argued that groups may cycle through many phases during a meeting, and phases may occur within phases. Contrary to the unitary sequence model, the spiral model argues groups make steady progress toward their goal through cyclical phases, not through one linear pattern.

This research and theory supports a multiple sequence model of group decision making, which assumes different groups may have different patterns of phases (Poole, 1981, 1983a). The research challenge shifts from looking for common

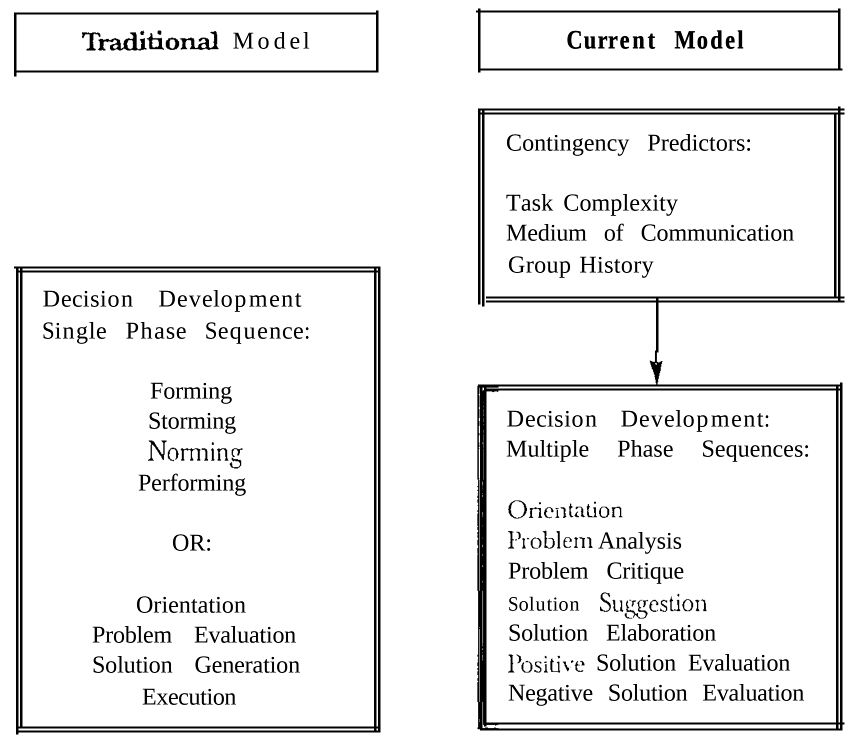

Figure 4.1. Comparison of traditional and current models of decision development.

patterns followed by all groups to identifying what combinations of contingency factors influence the likelihood of a group following a certain decision development path. The traditional and current models of decision development are summarized and contrasted in Figure 4.1.

Research based on the current model of decision development has attempted to accomplish three goals: a coding scheme to describe decision-making communication in groups, phase analytic techniques to identify coherent phases of decision development, and contingency analysis to systematically examine the effect of the proposed contingency variables (such as task complexity, communication medium, group history) on phases of decision development. The remainder of this section describes these three endeavors and critiques their adequacy.

Interaction Coding System

There has been considerable research that has attempted to measure and describe alternative decision development sequences in groups. Poole and his

Table 4.1. *The Decision Function Coding System.*

Decision Function	*Definition*
Problem Definition I: Problem Analysis (PA)	Statements that define or state the causes behind a problem.
Problem Definition II: Problem Critique (PC)	Statements that evaluate problem analysis statements.
Orientation I: Orientation (00)	Statements that attempt to orient or guide the group's process.
Orientation II: Process Reflection (PR)	Statements that reflect on or evaluate the group's process or progress.
Solution Development I: Solution Analysis (SA)	Statements that concern criteria for decision making or general parameters for solutions.
Solution Development II: Solution Suggestion (SS)	Suggestions of alternatives.
Solution Development III: Solution Elaboration (SEL)	Statements that provide detail or elaborate on previously stated alternatives.
Solution Development IV: Solution Evaluation (PSEV/NSEV)	Statements that evaluate (positively or negatively) alternatives before the group.
Solution Development V: Solution Confirmation (SC)	Statements that state the decision in its final form or ask for final group confirmation of the decision.
Nontask (NT)	Statements that do not have anything to do with the decision task. They include off-topic jokes and tangents.
Simple Agreement (SA)	
Simple Disagreement (SD)	

colleagues have developed the DFCS (Poole & Roth, 1989a) to help classify group interactions according to the decision functions they serve. The DFCS is a modified combination of Fisher's (1970) Decision Proposal Coding System and Bales' (1950) Interaction Process Analysis System. The coding categories, their definitions, and their abbreviations used in this chapter are presented in Table 4.1. As indicated, the DFCS categorizes the interaction into six categories: problem definition, orientation, solution development, nontask, simple agreement, and simple disagreement. The first four categories have subtypes, which are enumerated and defined in Table 1.1.

Phase Analytic Techniques

Poole and his colleagues have also developed phasic analytic rrchniclues (Holmes & Poole, 1991; Poole & Roth, 1989b) that aggregate the group's coded interactions into substantively meaningful phases of decision development. The first step in phasic analysis requires coding of group interaction with time-ordered categorical interaction codes indexing various aspects of interaction; the DFCS may be used to index aspects of the decision-making process. The identification of discrete phases and nonphasic periods is based on the assumption that phases are indicated by the consecutive occurrence of a number of the same type of statements. Poole and Roth (1989a) offered the following rules for identifying phases:

1. A phase is minimally defined as three consecutive codes of the same type. The initial boundary of the phase is the first statement type.
2. A phase continues until the occurrence of three consecutive statements that are not of the same type. The ending boundary of a phase is the last statement type before the nonmatching markers.
3. If three codes of three different statement types occur consecutively, the period is nonphasic, meaning no distinctive or coherent behavior is detected.

The phase markers PA PA PA PA 00 00 SS 00 00 00 SS 00 indicate a problem analysis (PA) phase lasting four time intervals (PA PA PA PA), followed by a period of nonphasic activity that includes orientation and solution suggestion statements (00 00 SS), followed by an orientation (00) phase (00 00 00 SS 00) that includes, but is not terminated by a solution suggestion statement. The orientation phase would continue until three consecutive nonorientation statements occurred. Hence phasic analysis can be used to summarize the pattern of phasic and nonphasic activity for any group meeting.

Poole and Roth (1989a) analyzed the phasic patterns followed by 47 groups. Results showed 11 different decision paths, which fell into three categories. The *unitary sequence* path was followed by 11 groups; 22 decision paths followed *com-*

plex cycles, where the groups move through alternating periods of problem analysis and solution development activity; and 19 decision paths were *solution oriented*, as groups spent very little time analyzing problems. The analysis in this study was descriptive; that is, it described different phasic patterns, and did not test specific propositions.

Contingency Analysis

Finally, research based on the current model of decision development has attempted to assess the extent to which alternative phase sequences, identified using the phase analytic techniques described earlier, are systematically associated with contingency variables such as task complexity, medium of communication, and group history (e.g., Poole & DeSanctis, 1992). The empirical research so far has had limited success in identifying a systematic relationship between the contingency variables and specific phase patterns. That is, groups working on similar task types, using similar communication media, and with similar group history are, in general, no more likely to have similar decision development phases than other groups working on different tasks, with different media, and different group histories.

Poole and Roth (1989b) tested 14 propositions predicting characteristics of group decision paths deduced from a contingency model. The contingency model consists of the following three categories of variables. *Objective task characteristics* describe the task independent of the group working on it. *Group task characteristics* are features of the task that depend on the specific group and specific context, such as the degree to which group members have previous experience with similar tasks (task novelty), the degree to which groups need to develop novel solutions (innovativeness), and the time pressure on the group (urgency). *Group structural characteristics* reflect the relationships behveen group members, and include the level of cohesiveness, concentration of power, level of conflict experienced by the group, and the size of the group.

Four measures were utilized to assess the decision development. *Nature of decision path* included the degree to which the path followed the unitary sequence model and the degree to which the decision path was oriented to solutions. *Derision path complexity* included the number of times the group recycles to functions engaged in previously, the number of discrete phases, the amount of conflict, and the length of decision path. *Amount of disorganization* was the amount of time in periods with no phasic activity. The final dependent variable *was proportion of time devoted to each derision activity*. Of the 14 propositions tested by Poole and Roth, two were supported, three were partially supported, and nine were rejected.

Hence, although recent empirical research, which incorporates powerful and sophisticated coding and aggregating tools, offers overwhelming evidence that groups follow different decision development patterns, there is little evidence that these differences can be systematically indexed to the proposed contingency variables.

CRITICAL REVIEW OF CURRENT MODELS OF DECISION DEVELOPMENT

There are at least three responses to this lack of empirical evidence. First, one can argue that the measuring and coding instruments being used are not sufficiently well calibrated to capture key aspects of decision development. Second, the phase analytic techniques used to aggregate the decision development can be further improved. Third, the group's decision development may not be systematically influenced by the contingency variables that have been examined in these studies; instead alternative contingency variables need to be included in future research. Although these are plausible criticisms, they are based on the ontological and epistemological assumptions that a group's decision development is predetennined by time-invariant contingency variables.

These assumptions preclude a situational explanation (Carley, 1991, Suchman, 1987) of the group's decision development. That is, the current model assumes that a group's decision development phases are not expected to be influenced by emergent and time-varying phenomena within the group. These time-variant phenomena may include, for instance, the history of the decision development, the evolving social influence relationships among group members, and the random fluctuations in the group's prior decision development. Allowing for such considerations implies that it is not appropriate to look for consistent decision development paths in groups that are exposed to similar time-invariant contingency variables.

Whereas studies based on the current model of decision development have had difficulty in making generalizable knowledge claims about observable group behavior, these claims may exist at the level of generative mechanisms (Contractor, 1994; Gersick, 1988), which take into account time-variant phenomena. Generative mechanisms are "the set of fundamental 'choices' a system has made of (1) the basic parts into which its units will be organized and (2) the basic activity pattern that will maintain its existence" (Gersick, 1988, p. 14). The same mechanism may result in different interaction patterns for similar initial conditions. This alternative approach argues in support of developing a self-organizing model (Contractor, 1994; Smith & Comer, 1994) that looks for consistency in the mechanisms that situationally generate the group's decision development.

Work groups must then be modeled as stochastic dynamic systems that are guided by consistent generative mechanisms resulting in unique emergent decision development phases. The emergent phases themselves are not necessarily consistent across groups. Empirical validation of the predicted decision development phases would indicate that generalizable knowledge claims about a work group's decision development exist at the level of generative mechanisms rather than at the level of observable behavior. The remainder of this chapter offers some preliminary steps for dynamically modeling decision development in work groups.

PROPOSED SELF-ORGANIZING MODEL OF DECISION DEVELOPMENT

Overview

A self-organizing model focuses on identifying generative mechanisms that situationally specify the dynamics of decision development. Rather than making a priori predictions about phasic patterns based on contingency variables, a self-organizing model specifies the extent to which various time-invariant and time-variant situational variables increase or decrease the likelihood of a certain interaction at a particular point in time. Later in this chapter, we describe how these specifications, or generative mechanisms, can be deployed to deduce hypotheses about the relationships behveen contingency variables and the empirically observed decision development phases.

An illustration may help distinguish the a priori propositions offered by the current model of decision development and the generative mechanisms proposed by the self-organizing model of decision development. A proposition based on the current models of decision development may predict that groups involved in brainstorming tasks will exhibit longer solution suggestion phases and fewer solution evaluation phases than groups involved in negotiating a solution to a problem. However, such a priori hypotheses do not take into consideration the influence of emergent interactions that may transpire within these groups. For instance, the relative social influence of members in these groups may influence, and be influenced by, the members' interaction such that the emergent decision development phases may contradict the hypothesized predictions. In contrast, a self-organizing model of decision development begins by specifying generative mechanisms that include time-invariant variables (such as task complexity, communication medium, and group history) and time-variant variables (such as decision development history, member's relative social influence, and random fluctuations). Unlike current models, a self-organizing model is equipped to hypothesize the circumstances and the likelihood of brainstorming groups engaging in shorter solution suggestion phases or more solution evaluation phases than negotiation groups.

As suggested earlier, a self-organizing model requires the specification of a generative mechanism for each type of decision communication. Building on research conducted within the current model of decision development, genera-

tive mechanisms need to be specified for each of the types of decision function categories identified in the DFCS. The likelihood that a statement classified in one of these decision function categories is made at any point in time is influenced by two classes of variables: time-variant and time-invariant.

Time-invariant variables correspond to the predictors used in the current models of decision development. They include task complexity, medium of communication, and group history. For instance, a *generative* mechanism for problem analysis statements (one of the DFCS categories) may specify task complexity as a time-invariant predictor. That is, there is a likelihood of a problem analysis statement being made in groups that are involved in complex tasks.

Time-variant variables index the group's emergent activities. We propose hvo such emergent activities: the group's prior decision development history and the group's social influence network. First, the group's prior decision development history will influence the likelihood of occurrence of certain types of decision statements. For instance, a generative mechanism for positive solution evaluation statements may specify solution suggestion as a time-variant predictor. That is, the occurrence of a solution suggestion statement increases the likelihood of a subsequent positive solution evaluation statement. Second, the group's emergent social influence nehvork will influence the likelihood of occurrence of certain types of decision statements. For instance, a generative mechanism for positive solution evaluation statements may specify the relative social influence of the member as a time-variant predictor. That is, a solution suggestion made by a group member with high relative social influence increases the likelihood of a subsequent positive solution evaluation. Likewise, a suggestion made by a group member with lower relative social influence attenuates the likelihood of a subsequent positive solution evaluation.

One may argue that the group's social influence network can be specified as a time-invariant variable that does not change during the group's decision development. However, there is empirical research indicating that group members' social influence is influenced by group participation (Skvoretz & Fararo, 1996). Hence, our model proposes that the group's social influence nehvork be considered as time-variant and emergent. This implies that we need to specify generative mechanisms that indicate what aspects of participation during the decision development are likely to increase or decrease a member's social influence relative to other group members. For instance, a generative mechanism for increasing a member's relative social influence may specify phase transition as a predictor. That is, members' likelihood of increasing relative social influence in the group increases if they are successfully able to transition the group's decision development from one phase to another.

Figure 4.2 summarizes the proposed self-organizing model of decision development and contrasts it with the current model. As already described, the model specifies a series of generative mechanisms for the occurrence of individual statements during the decision development. The generative mechanisms specify

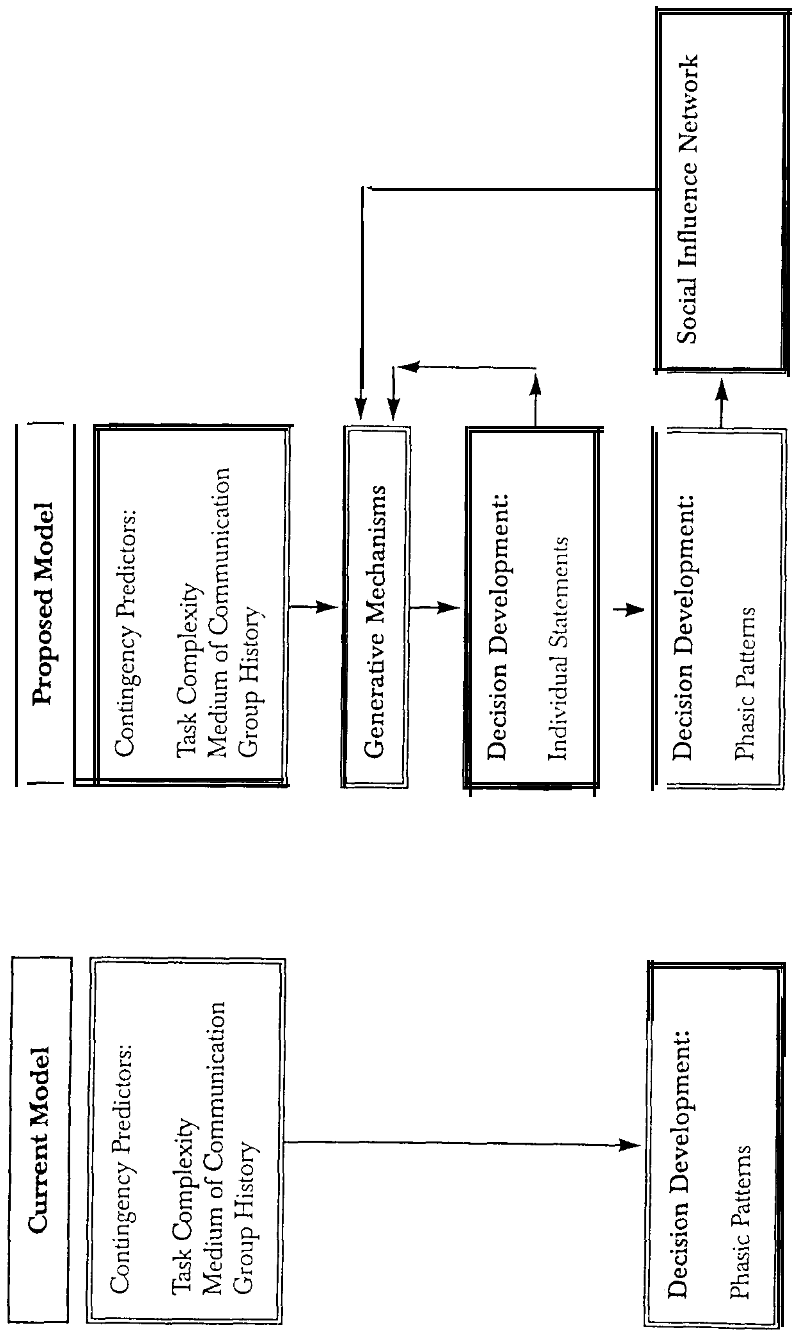

Figure 4.2 *Comparison of current and proposed models of decision development.*

three inputs: contingency predictors (such as task complexity, medium of communication, and group history), prior statements in the group's decision development, and the social influence nehvork. Further, the social influence network is itself influenced by the prior phases in the group's decision development.

Variables in the Self-Organizing Model of Decision Development

This section offers a detailed description of the time-invariant and time-variant variables outlined earlier, as well as indices of decision development. Time-invariant variables exist when a group begins its decision development and do not change subsequently. Included in this category are task type, communication medium, and length of prior group history. Time-variant variables include the group's decision development history and the group's social influence network. Indices of decision development include complexity, disorganization, and proportion of time devoted to each decision function activity.

Time-Invariant Variables.

Task type. Task type, the first time-invariant variable, is defined as the immediate objective a group is seeking to accomplish (Poole, 1983a), and has been demonstrated to have significant influence on the group process (McGrath & Hollingshead, 1994; Poole & Roth, 1989b). Of the several dimensions associated with group task, *task complexity* has been empirically demonstrated as being both stable across different contexts and having great promise for understanding the group process (Morris, 1966). Task complexity has been defined as the amount of effort required to complete the task (Morris, 1966) and as the degree of cognitive load required to solve a problem (Payne, 1976). Gouran and Hirokawa (1983) argued different types of tasks require groups to meet different preconditions to have a successful outcome. It follows that complex tasks should have more preconditions, and/or those preconditions should be more complex. Thus, tasks may be categorized as being simple or complex depending on the amount of effort required to complete a task and the preconditions needed for success.

Medium of communication. A second time-invariant variable is the communication medium used by groups. Many work groups are utilizing synchronous computer-mediated communication (CMC), which allows interactive communication of written text and graphics among group members via computer. Thus, nonverbal cues or auditory information are not available to group members. A burgeoning area of research analyzes how the communication process and decision outcomes over these systems vary from face-to-face meetings (Hiltz & Turoff, 1978, 1985; Kiesler, 1986; McGrath & Hollingshead, 1994; Poole & DeSanctis, 1992; Rice, 1980; Seibold, Heller, & Contractor. 1994; Watson, DeSanctis, & Poole, 1985).

Group history. The third and time-invariant variable is group history, defined as the length of time a group has already been working together. Groups with a longer history have developed norms for behavior (Applebaum, Bodaken, Sereno, & Anatol, 1974) that will influence subsequent interactions. For instance, Heller (1992) found that groups with a longer history were less likely to adapt their interaction norms as compared to groups that had no prior history. Group history is considered a time-invariant variable, in the sense that when a group meets, it has a fixed length of history, ranging from no history at all to many years of working together. This does not vary during the course of their decision development.

Time-Variant Variables

Decision development history. The first time-variant predictor variable is decision development history, or the type of statements made in previous time intervals. Statements of a given type should influence the likelihood that other types of statements will be made. For example, a solution suggestion statement is likely to be followed by a solution elaboration statement. This interact is represented by one type of statement in the DFCS, followed by a "–", followed by another type of DFCS statement. The example here is symbolized as: solution suggestion-solution elaboration.

Social influence network. The second time-variant variable is the group's social influence nehvork. We utilize a nehvork conceptualization of social influence, which emphasizes influence as an emergent property of the connection or linkage (Contractor & Eisenberg, 1990; Knoke & Kuklinski, 1982) among group members. In this conceptualization, social influence is viewed as an asymmetrical n by n matrix, where the cell entry represented by Row i and Column j refers to the social influence of Person i over Person *j*, and n represents the number of people in the group. The asymmetrical matrix indicates that any two indiviclunls in a group do not necessarily perceive each other as having the same influence. Person A may perceive Person B as influential, whereas Person B may not perceive A to be equally influential.

This section has described two types of factors that impact the group process. Time-invariant factors include task type, communication medium, and group history; time-variant factors include decision development history and social influence network. One or more of these factors influence the group members' likelihood of making statements categorized in the DFCS.

Decision** Development **Indices. As discussed previously, phasic analysis techniques are used to parse the group's decision development. Poole and Roth (1989b) developed three indices of decision development to characterize and compare various phase sequences. This section describes these three indices: path complexity, disorganization, and the proportion of time devoted to each decision function activity.

Complexity. Path complexity is defined as the number of distinct phases in the given path, controlling for meeting length. This is done by plotting each meeting's phasic sequences scaled on a 100-point time line. The length of each phase represents the percentage of the total discussion it occupies. A simple path has fewer phases of longer length; a complex path has a larger number of phases of shorter length.

Disorganization. The second decision development index is the amount of disorganization in the decision path. This is measured as the proportion of the total meeting time spent in nonphasic activity.

Proportion of time. The third decision development index is the proportion of time devoted to each decision activity by the group. There will be an individual proportion for each of the categories in the DFCS.

Generative Mechanisms in the Self-Organizing Model

This section demonstrates how the variables already described can be used to specify generative mechanisms. We specify, by way of example, generative mechanisms for four of the decision categories included in the DFCS: problem analysis, problem critique, orientation, and solution suggestion. We also specify generative mechanisms for the likelihood of increase or decrease in the group's social influence network at any point in time. Before articulating specific generative mechanisms, it is worth noting two components that are common across most self-organizing systems: influence of random fluctuations and the inertial tendency of dynamic processes (Contractor, 1991).

Generative mechanisms in self-organizing systems allow for the influence of random fluctuations. Random fluctuations are justified on logical and empirical grounds. Logically, the self-organizing model assumes that the emergent process of decision development is not deterministic and hence is open to, and responds to, random fluctuations. Empirically, the inclusion of random fluctuations serves a surrogate for unidentified variables that may influence the generation of problem analysis statements, but arc assumed to vary at random across the groups being modeled.

Further, generative mechanisms in self-organizing systems allow for the inertial tendency of dynamic processes. As discussed earlier, a self-organizing model of decision development is based on the premise that the likelihood of activity at a certain point in time is situationally influenced by the activities preceding it. Although this includes other variables, it also includes the prior status of the activity itself. That is, the likelihood of an event occurring at a certain point in time will be situationally influenced by the occurrence of that same event at the prior point in time. This rationale is heretofore summarily referred to as the *inertial tendency* of interaction.

Generative* Mechanism for *Problem Analysis Statements. In addition to random fluctuations and the inertial tendency, we identified three characteristics that will influence the generation of problem analysis statements by group members: task complexity, medium of communication, and prior negative solution evaluation statements.

First, as discussed earlier, simple tasks require a group to generate as many ideas as possible; complex tasks have more stringent criteria; the group needs to cither determine the correct decision, or reach consensus. The need to identify criteria for complex tasks will increase the need for group members to spend time analyzing the problem and its underlying assumptions. Hence, complex tasks will increase the likelihood of a problem analysis statement being made.

Second, Hiltz, Johnson, and Turoff (1986) and Strauss (1991) found that computer-mediated groups had proportionately more task-related communication than face-to-face groups. These results imply that the use of a computer-mediated communication medium will increase the likelihood of problem analysis statements being made

Third, during group interactions, solutions may be suggested and evaluated. If the given evaluation is negative, the respective solution may be rejected and the group may need to return to analyzing the pr-oblem to develop new alternatives. Hence, a *negative solution evaluation statement made in the preceding time interval will increase the likelihood of a problem analysis statement being made.*

T&en together, these three elements, along with random fluctuations and the inertial tendency, specify the generative mechanism for problem analysis statements being made at any point during the decision development. The generative mechanisms can be summarized in the following equation

$$PA_{jt} = TT + CMC + (NSEV_{i\,t-1})(I_{ij}) + (PA_{i\,t-1})(I_{ij}) + \text{Random Variable}$$

This equation states that PA_{jt}, the likelihood of group member *j* making a problem analysis (PA) statement at Time *t*, is an additive function of (a) the task type (TT) being complex; (b) the communication medium being computer-mediated (CMC); (c) the occurrence of a negative solution evaluation (NSEV) statement at the previous time interval *(t*–1) by Member *i*, weighted by I_{ij}, the influence of Member *i over* Member j; (d) the occurrence of a problem analysis statement at the previous time interval by Member *i*, weighted by I_{ij}, the influence of Member *i* over Member j; and (e) random fluctuations described by a random variable.

***Generative Mechanism for Problem Critique* Statements.** In addition to random fluctuations and the inertial tendency, we identified hvo characteristics that will influence the generation of problem critique statements by group members: medium of communication and prior problem critique statements.

First, as discussed earlier, research indicates that groups Using CMC engage in more task-related communication than face-to-face groups (Hiltz et al. , 1986; Strauss, 1991). These results imply that a group's use of a computer-mediated medium will increase the likelihood of problem critique statements being made.

Second, when group members make problem analysis statements, they are providing interpretations of issues Underlying the problem. It is unlikely that there will be total agreement about such statements, and members who do not agree with one another's analysis will likely be critical. Hence, a problem analysis statement made in the previous time interval will increase the likelihood of a problem critique statement being made in the present time interval.

Taken together, these hvo elements, along with random fluctuations and the inertial tendency, specify the generative mechanism for problem critique statements being made at any point during the decision development. The generative mechanisms can be summarized in the following equation:

$$PC_{jt} = CMC + (PA_{i\,t-1})(I_{ij}) + (PC_{i\,t-1})(I_{ij}) + \text{Random Variable}$$

This equation states that PC_{jt}, the likelihood of group Member j making a problem critique statement at Time *t* is an additive function of (a) the group's use of a CMC medium; (b) the occurrence of a problem analysis statement in the previous time interval by Member *i* ($PA_{i\,t-1}$), weighted by I, the influence of Member *i* over Member j; (c) a problem critique statement in the previous time interval by Member *i*, ($PC_{i\,t-1}$), weighted by the influence of Member *i* over Memberj (I_{ij}), and (cl) random fluctuations described by a random variable.

Generative Mechanism for Orientation Statements. In addition to random fluctuations and the inertial tendency, we identified two characteristics that will influence the generation of orientation statements by the group: task complexity and medium of communication.

First, Poole & Roth (1989b) discussed the *process effectiveness model* of group decision making, which argues that groups will organize to the extent to which the situation demands. When the task is a simple one, there is no need for an organized process; thus, the group will focus on the content of the discussion. However, complex tasks require groups to choose amongst alternatives. To accomplish this, groups must develop criteria by which to evaluate the solutions, and discuss solutions in relation to these criteria. These tasks will require more orienting of the group process than simply making suggestions independent of evaluation. Hence, complex tasks will increase the likelihood of an orientation statement being made.

Second, CMC is still a relatively new medium, and it is likely the typical group member will not have had much experience with this type of medium. Participants will need to decide how they will interact with each other over the computer, necessitating more orientation statements concerning the group process (McGrath & Hollingshead, 1994). Hence, a CMC will increase the likelihood of an orientation statement being made.

Taken together, these two elements, along with random fluctuations and the inertial tendency, specify the generative mechanism for orientation statements being made at any point during the decision development. The generative mechanisms can be summarized in the following equation:

$$OR_{jt} = TT + CMC + (OR_{i,t-1})(I_{ij}) + \text{Random Variable}$$

This equation states that OR_{jt}, the likelihood of Member j making an orientation statement at Time t, is the additive function of (a) the task type being complex (TT); (b) the use of a CMC medium; (c) an orientation statement at a previous time interval by Member i, weighted by the influence of Member i over Member j (I_{ij}); and (d) random fluctuations described by a random variable.

Generative Mechanism for Solution Suggestion Statements. In addition to random fluctuations and the inertial tendency, we identified three characteristics that will influence the generation of solution suggestion statements by the group: medium of communication, prior negative solution evaluation statements, and prior problem analysis statements.

First, several studies have analyzed how outcomes of brainstorming tasks taking place over a CMC system vary in different conditions. Computer-mediated systems offer the opportunity for concurrent brainstorming. Dennis and Valacich (1993) found 12-member CMC groups generated more novel ideas than 12-member nominal groups. This suggests that a computer-mediated medium will increase the likelihood of a solution suggestion statement being made.

Second, during group interactions, solutions may be suggested and evaluated. If the given evaluation is negative, the respective solution may be rejected. If this occurs, the group may suggest a different alternative for discussion. Hence, a negative solution evaluation statement made in a previous time interval will increase the likelihood of a solution suggestion statement being made in the present time interval.

Third, when a group is analyzing a complex task, they may determine issues that underlie the problem. After this is accomplished, they will be in a better position to suggest alternatives based on their discussions. Hence, a problem analysis statement made in the previous time interval will increase the likelihood of a solution suggestion statement being made in the present time interval.

Taken together, these three elements, along with random fluctuations and the inertial tendency, specify the generative mechanism for solution suggestion statements being made at any point during the decision development. The generative mechanisms can be summarized in the following equation:

$$SS_{jt} = CMC + (NSEV_{i,t-1})(I_{ij}) + (PA_{i,t-1})(I_{ij}) + (SS_{i,t-1})(I_{ij}) + \text{Random Variable}$$

This equation states that SS_{jt}, the likelihood of group Member j making a solution suggestion statement is the additive function of (a) the use of a CMC medium; (b) a negative solution evaluation statement ($NSEV_{t-1}$) at a previous time interval by Member i, weighted by the influence of Member i over Member j (I_{ij}); (c) a problem analysis statement (PA_{t-1}) at a previous time interval by Member i, weighted by the influence of Member i over Member j (I_{ij}); (d) a solution suggestion statement (SS_{t-1}) at a previous time interval by Member i, weighted by the influence of Member i over Member j (I_{ij}); and (e) random fluctuations described by a random variable.

*Generative Mechanism for the **Social Influence** Network* We identified five characteristics that will influence the generation of changes in the social influence network in the group. Three of these-phase initiation, phase transition, and solution suggestion followed by solution evaluation-increased social influence, whereas the remaining two–initiation of disorganization and solution evaluation followed by negative solution evaluation-decreased social influence.

First, a phase transition occurs when an individual makes a statement that initiates a new phase of a different type without causing a period of disorganization For example, a group may be in a problem analysis phase and a member is able to direct the process to a solution development phase without any intermediate disorganization. This demonstrates control over the group process, and thus the member's social influence in the group is likely to increase. Hence, when a group member triggers a phase transition, the member's social influence is likely to increase.

Second, a phase initiation occurs when a group is in a period with no phasic activity, and an individual makes a statement that initiates a phase. That is, discussion has shifted from unrelated issues and has become focused. Group members increase their social influence if they are able to control the flow of discussion by shifting the group from disorganization to phasic activity. Hence, when a group member makes a phase initiation statement, the member's influence is likely to increase.

Third, the solution suggestion–positive solution evaluation interaction will likely increase the social influence of the person who made the solution suggestion. When group members make suggestions, they open themselves up to evaluation by others in the group. If this evaluation is positive, members will be viewed as more influential. Hence. when a group member makes a solution suggestion statement that is followed by a positive solution evaluation statement, the social influence score of the member making the suggestion is likely to increase

Fourth, an initiation of disorganization occurs when an individual makes a statement that leads the group from a phasic period into a period of disorganization (nonphasic). If group members trigger a period of disorganization (a non phasic period), their influence will likely decrease. Hence, when a group member makes an initiation of disorganization statement, the individual's influence is likely to decrease.

Fifth, the solution suggestion-negative solution evaluation interaction will decrease the influence of members who made the solution suggestion statement. As discussed, when members make suggestions, they open themselves up to evaluation by others in the group. If this evaluation is negative, the members would likely be viewed as less influential. Hence, when a group member makes a solution suggestion statement that is followed by a negative solution evaluation statement, the influence score of the person making the suggestion is likely to decrease.

Taken together, these five elements, along with random fluctuations and the inertial tendency, specify the generative mechanism for changes in the group's social influence network at any point during the decision development. The generative mechanisms can be summarized in the following equation.

$$I_{ijt} = PI_{t-1} + PT_{t-1} + SS_i - PSEV_j - ID_i - SS_i - NSEV_j + I_{ijt-1} + \text{Random Variable}$$

This equation states that Member i's social influence over Member j (I_{ijt}), is likely to increase if there is (a) a phase initiation by Member i (PI_{t-1}); (b) a phase transition by Member i (PT_{t-1}); or (c) a solution suggestion by Member i is followed by a positive solution evaluation by Member j ($SS_i - PSEV_j$). Member i's influence over Member j is likely to diminish if (a) Member i is responsible for the initiation of disorganization (ID_i); (b) a solution suggestion by Member i is followed by a negative solution evaluation by Member j ($SS_i - NSEV_j$); and (c) random fluctuations are described by a random variable.

METHODS

Computer Simulations

The set of generative mechanisms for all the decision statement categories taken together comprise the self-organizing model of decision development. Because the generative mechanisms describe the likelihood of a group member making a particular decision function statement, from a computational standpoint, each group member is most appropriately modeled as an object (Pohl, 1993; Taylor, 1990). The self-organizing model of decision development can bc used to estimate the likelihood of various decision function statements being made, given a priori information about the group's task type, communication medium, history, existing social influence network, and decision development history.

Although it is possible for us to articulate each of these generative mechanisms from one time period to the next, it is not humanly possible for us to mentally construe the decision development paths over several points in time, for all the generative mechanisms taken together. The challenge is even more daunting for groups of larger size. Because there is considerable debate on the effect of size on group processes (Moreland & Levine, 1992), it is important that simulations be

Table 4.2 Simulation Design

Condition	Task Type 1 = Simple 2 = Complex	Medium 1 = Face-to-face 2 = CMC	History 1 = Short 2 = Long	Number of Simulation Runs
1	1	1	1	475
2	1	1	2	47.5
3	1	2	1	475
4	1	2	2	475
5	2	2	2	475
6	2	2	1	475
7	2	1	2	475
8	2	1	1	475

conducted with various group sizes. Computer simulations in an object-oriented environment are especially useful to overcome this problem (Zeggelink, 1993).

Table 4.2 presents a computer simulation design that will provide us with an opportunity to systematically examine the dynamic implications of the self-organizing model of decision development for four-member groups. This size was chosen because much of the small-group literature has utilized the four-person group (Hollingshead & McGrath, 1995); further, a four person group is large enough to allow conditions such as coalition formation to occur, as hvo groups of hvo people can take opposing positions on a conflict. Clearly additional simulations should be conducted for groups of different sizes. In an object-oriented programming environment, simulations for groups with different sizes can be conducted without any additional programming effort.

The simulations are designed to track the decision development among groups of four members who are exposed to one of two types of tasks, one of two communication media, and have either a short or long group history. These four-member groups can be created on the computer as objects that are then randomly assigned to one of the eight (2 × 2 × 2) conditions outlined in Table 1.2. The number of simulations to run for each condition should be determined by a statistical power analysis. Because this simulation is the first attempt at validating the proposed mechanisms, it is desirable to maximize the likelihood of identifying their implications. Thus, a low critical effect size of .15 is used with an alpha of .05 and power of .90 is desired. These criteria require 461 simulation runs for each condition. Thus, 475 simulations should be run in each of the eight conditions, for a total of 3,800.

Analysis

The data generated from the computer simulation described earlier is the analytic equivalent of longitudinal data coded from 3,800 groups' transcripts. Like those, this data should be analyzed using the phase analytic techniques described earlier. Next, the phases should be used to compute the three sets of decision development indices: identification of the number of phases, percentage of time spent in disorganized activity, and the percentage of time spent in each activity.

The decision development indices, which characterize the group's decision development, serve as the dependent variables in our analysis. The conditions used in the simulation design (task type, communication medium, and history) serve as the independent variables. A (multivariate analysis of variance) MANOVA can be used to assess direct as well as hvo-way and three-way interaction effects of the independent variables on the dependent variables. The presence of a significant effect will imply a hypothesis deduced from the self-organized model of decision development. This hypothesis will then require empirical validation. It is important to recognize that the proposed statistical analyses do not serve to test the hypothesis on empirical data. Instead, they are being used on computer-generated data, to deduce hypotheses that must then be validated empirically.

The methods described in this section are clearly very labor intensive and computationally demanding. However, the self-organizing model of decision development, including the entailed simulations and the subsequent deduction of hypotheses, offer a more sophisticated and plausible attempt at trying to address the lack of consistent findings in current research on decision development in work groups.

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