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# COMMUNICATION PATTERNS, PROJECT PERFORMANCE AND TASK CHARACTERISTICS: AN EMPIRICAL EVALUATION AND INTEGRATION IN AN R&D SETTING

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# COMMUNICATION PATTERNS, PROJECT PERFORMANCE AND TASK CHARACTERISTICS:

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ABSTRACT

This study examines the impacts of problem-solving and administrative communication patterns on the technical performance of 61 projects in an industrial R&D laboratory. While there were no differences in the relative patterns of these two types of communication, there were systematic differences in the mechanisms by which project groups transferred administrative and problem-solving information with other areas both within and outside the organization. The overall patterns of communication were influenced by the nature of the projects' work, while the effectiveness of the various interfaces was explored via two contrasting methods: direct contact by all project members and contact mediated through boundary spanning individuals. The effectiveness of each of these linking mechanisms was also contingent upon the projects' tasks. This research reinforces the importance of managing communication patterns in organizations and further supports the importance of boundary spanning individuals.

# Communication Patterns, Project Performance, and Task Characteristics: An Empirical Evaluation and Integration in an R&D Setting

To deal successfully with work-related uncertainty, organizations must efficiently gather information from external sources, process and disseminate that information within the organization, and transmit data back into the environment (Katz & Kahn, 1966; Thompson, 1967). The importance of gathering and processing information from external domains is accentuated in R&D laboratories given their dependence on external information and the need for effective coordination with other organizational areas (Achilladeles, Jervis & Robertson, 1971; Mansfield & Wagner, 1975).

Oral communication is an important medium by which information and new ideas are transmitted within and between organizations (Czepiel, 1975; Edstrom & Galbraith, 1977). Research has consistently demonstrated that oral contacts, rather than technical reports, publications, or other formal media are the primary means used by engineers and applied scientists to discuss and transfer technical information and new ideas (Allen, 1970; Menzel, 1966; National Academy of Science Report, 1969). Recognizing the strategic role of oral communications, the objectives of this study are to investigate both the actual patterns of communication between different kinds of project groups and their external sources of information, as well as the relationships between these communication patterns and project performance.[1]

## BASIC VARIABLES AND RESEARCH QUESTIONS

### Communication Patterns

Organizational differentiation is associated with systematic differences in goal orientations, time frames, norms, and shared coding or language schemes (Lawrence & Lorsch, 1967; Thompson, 1967). If there are different coding schemes and technical orientations within and outside the laboratory, then there may be specialized areas for effective feedback and technical support. If so, it may be most fruitful to study patterns of oral communication to distinct areas within and outside the organization rather than simply studying communication in an aggregated fashion (Hage, Aiken, & Marrett, 1971; Katz & Kahn 1966; March & Simon, 1958; Roberts, O'Reilly, Bretton, & Porter, 1974).

As a result, three broad sources of R&D project communication are considered in this study: (1) intraproject communication; (2) organizational communication (communication between a project and other internal organizational areas such as other R&D groups or other functional departments); and (3) extra-organizational communication (communication with external areas such as customers, suppliers, universities, consultants, or other professionals).

### Problem-Solving and Administrative Communication

Previous communication studies (especially in R&D settings) have typically focused on all work-related contacts without regard to the specific content of the interactions (Farris, 1972; Kelly & Kranzberg, 1975). However, research on R&D problem-solving (e.g., Baker, Siegmann & Rubenstein, 1967; Utterback, 1971) and on innovations (e.g., Mansfield & Wagner, 1975; Zaltman, Duncan; & Holbek, 1973) suggests that certain types of communication may be especially beneficial for work in innovative settings. For creative problems, performance may be positively associated with communication related to generating, sharing, and/or evaluating new ideas or solution approaches. Alternatively, for more organizationally related problems, communications that embrace administrative issues such as coordination between areas, scheduling, and budgeting may be particularly important. It may be that problem-solving communication attempts to reduce technical complexity while administrative communication attends to various organizational and interunit demands. Given these differences, it seems potentially useful to distinguish explicitly between problem-solving and administrative content areas in examining communication linkages between different task areas or projects and alternative information domains.

Project Task Characteristics

Substantial organizational research indicates that different types of tasks require different amounts of communication. Research by Hall (1962), Hage et al. (1971), and Van de Ven, Delbecq, and Koenig (1976), for example, have shown that task complexity is directly associated with greater amounts of communication. Furthermore, studies by Lawrence and Lorsch (1967), Duncan (1973), and Galbraith (1973) contend that the "optimal" degree of communication is contingent upon the nature of the subunit's task: the more complex the task, the greater the unit's work-related uncertainty, and the greater its communication requirements.

In R&D settings, a subunit's task can differ along several dimensions including: time-span-of-feedback, specific vs. general problem orientation, and the generation of new knowledge vs. using existing knowledge (Evan, 1962; Rosenbloom & Wolek, 1970). By considering such attributes, R&D projects can be categorized along a continuum ranging from research to development to technical service kinds of projects, i.e., from more complex to less complex projects (Pelz & Andrews, 1966; Smith, 1970a). Since oral communication is an important medium for managing work-related uncertainty, the nature of the unit's task is an important contingent variable for research on communication.

Although specific hypotheses will be developed, two general questions guide this research:

(1) Do the different kinds of R&D projects have significantly different patterns of problem-solving and administrative communication?

(2) What are the relationships between patterns of project communication and project performance?

## IMPACT OF TASK CHARACTERISTICS ON PATTERNS OF PROBLEM-SOLVING AND ADMINISTRATIVE COMMUNICATION

### Intraproject Communications

Research on intraproject communication in R&D settings has yielded equivocal results. Farris (1972), for example, reported that high performing R&D projects had significantly greater levels of intraproject communication than low performing projects, though Allen (1970) had previously failed to detect such differences. One possible explanation for these results lies in the task difference between the studies. In Farris's (1972) study, projects were performing research tasks of a basic and abstract nature, whereas Allen's (1970) groups were working on more applied problems. Consistent with our previous discussion, more complex tasks (i.e., Farris) required substantial intraproject communication to intermix effectively theoretical principles, ideas, and solutions. For more routine and applied tasks, however, extensive intraproject problem-solving communication is less essential since the number of exceptions are few and the locus of expertise may lie higher in the hierarchy (Becker & Baloff, 1969; Duncan, 1973; Lawrence & Lorsch, 1967). Accordingly, the following hypotheses are proposed.

Hypothesis 1:

> Research projects will have significantly more intraproject problem-solving communication than technical service projects.[2]

Hypothesis 1A:

> For research projects, there will be a positive association between intraproject problem-solving communication and technical performance while there will be no corresponding association for technical service projects.

Administrative communication focuses on organizational issues of coordination, planning, and control. Intraproject administrative communication is, then, a function of the location or distribution of critical expertise within the project (Duncan, 1973; Snadowsky, 1972). For more complex tasks (i.e., research projects), expertise is likely to reside lower in the hierarchy and is likely to be shared by project members (Duncan, 1973; Lawrence & Lorsch, 1967). As a result, there may be more group and less supervisory dominated decision-making in projects facing substantial task complexity (Becker & Baloff, 1969; Vroom & Yetton, 1973). For less complex tasks, however, relevant task expertise may reside higher in the hierarchy. If so, then high performing routine tasks will have greater supervisory and correspondingly less peer decision-making (Connolly, 1977; Conrath, 1967; Smith 1970b). These ideas suggest the following hypotheses:

Hypothesis 2:

Research projects will have significantly more intraproject administrative communication than technical service projects.

Hypothesis 2A:

For research projects, there will be a positive association between intraproject administrative communication and technical performance, while there will be no corresponding association for technical service projects.

## Organizational Communication

To develop new products or process ideas, several kinds of information must be synthesized; for instance, manufacturing requirements and market need information must be combined with organizational and technical capabilities (Goldhar, Bragaw, & Schwartz, 1976; Utterback, 1971). Since project members do not usually have all the requisite work-related expertise, information must be gathered from sources outside the project. While the R&D literature strongly emphasizes the importance of internal communications (Allen,1970, 1977; Pelz & Andrews, 1966), a more specific question can be raised: Are the patterns of internal organizational communication (both problem-solving and administrative) associated with project performance? Should communication be encouraged throughout the laboratory and with the larger organization, or will different projects have specific internal domains for exchanging technical information?

If the laboratory is highly specialized, then there will be substantial differences between subunits with respect to language schemes, goal orientations,and problem focus(March & Simon, 1958; Rosenbloom & Wolek, 1970; Whitely & Frost, 1973). These cognitive and task differences act as a communication impedance making communications across organizational boundaries relatively difficult and prone to bias and distortion (Katz & Kahn, 1966; Lawrence & Lorsch, 1967; Triandis, 1960). With such differentiation within the laboratory and between the laboratory and the larger organization, widespread internal communication may be relatively inefficient (Allen, 1977; Allen & Cohen, 1969; Tushman, 1977). Instead, it may be that only certain areas within the organization (those areas with similar technical orientations, problem focus, or professional backgrounds) are effective sources of technical feedback, information, and stimulation. If the laboratory is organized around different project areas, then high performing subunits may have systematically different patterns of organizational communication. Such ideas lead to hypotheses 3 and 3A.

Hypothesis 3:

> Communications outside the project (yet inside the organization) will differ for different task areas such that communication will be directed to those organizational areas with relatively similar technical orientations, goal orientation , or professional backgrounds.

Hypothesis 3A:

> The relationship between problem-solving communication and project performance will be positive only for communications between areas with relatively similar technical orientations, goal orientations or professional backgrounds.

Research on leadership in R&D settings suggests that an important role of project supervisors is to administratively link their projects with other laboratory and organizational areas (Andrews & Farris, 1967; Farris, 1972; Goldhar et al., 1976). It may be that administrative communication is most effectively mediated by project supervisors. Thus, not only will the overall amount of administrative communication be specialized by task area, but supervisors should account for the bulk of the extra-project administrative communication. If such role specialization is advantageous than one might posit an inverse relationship between extra-project administrative communication across all project members and overall project performance

Hypothesis 3B:

> Administrative communication outside the project will be inversely related to overall project performance.

Extra-Organizational Communication

Research indicates that oral communication outside the organization is of vital importance for gathering information on markets, technologies, and customers (Allen & Cohen, 1969; Czepiel, 1975), and to stimulate ideas and solution approaches to technical problems (e.g., Baker et al. 1967; Utterback, 1971). Consistent with the ideas of communication specialization due to consequences of differentiation, alternative task areas may have different sources of extra-organizational information according to their particular problem orientations and professional backgrounds (Rosenbloom & Wolek, 1970; Whitley & Frost, 1973). As a result, the following is hypothesized:

Hypothesis 4:

> Research projects will have more problem-solving communication with external professional areas (e.g., universities and professional societies) than development or technical service projects. Alternatively, technical service and development projects will have more problem-solving communication with operational areas (e.g., customers and suppliers) than research projects.

While there may be differences in the patterns of extra-organizational communication, it is also important to examine the relationships between extra-organizational communication and project performance. A number of studies, including Allen (1969, 1977), Shilling and Bernard (1964), and Achilladeles et al. (1971), have found an inverse relationship between extra-organizational communication and overall performance. One explanation for these results is that technical problems assigned to development and technical services areas are local in nature and specification. In these projects, problem definitions and corresponding solutions are not definable in universal terms but are idiosyncratically related to the specific organization--significantly influenced by local norms, values, language schemes, and subcultures.[3] External sources of information, then, may be less effective in supplying technical assistance and feedback than in-house consultation (Allen, 1977). On the other hand, individuals working on more universally defined tasks (i.e., research tasks) can take advantage of communications outside the organization, since the nature of these problems will not be as locally constrained. These ideas lead to the following hypothesis:

Hypothesis 5:

> There will be a positive association between project performance and external problem-solving communication for research projects. Contrastingly, there will be an inverse relationship between project performance and external problem-solving communication for development and technical service projects.

Despite the hypothesized inverse relationship between external communications and performance for more applied projects, interaction with sources outside the organization is essential (Myers & Marquis, 1969; Utterback, 1971). Under those circumstances in which performance is not directly associated with external communications, it is likely that special boundary roles are needed to deal with these important external sources of information (Aldrich & Herker, 1977; Allen & Cohen, 1969; Tushman, 1977). Such role specialization suggests that only certain individuals within the organization are able to deal effectively with areas outside the organization. Allen and Cohen (1969) demonstrated that a limited number of individuals within the laboratory, labelled "gatekeepers," occupied key boundary roles for channeling external technology and information into the organization. Boundary spanning individuals are, then, an important linking device for more locally oriented R&D projects. While several studies have found evidence of boundary spanning roles, no research has investigated the relationship between these specialized roles and subunit performance. These ideas lead to a final hypothesis:

Hypothesis 6:

> Role specialization in external communications will be positively related to performance for development and technical service projects but will be negatively related to performance for research projects.

## METHODS

### Sample

To test these hypotheses, a field study was conducted within the R&D laboratory of a major American corporation. Physically isolated from the rest of the organization, this laboratory was organized into seven divisions each containing its own set of projects. These projects were designed around specific types of problems and represent the basic unit of analysis. At the time of this study, 61 such projects existed across the laboratory's seven divisions resulting in the employment of 350 engineering and scientific professionals. Each respondent was a member of only one project.

### Communications Data

To collect communication data, each respondent specified (on specially provided forms) those individuals, both within and outside the corporation, with whom he or she had work-related oral communications on a particular day (respondents were not asked to report either written or social contacts). This sociometric-type data was collected on randomly chosen days each week for 15 weeks with equal numbers of weekdays. These procedures are similar to those used by other studies such as Allen and Cohen (1969), and Whitley and Frost (1973). During the 15 weeks, an overall response rate of 93 percent was achieved. Moreover, 68 percent of all the communications reported within the laboratory were reciprocally mentioned (external communications could not be checked for reciprocity). Given this response rate and degree of reciprocity (see Weiss & Jacobson, 1960, for comparative data), these methods provide a relatively accurate log of the oral communications of all professionals within this laboratory.

With respect to content, respondents were also asked to check whether each reported communication was related to either of the following content categories:

1. Problem-Solving Communication: Communication involving the discussion, development, or evaluation of new ideas or approaches to technical problems.
2. Administrative Information: Communication involving administrative or organizational problems and procedures.

To validate these self-responses, an analysis was made of the degree of agreement between pairs of individuals who independently rated the content of their particular communication episode. As shown by the diagonal percentages in Table 1, there was substantial agreement between respondents with respect to the content of their mutually reported communication. Although there was some content mismatching (see off diagonal percentages), there is sufficient agreement to justify the use of these categories.[4]

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Insert Table 1 about here
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Communication Measures

For each project, four distinct measures of internal communications were defined:

1. Intraproject: The amount of communication reported among all project members.
2. Division: The amount of communication reported between the project's members and other R&D professionals within the same division.
3. R&D Laboratory: The amount of communication reported between the project's members and other R&D professionals who were outside the division but within the laboratory.
4. Corporation: The amount of communication reported by the project members with other individuals who were outside the laboratory but within the corporation (manufacturing and marketing areas).

In addition, three separate measures of extra-organizational communication were defined: the amount of communications reported between the project's members and (1) customers and suppliers; (2) professionals from other organizations including universities; and (3) consultants (individuals, usually from consulting firms, who were hired for assistance on specific technical problems).

Measures for these internal and external communication domains were calculated by summing the relevant number of contacts reported during the 15 weeks. Though the overall response rate was very high, the raw communications data for incomplete respondents were proportionately adjusted by the number of missing weeks.

Since projects and divisions differed in size, it was also important to standardize the communication measures. As suggested by MacKenzie (1968), intraproject communication was standardized by the logarithm of possible interactions (i.e., $Log_2$ [n(n-1)] where "n" represents project size). Similarly, divisional and R&D laboratory communication variables were adjusted using the method developed by Allen and Cooney (1973) for standardizing interactions between two unequal groups. Corporate and all three external communication variables were standardized by dividing by project size. In support of these procedures, none of the standardized communication measures was significantly correlated with project or division size.

To test the empirical distinctions among the different internal and external communication variables, all communication measures were factor analyzed (with communalities). The measures of communication to the different areas formed their own separate and distinct factors, thereby, supporting the strategy of distinguishing among communication areas.

Project Task Characteristics

In R&D settings, tasks differ along several dimensions including: time-span-of-feedback, specific vs. general problem orientation, and generation of new knowledge vs. using existing knowledge (Rosenbloom & Wolek, 1970; Evan, 1962). Consistent with definitions used by the National Science Foundation and other studies including Pelz and Andrews (1966) and Mansfield and Wagner (1975), the following task categories were developed with the laboratory's management to form a complex (research) to less complex (technical service) task dimension.

1. Basic Research: Work of a general nature intended to apply to a broad range of applications or to the development of new knowledge about an area.

2. General Research: Work involving basic knowledge for the solution of a particular problem. The creation and evaluation of new concepts or components but not development for operational use.

3. Development: The combination of existing feasible concepts, perhaps with new knowledge, to provide a distinctly new product or process. The application of known facts and theory to solve a particular problem through exploratory study, design, and testing of new components or systems.

4. Technical Service: Cost/performance improvement of existing processes or systems. Recombination, modification, and testing of systems using existing knowledge. Opening new markets for existing products.

Using these definitions, respondents were asked to select the category which best characterized the objectives of their project and to indicate, on a 3-point scale, how completely the project's objectives were represented by the selected category. The 12 possible answers to this question were arranged and scored along a single numerical scale ranging from completely basic research to completely technical service. As in Pelz and Andrews (1966), respondents were also asked to indicate, on a separate question, what percentage of their project's work fell into each of the four previously defined categories. A weighted average of the percentages was calculated for each respondent to yield a score comparable with the previous question. Each individual's scored responses to these two questions were averaged (Spearman-Brown reliability = .91).

Project measures were calculated by pooling individual scores. To check on the appropriateness of pooling, a one-way ANOVA compared within project variance with between-project variance, while Bartlett's M-test tested for the homogeneity of intraproject variance. Measures for 55 projects passed these tests and clustered into the following task categories: General Research = 13 projects; Development = 22 projects; and Technical Service = 20 projects. None of the projects could be categorized as pure or basic research.

Project Performance

To generate a single set of dimensions appropriate to this setting, a group of top-level managers helped develop a set of specific dimensions which would tap the more general categories of project goal achievement, integration, and adaptability (Steers, 1975). Performance dimensions included: schedule, budget, and cost performance, innovativeness, adaptability, and the ability to cooperate with other areas in the larger organization.

All group managers (N = 7) and both laboratory directors (N = 2) were interviewed individually. Each was asked to evaluate the technical performance of all projects with which he was technically familiar. Each manager was asked for their overall technical evaluations based on a consideration of the dimensions discussed above. Each project was independently rated by an average of 4.7 managers on a seven-point scale (from very low to very high). Since the performance ratings across the nine judges were sufficiently intercorrelated (Spearman-Brown reliability = .81), individual ratings were averaged to yield overall project performance scores.[5]

## RESULTS

Table 2 examines the communication performance relationships for all reported contacts. In contrast to the findings of several other studies (including Allen, 1970; Pelz & Andrews, 1966; and Shilling & Bernard, 1964), the first column shows that for all projects, performance is not positively associated with total communications to any of the internal domains, nor inversely correlated with communications to external areas.

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Insert Table 2 about here

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Furthermore, the rest of Table 2 reveals that the overall internal communication measures are not consistently and positively related to performance even when independently examined by project task category. Only the overall communications of development projects with other corporate areas is directly related to performance. With respect to extra-organizational contacts, none of the communication measures are significantly related to the performance of development or technical service projects. On the other hand, the amount of contact with both external professionals and consultants is significantly associated with the performance of research projects. These results support the idea that external communications and performance are positively linked only for universally defined tasks.

To test hypotheses one through five, Table 3 presents standardized mean communication scores for research, development, and technical service projects. Because the amounts of interaction to different areas were separately adjusted for project and divisional size (see Methods section), any comparison of means across areas is inappropriate. To illustrate more clearly the relative differences among project communication scores within each area, project means have been normalized to a mean of unity. Table 3 also presents the correlations between performance and the amount of problem-solving and administrative communication for each task category to each communication area.

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Insert Table 3 about here

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Intraproject Communication

An examination of the intraproject means and correlation of Table 3 strongly supports hypotheses 1 and 2 as well as their complementary hypotheses (i.e., 1A and 2A). Research tasks have significantly more problem-solving and administrative intraproject communications than other project subgroups. More importantly, the amounts of problem-solving and administrative communication are positively associated with performance only for research projects; whereas, administrative communication and performance are inversely related for technical service projects. Thus, both the amount of intraproject communication and its relationship with performance are moderated by project task characteristics.

Organizational Communication

The means reported in Table 3 generally support hypothesis 3 in that different task areas have specialized intra-organizational communication patterns. Research projects have considerably more problem-solving and administrative communication both within their respective divisions as well as within the laboratory than other project subgroups. On the other hand, development and and technical service projects have significantly more communication with the corporation than research projects. Evidently, research tasks are able to obtain more effective feedback from colleagues within the laboratory, while technical service and development projects seem to rely more heavily on communication with areas in the larger organization (e.g., marketing, manufacturing).

Based on these results, one would expect from hypothesis 3A that problem-solving communication between research projects and divisional and laboratory areas would be positively associated with performance, while for technical service and development tasks, corporate communication and performance would be positively associated. An examination of the performance-communication correlations in Table 3, however, provides only partial support for hypothesis 3A. None of the project subgroups exhibits a positive relationship between performance and the amount of problem-solving communication to divisional or laboratory areas. In addition, the relationship between corporate problem-solving communication and project performance is significantly positive only for development tasks. Thus, while the overall amount of problem-solving communication is specialized by project area, the mechanism by which project subgroups effectively communicate with other organizational domains may be more complex than simply through widespread face-to-face communication.

Hypothesis 3B proposed that administrative communication outside the project would be inversely associated with project performance for all task subgroups. Table 3 indicates moderate support for this hypothesis in that all but one of the relevant correlations are negative. In sum, even though the patterns of problem-solving and administrative communication are similar by task category, these findings suggest that the mechanisms by which this linking occurs may be different for the two content areas.

Extra-Organizational Communication

Each task area, as shown via Table 3, has significantly more communication with a particular segment of the external environment. In support of hypothesis 4, research tasks have the most communication with outside universities and professional societies, while members of development projects interact with external consultants to a significantly greater degree than other task groupings. As expected, technical service projects have the most contacts with external customers, suppliers and vendors.

While the data support the notion of specialized external communications by project area, hypothesis 5 focused on the communication-performance relationships. As predicted, research projects not only have the most communication with external professionals, but their professional problem-solving communication is directly associated with overall performance. Surprisingly, a positive relationship between professional communication and performance exists for technical service projects. The specific nature of this unexpected communication-performance linkage will be explored shortly. Communication with external consultants also supports hypothesis 5 in that the performance-communication relationship is strongly positive for research projects but is negative, though not significantly, for both development and technical service projects. No significant relationships exist between communication with customers and suppliers and technical performance for any of the task categories.

Hypothesis 6 suggested that special boundary roles would be needed by development and technical service project areas to deal effectively with various external information domains. The degree of role specialization within a project to each information domain was measured by the variance in project members' communication scores (i.e., the distribution of contacts within a project to each specific area).[6] The greater the communication variability within a project, the greater the evidence for role specialization in that fewer members account for more of the communication. Conversely, with less variance in project communication, there is less evidence of boundary role specialization since communication is more evenly distributed. To test hypothesis 6, Table 4 presents the correlations between overall performance and communication variance (i.e., the degree of role specialization) to the various communication domains for the different task categories. For the professional area, role specialization is indeed inversely related to project performance for research tasks; yet,

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Insert Table 4 about here

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the corresponding relationship is strongly positive for technical service tasks. Even though external professional communication and project performance are directly associated for both research and technical service projects, the mechanisms by which these linkages occur are very different. In addition, there is a significantly positive association between performance and role specialization for the development projects ($p < .10$) vis-a-vis external consultants. Evidently, project performance is higher when relatively few of the technical service or development project members do most of the communicating with external professionals and consultants, while the opposite situation characterizes research projects. No clear role specialization findings emerge with respect to the customer/supplier domain.

Joint Effects

To summarize the major performance-communication relationships and to test for joint additive effects, separate stepwise regressions were calculated for each task category (see Table 5). For research tasks,

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Insert Table 5 about here

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problem-solving communication with external professionals entered the equation initially while both intraproject and divisional problem-solving communications are able to account for significant amounts of additional performance variance.[7] Evidently, the more effective research projects have more problem-solving interaction with either external professionals or with their own divisional colleagues but not with professionals from other R&D divisions or with employees from other corporate areas. In fact, the regression results indicate that the amount of corporate administrative communication relates negatively to the performance of research tasks. Not only are these various communication measures jointly associated with performance, but results from Table 4 suggest that a more equal distribution of such contacts among research project members is also positively related to performance.

The regression analysis for development projects reemphasizes the utility of corporate communications. Like research projects, Table 4 indicates that performance is also directly associated with a more uniform distribution of communication between development project members and corporate information areas. For development projects, then, role specialization is positively associated with extra-organizational communication yet negatively associated with intra-organizational communication.

For technical service projects, all but one of the communication variables that were individually associated with technical performance are also jointly related to project performance: intraproject and laboratory administrative communication (negatively) and problem-solving contacts with external professionals (positively). Unlike research projects, however, the performance of technical service projects is positively associated with role specialization for both laboratory and professional communication.

# DISCUSSION

Given the similar patterns of problem-solving and administrative communication, it appears that patterns of oral communication are specialized to specific domains according to informational demands of the project's work. Research projects had the most communications within their own projects and with other areas within the laboratory. Development and technical service projects, however, communicated with other corporate areas to a significantly greater extent than research tasks. Extra-organizational communication was also specialized by task area. Research projects had the most contact with external professional areas; development projects had the most contact with external consultants; and technical service projects were most strongly connected to external customers and suppliers. Thus, subunit communication was specialized to those particular areas that could provide effective feedback and technical support.

Analyses investigating the association between oral communication and technical performance suggested different mechanisms for achieving effective linkages between projects and external information areas. Administrative communication appeared to be handled most effectively by project leaders for each task category. The nature of the linking process for effective problem-solving communication, however, seemed more intricate. The results suggest that specialized boundary roles are needed by development and technical service projects to deal effectively with external professional and consultant domains. Even though overall performance and external professional communication were positively associated for technical service tasks, and even though the utilization of external consultants was substantial for development tasks, special boundary individuals accounted for much of this extra-organizational communication in the higher performing projects of both subgroups. Research projects, however, displayed no evidence of boundary role specializations; in fact, the opposite condition characterized the higher performing research projects with respect to outside professional contacts. Thus, it would appear that boundary role development is most important for less complex tasks whose problems are more locally definable, while more complex and more universally defined projects seem to benefit from widespread direct contact with extra-organizational areas.

Similarly, for communication outside the project, yet, within the firm, several contrasting linking mechanisms were suggested. The higher performing technical service projects relied most heavily on boundary spanning individuals for their laboratory communications and to a slight extent for their other internal communications. The more effective research projects, on the other hand,not only had more collegial contact within their project and within the laboratory in general, but the also had a more uniform participation in such interactions. Finally, development projects had the most communication with areas in the larger organization. Furthermore, their corporate communications were most effectively accomplished through widespread face-to-face communication even though their external communications were mediated more effectively through boundary spanning individuals.

These results indicate that not only are different communication patterns necessary for gathering information for different projects, but that the nature of the communication linkage also affects technical performance. For both internal and external areas, there are two contrasting ways through which a project can effectively communicate: through widespread direct contact by all project members or through communications mediated by a few boundary spanning individuals. By comparing the results for research and technical service projects, it seems that as tasks become more complex and more universal in orientation, projects are more effective when there is widespread interaction with relevant information areas. The overall performance of research projects, for example, is strongly and positively associated with widespread communications with external colleagues since these individuals share a common language and problem orientation (Allen, 1977).

Conversely, projects with less complexity and a more particularistic orientation are more effective when most of their communications are handled or mediated by boundary spanning individuals. Most likely, project managers of higher performing technical service tasks interface with external areas substantially more than do other project members. Development projects, which lie in the middle of the task complexity continuum, are locally defined yet involve a dynamic technology. These task areas are more effective when internal communications are more uniformly distributed among project members, especially corporate communications, and when extra-organizational contacts occur primarily through special boundary spanning individuals. In short, alternative task areas have systematically different mechanisms for gathering and transferring information. Both the amount of communication and the method by which subunits are effectively linked to different communication domains are contingent on the nature of the subunit's work.

## Implications and Conclusions

From a more pragmatic point of view, these results reinforce the importance of organizing and managing communication networks. High performing projects had distinctly different communication patterns and processes than low performing projects. Consistent with the ideas of Galbraith (1973) and Lawrence and Lorsch (1967), integrating mechanisms for high performing units are contingent on the nature of the unit's work. Complex tasks require widespread face-to-face contact with other areas (perhaps through teams or task forces), while more routine tasks can rely more on the hierarchy. These findings, then, reinforce the utility of considering organizational communication as a design variable in that communication is both an important organizational process, and it is amenable to managerial influence. Task characteristics by themselves do not cause communication patterns; rather, projects can develop particular communication structures and networks to deal more effectively with their information needs.

Contrary to the work of Pelz and Andrews (1966) and Achilladeles et al. (1971), neither internal nor external communications per se were significantly related to performance for any of the project areas. Policies or programs, then, which try to foster more internal or external communication may be questionable. Transfer programs, for example, designed to encourage greater amounts of communications throughout the department, laboratory, or corporation may not be the most appropriate strategy to enhance project performance, especially in light of studies by Berlew and Hall (1966) and Katz (1978) on the importance of initial socialization and the challenge of initial job assignments. In terms of project performance, it may be more important to solidify interpersonal relationships and communications with particular individuals and areas rather than trying to establish a broad spectrum of organizational contacts.

Finally, as this is a correlational study, one cannot be sure whether increased communication results in higher performance or whether high performance causes more communication. More than likely, it is a combination of both. In any case, it is important for future research to determine the influence of formal organization structures on communication patterns. Would the findings be different for different kinds of structural designs? Functional structures, for example, tend to inhibit intraproject communications. On the other hand, project and matrix designs tend to make communications between functional departments more difficult (Allen, 1977). In addition, matrix designs often prevent R&D professionals from maintaining contact with colleagues in their particular specialty; perhaps, resulting in technical obsolescence (Marquis, 1969). If we are to design complex organizations with their multiple tasks and divergent information needs, we must know more about the influence of different organizational structures on the actual flow of information and on the effectiveness of such exchanges. This research, then, is another step towards better understanding the determinants and effects of communication networks in organizations.

# NOTES

1. This study was conducted at the R&D facility of a major American corporation. The laboratory was divided into seven divisions which, in turn, were subdivided into 61 projects. The types of projects ranged across three kinds of task areas: from research, to development, to technical service. Definitions of these project task areas can be found in the Methods section.

2. The hypotheses and discussion are presented in terms of research and technical service projects as they represent ends of a task complexity continuum. The results, however, will be reported for all task areas: research, development, and technical service.

3. An individual receives a general education in engineering but is not educated on how to be an engineer at Dupont, General Motors, Westinghouse, etc. In fact, it is generally agreed that a substantial socialization and learning period is required in order for a new hiree to determine how to be an effective technologist in a particular organization. This local orientation is considerably different from the basic sciences where problems are definable in universal terms.

4. All sociometric data were used as reported. The response rate and the various degrees of reciprocity and correspondence are reported to demonstrate that our data represent a relatively accurate picture of the oral communication network in the laboratory over the weeks sampled. Missing data was evenly distributed across the laboratory.

5. Since the full project by rater matrix of performance data is substantially incomplete, the standard application of the simplified Spearman-Brown formula based on the average of the intercorrelations can be misleading. As a result, the more generalized analysis of variance model, from which the Spearman-Brown formula is derived, was used to estimate the reliability index (see Winer, 1962, pp. 124-132). In particular, a one-way, random effects model with unequal numbers of observations (Snedecor and Cochran, 1967, pp. 289-291) was used to calculate the variance of the errors of observation and the variance of the observed scores from which the reliability coefficient is defined.

6. Actually, the coefficient of variation was used in order to standardize for significant mean differences.

7. It is important to note that divisional communication is negatively associated with external professional communication ($r = -.50$; $p < .05$) only for research tasks.

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Table 1

Crosstabulation of Content Codes

| | | Person "J" | | | |
|---|---|---|---|---|---|
| | | Problem-Solving Communications | Administrative Communications | Other Communications | Total |
| Person "I" | Problem-Solving | 65 | 8 | 25 | 100% |
| | Administrative | 15 | 71 | 14 | 100% |
| | Other Communications* | 24 | 7 | 69 | 100% |

Note: Results are based on approximately 6,000 communications that were reciprocally-reported during the 15 weeks.

*Consists of all work-related communications that were not checked as either Problem-Solving or Administrative contacts.

Table 2

Correlations Between Project Performance and Overall Communications for Different Project Types

| Communication Variables | All Projects | Project Type: Research | Development | Technical Service |
|---|---|---|---|---|
| Intraproject | .08 | .30 | .07 | -.16 |
| Intra-Organizational | | | | |
| Division | -.08 | -.11 | -.19 | -.01 |
| R&D Laboratory | -.16 | -.27 | .14 | -.32 |
| Corporation | .14 | -.18 | .45* | -.05 |
| Extra-Organizational | | | | |
| Customers/Suppliers | -.06 | -.25 | .02 | -.19 |
| Professionals | .15 | .59** | .02 | -.02 |
| Consultants | .06 | .55* | -.15 | .13 |
| N = | 61 | 13 | 22 | 20 |

*p < .05

**p < .01

Table 3

Standardized Mean Communications and Performance Correlations

By Project Type and Content Category

| Communication Variables | Project Type | Problem-Solving Standardized Means | Problem-Solving Performance Correlations | Administrative Standardized Means | Administrative Performance Correlations |
|---|---|---|---|---|---|
| Intraproject: | Research (N=13) | 1.66[a] | .50* | 1.64[a] | .49*[a] |
| | Development (N=22) | .80[b] | .05 | .85[b] | -.18[b] |
| | Service (N=20) | .79[b] | .12 | .74[b] | -.51**[b] |
| Intra-Organizational | | | | | |
| Division: | Research | 1.12 | -.08 | 1.21[a] | .22 |
| | Development | .89 | -.01 | 1.12 | -.23 |
| | Service | 1.04 | .16 | .72[b] | -.42* |
| R&D Laboratory: | Research | 1.60[a] | -.24 | 1.26[a] | -.23 |
| | Development | .99[b] | .07 | 1.05 | -.15 |
| | Service | .62[b] | -.08 | .78[b] | -.36* |
| Corporation: | Research | .44[b] | -.10 | .38[b] | -.22 |
| | Development | 1.09[a] | .43* | 1.12[a] | -.18 |
| | Service | 1.27[a] | .00 | 1.26[a] | -.26 |
| Extra-Organizational | | | | | |
| Customers/ Suppliers: | Research | .48[b] | -.17 | N.A. | N.A. |
| | Development | .93[b] | .09 | N.A. | N.A. |
| | Service | 1.42[a] | .03 | N.A. | N.A. |
| Professionals: | Research | 2.22[a] | .77**[a] | N.A. | N.A. |
| | Development | .48[b] | -.12[b] | N.A. | N.A. |
| | Service | .78[b] | .40* | N.A. | N.A. |
| Consultants: | Research | .69[b] | .72**[a] | N.A. | N.A. |
| | Development | 1.59[a] | -.26[b] | N.A. | N.A. |
| | Service | .55[b] | -.14[b] | N.A. | N.A. |

*$p < .05$
**$p < .01$
N.A. = Not Applicable

Note: Communication means with superscript "a" are significantly ($p < .05$) greater than means with superscript "b". Similarly, correlations with superscript "a" are significantly ($p < .05$) greater than correlations with superscript "b".

Table 4

Correlations Between Project Performance and

Communication Variance by Project Type

| Communication Variable[a] | Project Type Research | Development | Service |
|---|---|---|---|
| Intraproject | -.78** | -.24 | .16 |
| Intra-Organizational | | | |
| Division | -.45* | -.20 | .00 |
| R&D Laboratory | -.12 | -.23 | .41* |
| Corporation | .13 | -.36* | .17 |
| Extra-Organizational | | | |
| Customers/Suppliers | -.16 | -.02 | .07 |
| Professionals | -.57* | .28 | .73** |
| Consultants | -.13 | .32 | .17 |
| N = | 12 | 20 | 15 |

*p < .05

**p < .01

[a]Actually, the coefficient of variation was used to represent the communication variance scores, i.e., the degree of role specialization, for each project to each of the seven areas.

Note: Underlined correlations are significantly different at the .01-level.

Table 5

Multiple Regressions on Project Performance

For Each Type of R&D Project

| Project Type | Communication Variable | (Content) | Standardized Coefficient | F-Value |
|---|---|---|---|---|
| Research | | | | |
| R = .95 | Professional | (Problem Solving) | .93 | 46.1** |
| F(4,8) = 18.3** | Division | (Problem Solving) | .51 | 15.4** |
| | Corporation | (Administrative) | -.44 | 14.0** |
| | Intraproject | (Problem Solving) | .29 | 5.0* |
| Development | | | | |
| R = .43 | Corporation | (Problem Solving) | .43 | 5.5* |
| F(1,20) = 5.5* | | | | |
| Service | | | | |
| R = .70 | Intraproject | (Administrative) | -.51 | 8.4* |
| F(3,16) = 5.4** | Professional | (Problem Solving | .32 | 3.6* |
| | R&D Laboratory | (Administrative) | -.33 | 3.3* |

*p < .05

**p < .01

Note: Variables designating extra-organizational communications are underlined.