SUPERVISORY ROLES, COLLEAGUE ROLES, AND INNOVATION IN SCIENTIFIC GROUPS

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Abstract

Innovation of groups of scientists was related to performance of "colleague roles," utilizing a model of organizational decision making proposed by Farris (1971). In more innovative groups, supervisors were named less often by group members as useful for original ideas, but more often for providing critical evaluation. Members of more innovative groups named one another more often as useful for providing technical information and help in thinking about technical problems. Organizational information was available from fewer sources inside or outside the more innovative groups. Supervisors of more innovative groups named more outside sources as useful to them for original ideas. These trends are very consistent with Maier's (1967) emphasis on the leader's "integrative function" in group problem solving.
In most research and development laboratories, work is carried out by groups of scientists and engineers. Within a given organization some groups are often cited consistently as being more innovative than others in their R & D work. What factors distinguish these more innovative from less innovative R & D groups?

Previous research has considered factors such as diversity of group members (Pelz, 1967; Pelz & Andrews, 1966), group age (Shepard, 1956; Wells & Pelz, 1966) and characteristics of the supervisor (Andrews & Farris, 1967). Although research on small group problem solving (for reviews, see Cartwright & Zander, 1968; Hoffman, 1965; and Collins & Guetzkow, 1964) suggests that characteristics of the interaction among group members are important determinants of group performance, little research has been devoted to the problem-solving process of scientific groups.

Recently, Farris (1971) proposed that the interaction among members of an organization in making decisions can be conceptualized in terms of the roles they perform for one another in this process. His model considers three stages in the problem-solving process: suggestion, proposal, and solution. (See Figure 1.) Different "colleague roles" -- activities

| Insert Figure 1 About Here |

performed by one scientist which facilitate the problem solving of another -- are hypothesized to be particularly important during each stage. (All roles may be somewhat helpful at any stage.) Providing original ideas, technical information, and administrative information are said to be impor-
tant colleague roles which help a scientist to come up with a suggestion. Help in thinking through a problem and critical evaluation are important in shaping the suggestion into a proposal. And, assuring a fair hearing and providing administrative help are colleague roles which can help in turning a proposal into a solution which is implemented in the organization. Research to date (Farris, 1971; Swain, 1971) has focused on individuals who perform these roles, examining their personal characteristics, working environments, and career development. The present research extends this conceptual approach to the group level.

A central concern in much of the literature on group problem solving has been the relative importance of the formal leader and group members in performing various roles important for innovation. One school of thought (e.g., Maier, 1967) has emphasized the importance of roles performed by the leader of a problem-solving group. Another, often considering "leaderless" groups, has emphasized roles which can be performed by any group member (e.g., Bales, 1950; Benne & Sheats, 1948). Bowers and Seashore (1966) discuss both "supervisory leadership" and "peer leadership." If, following French (1956), leadership is considered to be the ability of one person to influence the behavior of another, then three parties may exert leadership in the problem solving of scientific groups: the supervisor, the group members, and people from outside the group. The relative importance of each is subject to empirical investigation.

In the present study the innovation of scientific groups will be related to the performance of colleague roles for group members by three parties: the supervisor, other group members, and scientists from outside the group. Then the roles performed by the supervisor will be examined in more detail, relating the innovation of his group to his orientation inside and outside his group. Finally, the problem-solving processes of more and
less innovative groups will be compared by examining the performance of each colleague role at each stage. As shown in Figure 2, group innovation will be related to seven colleague roles performed by:

1. The supervisor for his group.
2. Group members for other members.
3. Outsiders for group members.
4. The supervisor for outsiders.
5. Outsiders for the supervisor.
6. Group members for the supervisor.

**METHOD**

The study was conducted in a division of a NASA research center engaged in a wide variety of R & D activities related to aerospace. Their tasks ranged from basic research on physical and chemical processes to the conduct of atmospheric and deep space experiments using rockets and satellites. One hundred and seventeen professionals participated in this study, including 87 bench scientists in 14 groups, headed by first-line supervisors. The mean group size was 6.2 members, excluding the supervisor, and half the groups contained fewer than 5 members. The groups ranged in size from 2 to 17 members.

As part of an extensive questionnaire describing aspects of their working environment and motivation, the participants in the study were asked to name individuals they saw as being useful to them for seven colleague roles:

Considering the technical activities you have been involved in over the past few years, which people have been most useful to you for the following:

(The same person may be named as many times as
A. Locating relevant technical information you did not know about previously. (Spaces for up to eight names were provided in each part).

B. Helping your thinking about technical problems -- e.g., picking out fruitful problems, clarifying the nature of a problem, changing the direction of your thinking about a problem.

C. Critical evaluation of your ideas.

D. His own original ideas.

E. Making sure your ideas get a fair hearing or preventing competing ideas from winning out prematurely.

F. Providing administrative help in getting you needed resources and facilities.

G. People from whom you learn about technical and administrative developments happening in (name of division.)

For each role, six scores were determined for each group, corresponding to the possibilities shown in Figure 2.

1. The per cent of group members who mentioned their supervisor.

2. The percent of possible choices of group members by other group members. The number of possible choices was N(N-1), where N = the number of bench scientists in a group.

3. The average number of scientists outside the group mentioned by a group member.

4. The number of times the supervisor was mentioned by "outsiders," (people from outside the group who participated in the study).

5. The number of outsiders mentioned by the supervisor.

6. The per cent of group members who were mentioned by their supervisor.
The innovation of each group member was rated by judges who claimed to be familiar with the scientist's work. Innovation was defined for the judges as the extent the scientist's work had "increased knowledge in his field through lines of research or development which were useful and new". Judges were supervisors or senior-level non-supervisors. An average of 7.6 judges, working independently, used a modified rank-ordering procedure to rate the innovation of each scientist's work. Since the judges showed reasonably good agreement (Spearman-Brown estimate for reliability of a multiple item scale = .87), their evaluations were combined into a single percentile score for each scientist. These percentile scores were then adjusted to remove effects attributable to two background factors: time at R & D center, and degree (B. S., M. S., or Ph. D.). Group innovation scores were then calculated by determining the mean adjusted innovation score of the group members (excluding the supervisor). Details on these types of procedures for collecting, combining, and adjusting measures of scientific performance are more fully described in Pelz and Andrews (1966).

RESULTS

The groups were divided at the median innovation score into high and low-innovation categories. The scores on the seven colleague roles were then examined to determine 1) whom the group members find helpful for performing colleague roles, 2) the supervisor's orientation toward his group and outsiders in the performance of colleague roles, and 3) for each colleague role, at each stage in the problem-solving process, the differences which occur between the more and less innovative groups.2

Roles performed for group members

Figures 3-5 show the extent to which members of high and low innovation groups have found three parties to be helpful in their technical work:
their supervisor, other group members, and people outside the group.

Insert Figure 3 About Here

Figure 3 shows the per cent of group members who mention their supervisor for colleague roles. On the average, slightly more than fifty per cent of them mention their supervisor. This figure ranges from a high of over 60% for help in thinking and critical evaluation to a low of less than 40% for original ideas. Supervisors are mentioned quite frequently for both technical and administrative roles.

In general the high innovation groups mention their supervisor more than the low innovation groups. Differences are most pronounced for critical evaluation and slightly smaller for help in thinking and administrative help. There appears to be a tendency for the low innovation groups to mention their supervisor more often as being useful for his original ideas.

Figure 4 shows the choices of group members by other group members for

Insert Figure 4 About Here

the seven colleague roles. Overall, group members choose one another quite often, but because there is also a high number of possible choices, the percentages shown in Figure 4 are quite low. They range from 1% to 14%, with an average a little over 6%. Group members tend to find one another useful chiefly for technical roles and least for administrative help and making sure their ideas receive a fair hearing.

Members of the high innovation groups tend to choose one another more often for two technical roles: locating technical information and help in thinking about technical problems; members of low innovation groups tend to
find one another as more useful for administrative roles, especially providing news of developments in the R & D division.

Figure 5 shows the number of scientists outside the group who are mentioned by group members for the seven colleague roles. Overall, they mention about one outsider per man. Outsiders are seen as most useful for providing technical information and help in thinking and least useful for assuring a fair hearing for group members' ideas.

Although the differences are small, there is a trend for the low innovation groups, more than high innovation groups, to mention more outsiders as useful to them. Outsiders are especially more useful to the low innovation groups for help in thinking and assuring a fair hearing for their ideas.

To summarize these trends, it appears that all three parties -- the supervisor, other group members, and outsiders -- perform colleague roles for these scientific groups. Group members are named most often, but the supervisor receives a higher percentage of possible choices. The supervisor and outsiders provide both technical and administrative help, while group members are helpful chiefly in technical areas. The high innovation groups appear to solve problems more as teams. Members find one another more useful for technical roles but less for administrative roles; outsiders are mentioned less often as useful; and their supervisor is more useful to them. This finding indicates that the supervisor may be very much a member of the high innovative groups as they engage in technical problem solving. Let us examine the supervisor's roles in more detail.

**Supervisor's inside-outside orientation**

Figure 6 shows the average number of times the supervisors were mentioned
for the colleague roles by scientists outside their group. Across all roles, supervisors are mentioned by an average of a little over one outside person. Outsiders mentioned the supervisors most often for locating technical information and least often for providing a fair hearing or administrative help.

Overall, supervisors of low innovation groups tend to be mentioned more often by outsiders than supervisors of high innovation groups. The strongest differences in this direction occur for the technical roles, especially help in thinking and providing original ideas. For two administrative roles -- providing a fair hearing for ideas and administrative help -- the trend is reversed.

Figure 7 shows the average number of outsiders mentioned by the supervisors for the various colleague roles. Across all roles, supervisors mention slightly under three outsiders per role. Outsiders are mentioned most often by supervisors as helpful to them for providing technical information and least often as useful for original ideas.

Compared to supervisors of high innovation groups, supervisors of low innovation groups mention more outsiders as useful to them for five of the seven roles. Outsiders are especially more useful to supervisors of low innovation groups for help in thinking about technical problems and providing news of developments in the division. Supervisors of high innovation groups tend to mention more outsiders as useful to them for their original ideas.

Finally, Figure 8 shows the per cent of group members who are mentioned
by their supervisor as helpful to them in their technical problem solving.

Virtually no group members are mentioned by their supervisor as helpful for administrative roles. For the four technical roles, an average of about one in five group members is mentioned by his supervisor. Group members are especially useful to their supervisor for help in thinking and original ideas; they are least helpful for providing critical evaluation.

The differences between the high and low innovation groups are striking. Supervisors of high innovation groups mention more group members as helpful to them for all technical roles: locating technical information, help in thinking about technical problems, critical evaluation, and original ideas.

In summary, these trends indicate that the supervisors of the high innovation groups are a more integral part of their groups' technical problem solving and less oriented toward the outside for technical roles. They find their groups more useful to them for their own technical problem solving, and, as shown in Figure 3 above, their groups mention them more often as helpful. Moreover, they are mentioned less often by outsiders for technical roles, and they mention fewer outsiders for technical roles (except original ideas). For the more organizationally oriented roles, the trends are mixed. Let us explore the trends for each role in greater detail.

Roles in the decision-making process

Recall that Farris' (1971) model of organizational decision making consider the process in three stages: suggestion, proposal, and solution (see Figure 1).
Different colleague roles were said to be more important for each stage: original ideas, technical information, and administrative information for coming up with a suggestion; help in thinking and critical evaluation in shaping the suggestion into a proposal; and a fair hearing and administrative help in the executive decision to make the proposal an actual solution. How does this process differ in the high and low innovation groups? Although the present study was not longitudinal so that colleague roles and problem-solving stages could be investigated over time, an examination of colleague roles according to the stages with which they theoretically should be most strongly associated produced some interesting trends.

Table 1 recasts the data on colleague roles according to the stage of the decision making process. Let us examine each stage separately.

**Suggestion stage.** Supervisors of the high innovation groups name more colleagues -- both group members and outsiders -- as helpful to them for providing original ideas. On the other hand, they tend to be named less often by others -- both outsiders and group members -- as helpful for their own original ideas. No differences were found in the original ideas colleague role as performed by other group members or outsiders.

Supervisors of the high innovation groups tend to name more group members and fewer outsiders as useful to them for locating technical information. They are named slightly less often by outsiders for this role. There is a tendency for members of the high innovation groups to name one another more often as useful for providing technical information, but no differences occur in the extent to which they name their supervisor or outsiders.
Both the supervisor and the members of the high innovation groups name fewer colleagues -- group members, outsiders, or the supervisor -- as useful to them for providing news of technical and administrative events in the organization.

To summarize, in the suggestion stage it appears that the supervisors of the high innovation groups bring to their groups original ideas from more sources (other scientists' ideas, not their own) and technical and organizational information from fewer sources. Group members furnish one another with more technical information and less organizational information. Thus, in the suggestion stage, the high innovation groups appear to have available original ideas from more sources inside and outside the group but not from the supervisor himself, more technical information generated within the group, and organizational information from fewer sources of any kind.

Proposal stage. Supervisors of the high innovation groups name fewer outsiders and more group members as useful to them for help in thinking about technical problems. Similarly, they are named less often by outsiders and more often by their group for this role. Also there are tendencies for group members to receive more help from one another and less from outsiders.

A similar pattern occurs for critical evaluation. Compared to supervisors of the low innovation groups, supervisors of the high innovation groups name their groups more and outsiders less as helpful in this role. These supervisors in turn are named much more often by their groups and less often by outsiders as helpful for critical evaluation. No difference occurs in the performance of the critical evaluation role for the group by either other group members or outsiders.

In summary, all members of the high innovation groups, including the supervisor, are apt to help one another in thinking about technical pro-
blems. For giving and receiving critical evaluation, the supervisor is similarly more oriented toward his own group than outsiders. Moreover, the extent to which the supervisor provides critical evaluation for his group is a key factor in distinguishing the high and low innovation teams.

Solution stage. The differences between the high innovation and the low innovation groups are smaller at this stage of the problem-solving process. Both the group and outsiders tend to name the supervisors of the high innovation groups more often for providing administrative help. Very small differences in the same direction occur for the role, "providing a fair hearing for your ideas." Supervisors of the high innovation groups tend to name outsiders less often for a fair hearing and more often for administrative help.

DISCUSSION

The findings of this exploratory study indicate that the problem solving of scientific groups is facilitated by their supervisors, fellow group members, and scientists from outside the groups. Group members are especially helpful in performing technical roles; supervisors and outsiders are helpful in both technical and administrative areas.

A comparison of the relatively high and low innovation groups in this laboratory indicated that the high innovation groups tend to work more as a technical team. Members name each other more often as helpful for performing technical roles. Detailed examination of the supervisor's role nets indicated that he is very much a part of that team. The supervisors of the high innovation groups were named more often by their groups for performing technical and administrative roles; they were named less often by outsiders as helpful for most roles; and, in turn, they received more technical help from their groups.
As the technical decision-making process evolves, it appears more apt to result in innovative work if certain colleague roles are performed by certain parties, especially in the stages of problem solving which theoretically occur earlier (see Farris, 1971). During the idea suggestion stage, the roles most associated with group innovation are the supervisor's receiving original ideas from more outside sources but having fewer original ideas himself, group members providing each other with technical information, and the availability of organizational information from fewer sources inside or outside the group. During the proposal development stage, the high innovation groups are characterized by greater exchange of help among themselves in thinking through technical problems and greater usefulness of their supervisors in critically evaluating their ideas.

Like most field research in organizations, this exploratory study suffers from the common problems of small sample size, failing to sample from a finite population, and inability to determine causality. Thus, these findings, although they are based on consistent trends, should be regarded as tentative. To the extent that they accurately describe colleague interaction in the problem-solving process of these scientific groups, however, they have some intriguing implications for theories of problem solving and leadership as well as some practical applications. Let us turn to these now.

Theoretical implications

Three types of theories of group problem solving were mentioned earlier in this paper: those which emphasize the role of the leader (e.g., Maier, 1967 and Bowers & Seashore, 1966), those stressing peer leadership in roles performed by group members for one another (e.g., Benne & Sheats, 1948; Bales, 1950; and Bowers & Seashore, 1966), and those which emphasize the group in its organizational context. The tentative findings of this study have implications for each type of theory.
Maier (1967) suggests that a group is most apt to succeed in its problem-solving efforts when its leader performs an integrative function analagous to that of the nerve ring of the starfish. He does not dominate the discussion and produce the solution, but instead serves as an integrator by receiving information, facilitating communication among group members, relaying messages, and integrating ideas so that a single unified solution can occur. Moreover, "the idea-getting process should be separated from the idea-evaluation process because the latter inhibits the former". (Maier, 1963, p. 247.)

Supervisors of the high innovation groups in this study were seen as behaving very much in the way Maier says they should. They were named more often by their groups as useful for facilitating thinking and providing critical evaluation, two roles which can be considered integrative functions. Moreover, they received original ideas from more sources outside the group, probably relaying them to group members as appropriate. Equally important, the supervisors of the high innovation groups were seen as less useful for their own original ideas. Thus, they were probably less apt to impose their own ideas on their group, an activity which Maier argues strongly will inhibit group innovation. Probably this situation also represents a considerable degree of separation of evaluation from the production of ideas. The supervisors of the high innovation groups were more useful for critical evaluation, but the ideas they evaluated tended to come more often from other sources -- outsiders (see Figure 7) or group members (see Figure 8).
Theories of group problem solving which emphasize roles performed by group members also received some support. The high innovation groups found other members of their groups to be more useful for providing technical information and help in thinking, and outsiders tended to be less useful for several roles. Apparently, peer leadership occurred more often in the high innovation groups with respect to these roles, and the high innovation groups may have been more cohesive in that they found outsiders generally to be less helpful. Against a "peer leadership" theory of group problem solving, however, is the failure of differences to occur between the high and low innovation groups in two other technical roles: critical evaluation and original ideas. Perhaps peer leadership is more important for group innovation only when it is exercised in particular areas. It should be added that the positive findings regarding peer leadership do not deny Maier's emphasis on the role of the leader. His acting in ways Maier says he should would be expected to create a situation where group members are better able to facilitate each other's problem solving.

Theories which emphasize the organizational context of the group receive the least support from the tentative findings. Having more sources of information about technical and administrative developments in the organization was related negatively to group innovation. This held whether the sources were the supervisor, other group members, outsiders, or outsiders talking to the supervisor. Moreover, the roles of providing a fair hearing for ideas and providing administrative help generally did not distinguish the high and low innovation groups. Finally, members of the more innovative groups and their supervisors typically performed more roles for one another and fewer roles for outsiders and received less help from outsiders. An important exception to this overall pattern, however, was
that the supervisors of the high innovation teams were "tuned in" to more outside sources of original ideas. These findings do not mean that the organizational context of a group is unimportant for its innovation; rather, they seem to suggest that excessive orientation to the outside can be bad for a group's innovation, that an important role performed by outsiders is making original ideas available to a group through its supervisor, and that increased attention to sources of administrative help or a fair hearing for ideas will not pay off in increased group innovation.

The trends in the present research fit well with findings by Andrews and Farris (1967) that a supervisor's technical skills are consistently associated with his group's innovation. High technical skills are required for a supervisor to be useful to his group for critical evaluation or for him to recognize original ideas which come from the outside.

The associations between group innovation and the performance of colleague roles in the present study complements previous findings in studies of individuals in the same organization by Farris (1971) and Swain (1971). Farris found that high past performance predicted that an individual scientist would be named more often as useful to his colleagues, and Swain (1971) and Farris (1971) found that higher performers were named more often as helpful to their colleagues. The trends in the present study suggest that the high performing individuals are especially helpful to other members of their scientific teams. In addition, Farris (1971) found that more innovative individual scientists named more colleagues as helpful to their problem solving for only two of the seven colleague roles: providing technical information and critical evaluation. The more innovative groups in the present study found particular colleagues as more helpful in these areas: fellow group members for providing technical information, and their supervisors for providing critical evaluation.
Another analysis in the present study related group innovation to
the number of people with whom participants said they discussed technical
matters once a week or more. This global communications question has
been used by Allen and his colleagues (e. g., Allen & Cohen, 1969) to
study information flow in research and development laboratories. The
same scores were constructed for this communications question as for the
colleagues' roles. Except for a tendency for members of the high innovation
teams to mention one another more often for frequent communication, these
scores were unrelated to group innovation. This analysis supports the
finding that members of the high innovation groups frequently name one another
as useful for several colleague roles, but at the same time it emphasizes
the importance of examining particular colleague roles in the problem-
solving process. Examination of communications patterns alone would have
obscured differences which occurred for particular colleague roles. In
describing the problem-solving process associated with group innovation,
it is important to know not only who talks to whom, but also who talks to
whom about what.

Another trend in the present study is consistent with Allen's treat-
ment of information flow in R & D as a two-step process. Supervisors
of the high innovation groups named more outsiders as useful for one type
of technical information: original ideas. It could be inferred that
these supervisors serve as "technological gatekeepers" for these
original ideas, passing them on to their teams as appropriate. Al-
though the data indicate that the supervisors of the high innovation teams
were not more apt to be gatekeepers for the role of locating technical
information, some members of these teams may have been. Although members
of high innovation teams did not name their supervisors often as useful
for providing technical information, they did name a greater percentage of their fellow team members for this role.

**Practical implications**

The trends in the present study point to the importance of teamwork in group innovation. Members of more innovative groups, including the supervisor, were more helpful to one another for several colleague roles. Much has been written about ways to encourage teamwork. Likert (1961, 1967) and Maier (1963) are good sources.

The trends suggest also that the supervisor himself need not be innovative in order to have an innovative group. In fact, the data suggest that when the supervisor is more useful for his original ideas, his group's innovation is lower. However, the supervisor should have the technical competence necessary for him to be able to recognize original ideas and provide critical evaluation. And he should have an interpersonal and cognitive style which allows him to help others to think through their problems and lets him provide critical evaluation in a manner which is constructive.

How may a group be made more innovative? The trends suggest that their supervisor may be a key man. He should encourage them to exchange technical information and help each other think through their technical problems, and he should be an active part of that process himself. He should seek original ideas from outside the group, but not impose his own ideas on them. Probably, he should keep them abreast of developments in the organization so that they do not spend the energy necessary to go to a number of sources of such information themselves. If group members are less helpful to one another, they may rely on colleagues outside the
group for help in their technical problem solving. When they do, group innovation is lower.

In closing, let us offer a word of caution to the manager. Group innovation is not the only characteristic to be desired in the output of the decision-making process in a scientific laboratory. Moreover, the teamwork which appears to be associated with group innovation may reach a level which in some situations is dysfunctional for the laboratory as a whole. Other aspects of scientific performance -- steady, productive work or work especially useful to the organization -- are important as well. Although the trends in this study show consistent patterns of colleague roles related to group innovation, different networks of colleague roles may turn out to be related to such other important aspects of scientific performance.
Footnotes

1 This research was supported by grant NGR23-005-395 from the National Aeronautics and Space Administration, Frank M. Andrews and George F. Farris, principal investigators. The author gratefully acknowledges the comments of Frank M. Andrews, Thomas F. Lyons, Donald G. Marquis and Edgar H. Schein on an earlier draft of this paper.

2 Before relating colleague roles to innovation, two preliminary analyses were performed. In the first, the variance between groups was found to be greater than the variance within groups in innovation, suggesting that innovation is a quality associated with group membership. In the second, a comparison of the sizes of the high and low-innovation groups determined that group size was unrelated to group innovation.

Morrison and Henkel (1970, p. xi) point out "that the significance test as typically employed in behavioral science is bad statistical inference, and that even good statistical inference in basic research is typically only a convenient way of sidestepping rather than solving the problem of scientific inference."

The appropriate test of statistical significance to use with these data is subject to debate. The most conservative approach would be not to perform tests of significance, since these data do not represent a probability sample from a defined population, and since the purposes of this study are descriptive rather than inferential. A less conservative approach would be to report tests based on group averages, under the partially true assumption that an individual's scores are substantially associated with his team membership. The least conservative approach would be to report tests based on
a comparison of individuals in the high and low innovation teams, under the partially true assumption that an individual's scores are substantially independent of his team membership. Unfortunately, there is no covariance analysis technique known to the author which is appropriate to use with these data to control for the association between an individual's score and his team membership.

In view of these issues, the data are reported on the basis of group averages, and tests of statistical significance are not shown. The criteria for reaching conclusions throughout this study were that a trend be clear and, where appropriate, reasonably consistent. Readers accustomed to looking for tests of statistical significance, however, can be assured that many of the trends would appear as "significant" if tested in conventional ways based on either of the less conservative assumptions. The general conclusions were not altered by the decision not to test "significance".

3 The scores were: (listed in the same order as in Table 1) 2.3, 2.1; .75, .64; 2.6, 2.9; .68, .74; .37, .26; and 1.0, 1.1.

4 Supervisors of the high innovation teams also scored lower on a test of creative ability than did the supervisors of the low innovation teams.


TABLE 1

Colleague Roles in High and Low Innovation Groups at Each Stage of Decision Making

<table>
<thead>
<tr>
<th>Suggestion Stage</th>
<th>Proposal Stage</th>
<th>Solution Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orig Ideas</td>
<td>Tech Info</td>
<td>Orig Info</td>
</tr>
<tr>
<td>For Supervisor by Outsiders (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Innovation</td>
<td>2.3</td>
<td>3.4</td>
</tr>
<tr>
<td>Low Innovation</td>
<td>1.0</td>
<td>4.1</td>
</tr>
<tr>
<td>For Supervisor by Group (6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Innovation</td>
<td>.39</td>
<td>.36</td>
</tr>
<tr>
<td>Low Innovation</td>
<td>.12</td>
<td>.05</td>
</tr>
<tr>
<td>For Outsiders by Supervisor (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Innovation</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Low Innovation</td>
<td>1.9</td>
<td>2.4</td>
</tr>
<tr>
<td>For Group by Supervisor (1)</td>
<td></td>
<td></td>
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<td>High Innovation</td>
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<td>.50</td>
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<tr>
<td>Low Innovation</td>
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<td>.51</td>
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<tr>
<td>For Group by Group (2)</td>
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<td>.14</td>
</tr>
<tr>
<td>Low Innovation</td>
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<td>.09</td>
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<tr>
<td>For Group by Outsiders (3)</td>
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<td>High Innovation</td>
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<td>1.2</td>
</tr>
<tr>
<td>Low Innovation</td>
<td>.6</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Note. - The numbers in parentheses refer to the corresponding arrows in Figure 2. See text for the bases used for calculating the data in the table.
Figure Captions

Figure 1 Some factors in organizational decision making.

Figure 2 Role nets of scientific groups.

Figure 3 Per cent of group members who mention their supervisor for colleague roles.

Note. -- In Figures 3-8 the discrete points for each colleague role are connected for the data from the high and low innovation groups in order to facilitate clarity.

Figure 4 Choices of group members by other group members for colleague roles.

Figure 5 Average number of outsiders mentioned by group members for colleague roles.

Figure 6 Number of times supervisor was mentioned by outsiders for colleague roles.

Figure 7 Average number of outsiders mentioned by supervisors for colleague roles.

Figure 8 Per cent of group members mentioned by their supervisor for colleague roles.
Colleague Role

High innovation
Low innovation
The diagram illustrates the number of mentions for different roles in a colleague context. The x-axis represents the colleague role categories: Tech Info, Help Think, Crit Eval, Orig Ideas, Fair Hearing, Adm. Help, Org Info. The y-axis represents the number of mentions. Two lines are shown, one solid and one dashed, indicating high and low innovation. The number mentioned decreases as you move from the top left to the bottom right on the chart.